# Coffee Gold Mine

# YESAB Project Proposal

# Appendix 14-B Fish and Fish Habitat Valued Component Assessment Report

# VOLUME III


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# ACRONYMS AND ABBREVIATIONS

| Acronym / Abbreviation | Definition |
|---|---|
| AEG | Access Consulting Group |
| AFDM | Ash-Free Dry Mass |
| ARD/ML | Acid rock drainage/metal leachate |
| BC FLNRO | BC Ministry of Forests, Lands and Natural Resources |
| BC MoE | British Columbia Ministry of Environment |
| BC MoF | British Columbia Ministry of Forestry |
| BMP | Best Management Plan/Practice |
| CCME | Canadian Council Ministers of the Environment |
| CCME AL | CCME Water Quality Guidelines for the Protection of Aquatic Life |
| CEA | Cumulative Effects Assessment |
| CFIA | Canadian Food Inspection Agency |
| CoPCs | Contaminants of Potential Concern |
| CRA | Commercial, recreational or aboriginal (fishery) |
| DFO | Fisheries and Oceans Canada |
| EDI | EDI Environmental Dynamics Inc. |
| eDNA | Environmental Deoxyribonucleic Acid |
| EPT | Ephemeroptera-Plecoptera-Trichoptera |
| FNNND | First Nation of Na-cho Nÿak Dun |
| GC | Government of Canada |
| HLF | Heap Leach Facility |
| JTC | The United States and Canada Yukon River Joint Technical Committee |
| LAA | Local Assessment Area |
| LWD | Large Woody Debris |
| MAD | Mean Annual Discharge |
| MMER | Metal Mining Effluent Regulation |
| NAR | Northern Access Route |
| OWPM | Open Water Performance Measure |
| PAG | Potentially Acid Generating |
| PECG | Palmer Environmental Consulting Group |
| PoE | Pathway of Effects |
| QA/QC | Quality Assurance/Quality Control |
| RAA | Regional Assessment Area |
| SFN | Selkirk First Nation |
| ROM | Run-of-mine (ore) |
| PSSWQO | Proposed Site-Specific Water Quality Objectives |

| Acronym / Abbreviation | Definition |
|---|---|
| TAC | Transportation Association of Canada |
| TH | Tr'ondëk Hwëch'in |
| TK | Traditional Knowledge |
| TSS | Total Suspended Solids |
| TWG | Technical Working Group |
| US EPA | United States Environmental Protection Agency |
| VC | Valued Components |
| WAD-CN | Cyanide, Weak Acid Dissociable |
| WBM | The water balance model described in the Hydrology IC report (**Appendix 8-B**). |
| WRFN | White River First Nation |
| WRSF | Waste Rock Storage Facility |
| YG | Yukon Government (territorial) |
| YOY | Young of the year |

## SYMBOLS AND UNITS OF MEASURE

| Symbol / Measurement | Definition |
|---|---|
| ha | Hectare |
| km | Kilometre |
| $km^2$ | Square kilometre |
| m | Metre |
| $m^2$ | Square metre |
| $m^3/s$ | Cubic metre per second |
| mg/L | Milligram per litre |
| µg/L | Microgram per litre |

# 1.0 INTRODUCTION

The Coffee Gold Mine (Project) is a proposed gold mine fully owned by Goldcorp Inc. (Proponent) and located in the White Gold District of west-central Yukon, approximately 130 kilometres (km) south of the City of Dawson. The Project contains a substantial oxide resource that will be mined by open pit mining methods and recovered with heap leach processing.

Four Open Pits (called Latte, Double Double, Supremo, and Kona) will be developed using standard drill and blast methods, and mined using conventional shovel and truck methods. The ore will be crushed and placed onto a Heap Leach Facility. Gold extraction will utilize sodium cyanide heap leaching technology. A diluted solution of alkaline cyanide will be applied to the stacked ore on the heap leach pad using drip irrigation. As the solution percolates through the heap leach, gold will react with the cyanide and dissolve into the solution. This gold-bearing solution will be collected at the base of the heap leach pad and will be transported by pipe to the process facility where it will be processed via conventional gold recovery methods at an on-site adsorption, desorption, and recovery carbon plant to produce a final gold doré product. In addition to the Open Pits, the Heap Leach Facility and processing facilities, the overall Mine Site footprint will include two Waste Rock Storage Facilities (Alpha and Beta WRSF), a water treatment plant, water management structures, haul and service roads, a Camp Site and other ancillary buildings and facilities. Electricity will be generated on-site by diesel-powered generators.

The Mine Site will be accessed by road from Dawson via a 214-km, all-weather access road with river barge crossings, referred to as the Northern Access Route (NAR). The NAR includes upgrades to existing road and construction of approximately 37 km of new single-lane road with pullouts, with a design speed of 50 km per hour (km/hr). The NAR includes seasonal barge crossings on both the Stewart and Yukon rivers, with ice bridges in the winter months. Road activities will likely be suspended for approximately six weeks in November/December for fall freeze-up (Suspension Period), and approximately four weeks in April/May for spring thaw. Air transportation and the use of airstrips at the Mine Site will provide year-round access, and will be utilized to transport most mine personnel to and from site by charter aircraft from Whitehorse and other communities, as well as some freight. The detailed Project Description is provided in **Volume I, Section 2.0**.

This volume is the detailed assessment of the potential Project-specific and cumulative effects of the Coffee Gold Mine on Fish and Fish Habitat. The assessment quantifies or qualitatively describes the potential effects of the Project on important fish species and indicators. Subcomponents and indicators focus the assessment on information known to be important or of key interest to First Nations, government and other technical reviewers. The volume characterizes the potential Project interactions with Fish and Fish Habitat and identifies the mitigation actions and protection plans that the Proponent will establish to reduce or eliminate negative effects on fish.

This report is structured as a stand-alone document so that reviewers can find the information required to assess the Project's potential effects on Fish and Fish Habitat. A brief description of the Project includes information relevant to the potential interactions of the Project with the aquatic environment. The Scope of Assessment section includes a description of the basis for the scope of the assessment and justifies the use of fish as a Valued Component in Yukon. It identifies the fish subcomponents and indicators that are used to focus the assessment on metrics that are likely to be negatively affected by the Project and important to reviewers when considering the effects of the Project on Fish and Fish. This section also identifies the temporal, spatial administrative and technical boundaries of the Fish and Fish Habitat assessment.

The Assessment Methods section describes the quantitative and qualitative approaches used in assessing potential Project-related and cumulative effects. The methods focus on using the best available information, analysis and environmental assessment best practice for predicting effects on Fish and Fish Habitat. While general methods of the overall assessment are described in **Section 5.0 of Volume I**; the methods described in this section are specific to the Fish and Fish Habitat assessment.

The Existing Conditions section describes baseline conditions of Fish and Fish Habitat that are relevant to potential Project interactions with the aquatic environment. It includes a summary discussion of the regulatory context in which the Proponent assessed effects and proposed management and mitigation actions to reduce effects on fish. A summary section indicating where or how traditional knowledge was incorporated in the assessment methods, where scientific and other studies was, and how the information from baseline studies conducted in the Project area is provided. The section concludes with a summary of the existing Fish and Fish Habitat conditions to place the following effects assessment in the context of local and regional Fish and Fish Habitat conditions.

The Assessment of Project-Related Effects section provides the technical details that describe the potential effects of the Coffee Project on Fish and Fish Habitat. The section identifies the potential Project interactions with fish, identifies mitigation measures that are implemented at the project design level, and outlines other fish and habitat-specific measures that can be used by the Proponent in the design and management of the Coffee Project. The section describes the commitments that the Proponent makes to reduce or eliminate interactions or disturbances to fish prior to a determination of significance of those potential effects. The technical details of the effects on fish species that were selected as subcomponents are provided in subsections.

The Assessment of Cumulative Effects section provides a broader overview of the potential combined effects of past, present and reasonably foreseeable future projects and disturbances. The section characterizes the combined residual Project-related effects (i.e., those effects that cannot be completely avoided) with other effects potentially having occurred, currently occurring, or likely to occur within the seasonal ranges of the species being assessed. A list of those projects and disturbances considered in the cumulative effects are identified in this section. Where necessary, and if separate from Project-related effects, mitigation actions to address potential cumulative effects are described.

The Summary of Effects Assessment on Fish and Fish Habitat section provides an overview of the technical assessments described in the Project-Related Effects and Cumulative Effects sections. Readers who do not need all technical details of the effects assessment can refer to this section if they only need to reference the overall conclusions of the predicted significance of the potential effects of the Coffee Project on Fish and Fish Habitat.

The report concludes with a description of the actions that the Proponent will move forward with following approvals in the Effects Monitoring and Adaptive Management section. The information provided includes what the Proponent will do to actively manage disturbances and effects as the Project moves forward through Construction, Operation, Reclamation and Closure, and Post-Closure. It identifies an approach to adapt to changes in techniques and information of fish response to disturbances, and to continue to collaborate with First Nations and regulators on project monitoring and effects management decision making. It shows that the Proponent will be committed to regular monitoring and re-assessment, and can readily adapt to changes necessary to reduce Project-related effects.

### 1.1 ISSUES SCOPING

The scope of this assessment is based on input from regulatory agencies. Available information regarding other existing and proposed quartz mining projects in the Yukon and other parts of northern Canada, including environmental assessments were reviewed. Issues and concerns were also identified through consultation and engagement activities with communities, stakeholders and First Nations, and the professional judgement and experience of the Project team

The scope of the assessment considered the Project's potential direct and indirect effects, residual effects and cumulative effects associated with Construction, Operation, Reclamation and Closure, and Post-Closure phases. The initial step in the effect assessment process was the completion of fisheries and aquatic resource baseline reports (**Appendix 14-A**). These reports characterize the existing Fish and Fish Habitat conditions upon which the Project may have an effect.

To support the scoping of issues for the Project, the Proponent conducted an engagement and consultation process, as defined under section 50 (3) of the *Yukon Environmental and Socio-economic Assessment Act* (YESAA); see **Sections 3.0** through **3.6** for details on the consultation program. The Proponent continues to consult and engage with affected First Nations and communities, government agencies, and interested persons and/or other stakeholders who may be interested in the Project and its related activities. This consultation and engagement process included meetings with First Nations and government departments (e.g. Environment Yukon), community meetings, one-on-one and small group meetings, and ongoing communications such as print communication, newsletter, and website updates, including specific presentations and discussions regarding fish and aquatic resource baseline studies. The consultation and engagement process also included the establishment of the Tr'ondëk Hwëch'in (TH) Technical Working Group (TWG) which was formed during the Project scoping stage to provide the Proponent with ongoing advice and detailed information to better inform their environmental baseline and effects assessment programs for the Coffee Project. The intent of the TWG was to provide a forum for the Project to engage with the TH and receive direct feedback regarding valued components including Fish and Fish Habitat.

Traditional Knowledge informed on historical and current use of the Fish and Fish Habitat Regional Assessment Area (RAA; **Section 1.2**) by various fish species valued by local First Nations. Scientific sampling of the project area by professional biologists from both Palmer Environmental Consulting Group (PECG) and EDI Environmental Dynamics Inc. (EDI) provided comprehensive baseline data on Fish and Fish Habitat present throughout the Fish and Fish Habitat Local Assessment Area (LAA; **Section 1.3**).

Important issues related to Fish and Fish Habitat were derived from the above mentioned engagement/consultation process supported with relevant scientific information that has been collected by qualified professional biologists and consultants of various disciplines including those that interact with Fish and Fish Habitat. With this information in hand, a thorough review of all Project activities and associated pathways of effect (PoE) to Fish and Fish Habitat was conducted.

Project activities that could potentially change surface water hydrology, surface water quality, groundwater, air quality and noise could all contribute to effects on Fish and Fish Habitat. DFO has developed pathway of effect (PoE) guidance diagrams that can be applied to Project activities to determine potential effects (DFO 2014). Both land-based and in-water activities can have a PoE for Fish and Fish Habitat. Land-based construction activities including, but not limited to, vegetation clearing, construction and maintenance of the NAR and bridges, excavation and grading, and use of explosives can potentially result in increased sediment, contaminant, and nutrient inputs to watercourses, alter baseflow through changes to groundwater pathways, change habitat structure and cover, food supplies, and potentially alter water temperatures. In water activities including, but not limited to, changes in timing, duration and frequency of flows, placement of material and structures in water, fish passage issues and use of industrial equipment can potentially result in a decrease in the amount of useable fish habitat, change in access to fish habitat, increases in sediment inputs to watercourses, or entrainment or mortality of fish species.

## 1.2 FISH AND FISH HABITAT AS A VALUED COMPONENT

Valued Components (VCs) are attributes of cultural or ecological importance that interact with the Project. Fish and Fish Habitat, was selected as Valued Component (VC) for social, biological, and environmental assessment best practice procedures. Fish and Fish Habitat, as a whole, is of significant importance to the local First Nations and other local Yukon residents. Fish species, including Arctic Grayling (*Thymallus Arcticus*), Chinook Salmon (*Oncorhynchus tshawytscha*), Chum Salmon (*O. keta*), burbot (*Lota lota*), northern pike (*Esox lucius*) and whitefish (multiple species) are of traditional and cultural importance (**Volume 1, Section 3.3**). These species provide a valued food source, are of recreational value and in the case of the two salmon species, commercial value. These species, in turn, rely on the health and integrity of their surrounding environment to grow and thrive. The environmental components important to the health of fish species include habitat, water and sediment quality, as well as the presence of benthic invertebrate and phytoplankton populations that provide food sources for the fish species.

### 1.2.1 CANDIDATE VCS

A number of candidate VCs were considered during the development of the Project including individual fish species, aquatic biota and fish habitat. There are distinct interactions between the Project activities and the aquatic environment including aquatic biota and ultimately the fish species that use the stream habitats adjacent to (i.e. NAR) or downstream of Project infrastructure (i.e. Mine Site). Details regarding the evaluation of candidate VCs are presented in **Table 1.2-1**.

Aquatic ecosystems are heavily interconnected; selection of a broad, more encompassing VC such as Fish and Fish Habitat assumes that effects to other resident aquatic species and components (e.g., benthic invertebrate and periphyton communities) are indirectly considered. Ultimately the selection of Fish and Fish Habitat best addresses the key fish species that interact with the project and properly considers aquatic biota with respect to the overall health of valued fish species/communities. It is also addresses the broad interests of First Nations, regulators, stakeholders and community members that were expressed during consultation for the Project.

**Table 1.2-1 Candidate Valued Components for Fish and Fish Habitat – Evaluation Summary**

| Candidate VC | Project Interaction | | | Third Party Input | | Supports the Assessment of Which Other VC? | Selected as a VC? | Decision Rationale |
|---|---|---|---|---|---|---|---|---|
| | Interaction? | Project Phase / Project Component / Activity | Nature of Interaction | Source | Input | | | |
| Fish and Fish Habitat | Yes | Construction, Operation, Reclamation and Closure, Post-closure | Potential change in habitat suitability, accessibility, contaminant toxicity, stream productivity and fish mortality | YESAB guidance documents, YG, DFO | Concerns regarding changes to Fish and Fish Habitat | Traditional & Non-Wage Economy, Traditional land & Resource Use, and Community Health & Well-being | Yes | Encompasses multiple species and potential effects |
| Chinook Salmon | Yes | Construction, Operation, Reclamation and Closure, Post-closure | Potential change in habitat suitability, accessibility, contaminant toxicity, stream productivity and fish mortality | TH, DFO | Concerns regarding changes to this species and associated habitat | Traditional & Non-Wage Economy, Traditional land & Resource Use, and Community Health & Well-being | No, identified as a subcomponent of Fish and Fish Habitat | Are included under Fish and Fish Habitat and will be evaluated at the sub-component level |
| Arctic Grayling | Yes | Construction, Operation, Reclamation and Closure, Post-closure | Potential change in habitat suitability, accessibility, contaminant toxicity, stream productivity and fish mortality | TH, DFO | Concerns regarding changes to this species and associated habitat | Traditional & Non-Wage Economy, Traditional land & Resource Use, and Community Health & Well-being | No, identified as a subcomponent of Fish and Fish Habitat | Are included under Fish and Fish Habitat and will be evaluated at the sub-component level |
| Chum Salmon | Yes | Construction, Operation, Reclamation and Closure, Post-closure | Potential change in habitat suitability, and fish mortality | TH, DFO | Concerns regarding changes to this species and associated habitat | Traditional & Non-Wage Economy, Traditional land & Resource Use, and Community Health & Well-being | No, identified as a subcomponent of Fish and Fish Habitat | Are included under Fish and Fish Habitat and will be evaluated at the sub-component level |

| Candidate VC | Project Interaction | | | Third Party Input | | Supports the Assessment of Which Other VC? | Selected as a VC? | Decision Rationale |
|---|---|---|---|---|---|---|---|---|
| | Interaction? | Project Phase / Project Component / Activity | Nature of Interaction | Source | Input | | | |
| Slimy Sculpin | Yes | Construction, Operation, Reclamation and Closure, Post-closure | Potential change in habitat suitability, accessibility, contaminant toxicity, stream productivity and fish mortality | - | - | None | No | No significant cultural or fisheries value; potential pathways similar to other species |
| Whitefish (all species) | Yes | Construction, Operation, Reclamation and Closure, Post-closure | Potential change in habitat suitability, accessibility, contaminant toxicity, stream productivity and fish mortality | TH | Noted interest about this species in study area | Traditional & Non-Wage Economy, Traditional land & Resource Use, and Community Health & Well-being | No | Potential pathways of effect similar to other species that are more prevalent in area |
| Northern Pike | Yes | Construction, Operation, Reclamation and Closure (NAR only). | Potential change in habitat suitability, accessibility, and fish mortality | TH | Noted interest about this species in study area | Traditional & Non-Wage Economy, Traditional land & Resource Use, and Community Health & Well-being | No | Potential pathways of effect similar to other species that are more prevalent in area |
| Burbot | Yes | Construction, Operation, Reclamation and Closure (NAR only). | Potential change in habitat suitability, accessibility, and fish mortality | TH | Noted interest about this species in study area | Traditional & Non-Wage Economy, Traditional land & Resource Use, and Community Health & Well-being | No | Potential pathways of effect similar to other species that are more prevalent in area |
| Aquatic Biota | Yes | Construction, Operation, Reclamation and Closure, Post-closure | Potential change in stream productivity, contaminant toxicity, and invertebrate comminutes | TH | Concerns regarding changes to aquatic biota and associated habitat | Fish and Fish Habitat | No, considered in the assessment of Fish and Fish Habitat | Not used by humans. Changes in aquatic biota are evaluated with respect to Fish and Fish Habitat |

### 1.2.2 FISH AND FISH HABITAT SUBCOMPONENTS

Fish and Fish Habitat VC is divided into several subcomponents, or in this case, species of interest to focus the assessment on likely interactions and issues of interest within the Local Assessment Area[1] (LAA). The selected VC subcomponents include Arctic Grayling, Chinook Salmon and Chum Salmon (**Table 1.2-2**). This section also describes other fish species/aquatic resources that were considered and excluded during the VC subcomponents scoping process (**Table 1.2-3**); it details how selected VC subcomponents address the potential pathways of effect (PoE) for all fish habitat and all fish species considered during the scoping process.

**Table 1.2-2 Subcomponents Selected for Fish and Fish Habitat**

| Subcomponent | Representative of | Rationale for Selection |
|---|---|---|
| Arctic Grayling | Non-salmon species; recreational fish species and food species for First Nations | Widespread in the LAA; important recreational/food fish species. |
| Chinook Salmon | Salmonids; target species for First Nation fishery. Also targeted by recreational and commercial fisheries. | Importance to local First Nations, present as juveniles in LAA. |
| Chum Salmon | Salmonids; important species for First Nation and commercial fisheries | Importance to local First Nations and return to LAA to spawn (Yukon River) |

**Table 1.2-3 Subcomponents Excluded for Fish and Fish Habitat**

| Species | Rationale for Exclusion as Subcomponents |
|---|---|
| Slimy Sculpin | No cultural or fisheries value; potential pathways of effect addressed through effects assessment of Arctic Grayling and Chinook Salmon as VC subcomponents. |
| Northern Pike | Not prominent in the LAA; potential pathways of effect addressed through effects assessment of Arctic Grayling and Chinook Salmon as VC subcomponents. |
| Whitefish (all species) | Not prominent in the LAA; potential pathways of effect addressed through effects assessment of Arctic Grayling and Chinook Salmon as VC subcomponents. |
| Burbot | Not prominent in the LAA; potential pathways of effect addressed through effects assessment of Arctic Grayling and Chinook Salmon as VC subcomponents. |
| Aquatic Biota | No direct cultural or human value; potential pathways of effect addressed through effects assessment of Arctic Grayling and Chinook Salmon as VC subcomponents. |

Available fish sampling data documents a diverse assemblage of fish species that are known to inhabit the Yukon River watershed (FISS 2016). A total of 14 species of fish can be found within the streams adjacent to or downstream of the Project infrastructure including two species of salmon and 12 species of resident freshwater fish species. The majority of these species are found only in the Yukon and Stewart rivers with three of these species documented in the small/medium sized streams downstream of proposed mine. These species include Slimy Sculpin *(Cottus cognatus)*, Arctic Grayling, and juvenile Chinook Salmon.

[1] Refer to Section 1.3 for specific locations on the Local Assessment Area.

Traditional Knowledge (TK) and Current Land Use information supplements this data, provides information more local to the Project Area, and speaks to fish species of interest to First Nations and local Yukon residents. TK identifies Whitefish (various species), Burbot (Lota lota), Northern Pike (Esox lucius), Arctic Grayling, and Chinook and Chum Salmon as fish species in the Yukon River (Bates et al. 2014, TH 2012, DRPC 2013; Interview 14, pers. comm. 2016).

The VC subcomponent selection process focused on the fish species that have been documented by both TK and baseline studies; species selected include Arctic Grayling, Chinook Salmon and Chum Salmon. Slimy Sculpin were identified during baseline studies but this species was not identified as focal species by TK, nor is it a species that is targeted in any recreational, commercial or First Nation fisheries or otherwise consumed by humans. In addition, the other fish species in the study area are not piscivorous and therefore, the local Slimy Sculpin would not represent a significant food source for the VC subcomponent species (i.e., Arctic Grayling and juvenile Chinook Salmon feed primarily on invertebrates and adult Chinook and Chum Salmon do not feed in freshwater).

Other fish species identified in the TK study, including Burbot, Northern Pike and Whitefish are present in the Yukon River and could utilize some of the smaller streams in the LAA. Selected VC subcomponents Arctic Grayling and juvenile Chinook Salmon are the most widespread in the LAA and potential PoE relating to changes in fish habitat, contaminant toxicity and changes in food sources and primary productivity can be better addressed by selection of Arctic Grayling and Chinook Salmon as VC subcomponents, rather than Burbot, Northern Pike or a Whitefish species which are only present in the larger rivers in the LAA.

Aquatic biota do not provide direct cultural or human value; however, are prevalent in all streams and are food sources for fish populations. Selection of key fish species as subcomponents that rely on aquatic biota (grayling and juvenile Chinook) ensures that effects to aquatic biota are indirectly considered in the assessment. Change to food supply including benthic invertebrates and periphyton has to be assessed to determine if there are effects to the fish species that feed on them.

### 1.2.3 INDICATORS

The selection of indicators was based on the consideration of the potential PoE on VC subcomponents and, applicable regulatory requirements described in **Section 3.1** of this document including the Fisheries Act (Government of Canada 1985) and the annexed Metal Mining Effluent Regulation (Government of Canada 2002). In some instances, the potential PoE is the same for each VC subcomponent and thus the same indicators are used for more than one VC subcomponent. Habitat suitability and mortality are the only indicators for Chum Salmon as this species uses the LAA for spawning only, does not utilize small creek habitats and does not interact with the aquatic food chain in the LAA. The measurable parameters and the rationale for selection of each indicator are summarized in **Table 1.2-4** in and are further described in this section.

### Table 1.2-4 Indicators for Fish and Fish Habitat Subcomponents

| Indicator | Measurable Parameter | Rationale for Selection of Indicator |
|---|---|---|
| **Arctic Grayling and Chinook Salmon** | | |
| Habitat Suitability | Change in area and quality of potential spawning, rearing and overwintering habitat | Importance to fish population recruitment; consultation with regulators, First Nations; CCME Water Quality Guidelines, regulatory requirement of Section 35 of the *Fisheries Act.* |
| Habitat Accessibility | Change in area of accessible habitat related to the creation or reduction in the number of barriers to fish migration | Importance to fish population recruitment; consultation with regulators, First Nations; regulatory requirement of Section 20 and Section 35 of the *Fisheries Act.* |
| Contaminant Toxicity | Change in contaminant concentrations including nutrient parameters, cyanide, and metals affecting fish health | Importance to fish population health; consultation with regulators, First Nations; water quality guidelines (CFIA, CCME, US EPA), regulatory requirement of Section 36 of the *Fisheries Act* and Part 2, 7(1) of the *Metal Mining Effluent Regulations.* |
| Stream Productivity | Changes in food supply including benthic invertebrates and periphyton (aquatic biota) associated with changes in water temperature, nutrient concentrations, and the amount of sediment mobilization into streams (i.e. total suspended sediment [TSS] concentrations and sediment deposition) | Importance to fish population recruitment; consultation with regulators, First Nations, regulatory requirement of Part 2, 7(1) of the *Metal Mining Effluent Regulations.*<br>Importance to fish population recruitment; consultation with regulators, First Nations. |
| Fish Mortality | Amount of direct mortality (e.g. from habitat infilling, blasting)<br>Change in the amount of sediment mobilization into streams (i.e. TSS concentrations and sediment deposition) | Importance to fish population health; consultation with regulators, First Nations; water quality guidelines (CFIA, CCME, EPA), regulatory requirement of Section 36 of the *Fisheries Act* and Part 2, 7(1) of the *Metal Mining Effluent Regulations.* |
| **Chum Salmon** | | |
| Habitat Suitability | Change in area and quality of potential spawning, rearing and overwintering habitat<br>Change in the amount of sediment mobilization into streams (i.e. TSS concentrations and sediment deposition) | Importance to fish population recruitment; consultation with regulators, First Nations; CCME Water Quality Guidelines, regulatory requirement of Section 35 of the *Fisheries Act.* |
| Fish Mortality | Amount of direct mortality (i.e. from habitat infilling, blasting)<br>Change in the amount of sediment mobilization into streams (i.e. TSS concentrations and sediment deposition) | Importance to fish population health; consultation with regulators, First Nations; water quality guidelines (CFIA, CCME, EPA), regulatory requirement of Section 36 of the *Fisheries Act* and Part 2, 7(1) of the *Metal Mining Effluent Regulations.* |

Effects on habitat suitability (**Table 1.2-4**) have the potential to reduce fish population health through increased competition for optimal biophysical conditions that support key life requisites; thereby, reducing the abundance or diversity of the fish community. Habitat suitability effects will be assessed by modeling changes in stream depth, velocity and cover associated with flow changes and measuring amounts/quality of habitat that will be directly altered. Project components that influence erosion and sediment mobilization into streams will be assessed to determine if increased sediment load will result in adverse effects to streambed composition.

Effects on habitat accessibility (**Table 1.2-4**) have the potential to obstruct fish movement patterns; thereby, indirectly reducing the abundance or diversity of the fish community. The amount of Project related change to habitat accessibility will be measured by identifying potential barriers to fish passage and quantifying the amounts and types of isolated habitats. There is no potential PoE by which the Project could reduce habitat accessibility within the Yukon or Stewart rivers or at the mine site, and as such, this indicator applies only to the smaller streams, associated with NAR stream crossings.

Effects of contaminant toxicity (**Table 1.2-4**) have the potential to reduce fish population health through reduced fitness levels, as measured through a variety of health indices, and increased mortality rates. The level of Project related change in contaminant toxicity will be assessed by predicting fish tissue metal concentrations based on project changes to water quality and comparing measurements to relevant published or site specific guidelines, as well as scientific literature describing sub-lethal toxicity effects.

Effects associated with changes in stream productivity (**Table 1.2-4**) can result in changes to food supply. Changes in the amount of plants and organic debris, and abundance and diversity of primary consumers (benthic invertebrates) within the aquatic food chain can result in changes in the abundance and/or species composition of secondary consumers (fish). The ultimate result could be less diverse food sources and a decrease in fish health and fitness. The level of Project related change in food sources will be assessed by evaluating predicted changes in nutrient concentrations and changes in suspended sediment concentrations.

Fish mortality is prohibited under the Fisheries Act. Effects resulting in fish mortality could occur due to instream work (e.g. habitat infilling), and sediment deposition over incubating eggs. Longer term health effects and mortality from contaminants are considered under the contaminant toxicity indicator.

## 1.3 Assessment Boundaries

This section identifies the spatial and temporal boundaries established for the assessment of Fish and Fish Habitat. No administrative boundaries for the assessment of Fish and Fish Habitat were identified.

### 1.3.1 Spatial Boundaries

The Fish and Fish Habitat Local Assessment Area (LAA) is defined as the maximum geographical extent that direct and indirect Project effects are expected to occur on the Fish and Fish Habitat VC. The extent of the LAA was based on the Project area extent and the understanding of the extent of potential effects downstream on Fish and Fish Habitat as a result of changes in water surface water hydrology and/or water quality. The spatial extents of the LAA were defined differently for watercourses in the vicinity of the proposed mine site than for watercourses in the vicinity of the proposed alignment for the NAR because of the localized influence of the road.

Fish living in the near downstream vicinity of the proposed mine site could potentially be affected by mine effluent. Accordingly, watersheds in and downstream of the exposure area of the proposed mine site were included in the LAA including a portion of the Yukon River extending from upstream of Coffee Creek to downstream of Halfway Creek. Along the NAR, potential Project related effects include short-term water quality degradation associated with erosion and sedimentation, fish passage and localized changes to instream habitat associated with crossing structures. As such, the spatial extent of the LAA includes 100 metres upstream and downstream of the NAR (**Figure 1.3-1**); an area where watercourse will be most susceptible to changes associated with road construction and operation (e.g. sediment inputs).

The Fish and Fish Habitat LAA is 527 km² and includes Coffee Creek, Latte Creek, Halfway Creek, YT-24 and a portion of the Yukon River in the vicinity of the mine site, as well as streams that are intersected by the NAR (**Table 1.3-1**). Two additional watersheds, Los Angeles and Independence Creeks, are included as reference sites, but are not located within the LAA. The Los Angeles Creek watershed is located approximately 10 km downstream of the Fish and Fish Habitat LAA boundary, and is outside of the exposure area of the mine. Independence Creek is located near the mine site (**Figure 1.3-1**), however, no Project-related effects are expected to Fish and Fish Habitat in this creek (**Appendix 8-B and Appendix 12-B**). Therefore, monitoring data from the exposure area watersheds in the LAA can be compared to data from Los Angeles and Independence creeks (**Table 1.3-1**) to assist in determining if potential effects are related to Project activities. It should be noted that there is currently exploration activities being conducted by another mining exploration company that could potentially impact Independence Creek in the future, and therefore its use as a reference creek will continue to be re-assessed as the Project advances.

Stream and river crossings of the proposed NAR include portions of the following watersheds: Hunker Creek, Sulphur and Eureka creeks (tributaries to the Indian River), Maisy May and Barker creeks (tributaries to the Stewart River) and Ballarat Creek (tributary to the Yukon River). No road upgrades are proposed for the portion of the NAR in the Hunker Creek watershed. There are also barge/ice bridge crossings of the Stewart and Yukon rivers (**Figure 1.3-1**). The spatial extent of the LAA includes a 17 km segment of the Yukon River and a 9 km portion of the Stewart River where Chinook and Chum Salmon could potentially occur in the vicinity of the Project (**Figure 1.3-1**). These segments include areas in the vicinity of proposed barge crossing and barge landings locations on both rivers; a back channel area in the Stewart River that may be affected by the proposed NAR alignment is also included in the area of the Stewart River within the LAA.

The Fish and Fish Habitat Regional Assessment Area (RAA) is defined as the maximum geographical extent that any effects of the Project on Fish and Fish Habitat are likely to interact with the effects of other past, present of future projects or activities. As a result, the Fish and Fish Habitat RAA defined the boundaries of the cumulative effects assessment for Fish and Fish Habitat. The spatial extent of the RAA fully encompasses the LAA and provides a regional context for the assessment of Project effects.

The Fish and Fish Habitat RAA is 8,807 km² and includes the full spatial extent of all tributary streams that flow into the Yukon River between (and inclusive of) the confluence of Isaac Creek to the east and the confluence of Los Angeles Creek to the west (**Figure 1.3-1**), as well as the full drainage extent for every watercourse that crosses the proposed NAR (except the Klondike, Yukon and Stewart rivers). The spatial extent of the RAA also includes the segment of the Yukon River from the mouth of Ballarat Creek to Dawson City, and the segment of the Stewart River from the mouth of Maisy May Creek confluence of the Yukon and Stewart rivers (**Figure 1.3-1**). These two river segments are included in the RAA based on TK regarding the importance of the Chinook and Chum Salmon fisheries downstream of the Project area, as well as to allow for the assessment of cumulative effects on the VC subcomponents of Chum and Chinook Salmon downstream of the Project area.

**Table 1.3-1 Spatial Boundary Definitions for Fish and Fish Habitat**

| Spatial Boundary | Description of Assessment Area |
|---|---|
| Local Assessment Area | • Entire watersheds of Latte Creek, Halfway Creek and YT-24.<br>• Lower Coffee Creek watershed –from the confluence with the Yukon River extending 10 km upstream.<br>• A 17 km portion of the Yukon River in the vicinity of the mine site (includes area of barge operation and ice bridge) and a 9 km portion of the Stewart River in the vicinity of the proposed barge crossing and ice bridge location.<br>• 100 m upstream and downstream of stream crossings along the proposed NAR. |
| Regional Assessment Area | • Entire watersheds of tributary creeks to the north of the Yukon River, between and including Isaac Creek to east and Los Angeles creek to the west.<br>• Full watershed extent of any watercourse that is crossed by the proposed Northern Access Route, or is within the catchment area for runoff from the proposed NAR.<br>• Yukon River from Ballarat Creek confluence downstream to Dawson City (163 km) and Stewart River from upstream of Maisy May Creek confluence downstream to confluence of Yukon and Stewart rivers (51 km). |
| Cumulative Effects Assessment Area | • Same as RAA |

### 1.3.2 TEMPORAL BOUNDARIES

The temporal characteristics of the Project's Construction, Operation, Reclamation and Closure, and Post-Closure phases are described in **Volume I**, **Section 2.0 Project Description**. The temporal boundaries established for the assessment of Project effects on Fish and Fish Habitat encompass these Project phases.

### 1.3.3 ADMINISTRATIVE BOUNDARIES

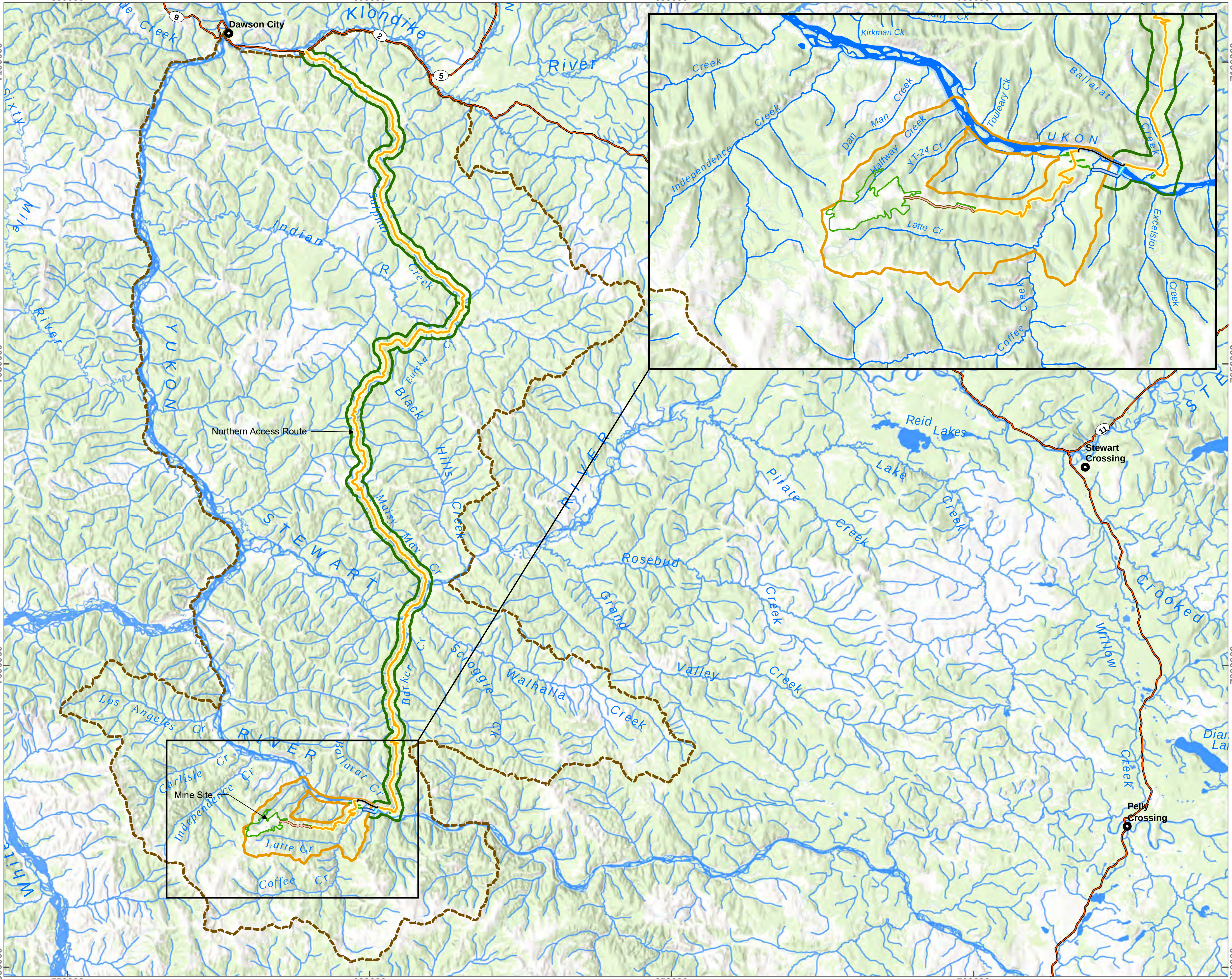
There are no political, economic, fiscal or social constraints that constrain the boundaries of the LAA or RAA or otherwise interfere with the ability to identify or assess potential effects on Fish and Fish Habitat. No administrative boundaries were identified for Fish and Fish Habitat.

### 1.3.4 TECHNICAL BOUNDARIES

Fish and Fish Habitat information was collected from representative sites within the LAA. Information on variables affecting Fish and Fish Habitat (i.e. gradients, stream order) was used to support such information and provide insight on fish distribution. The gradient information was obtained from high quality (2 m resolution) LIDAR information around the mine site and 1:250,000 mapping along the NAR. Of these, the LIDAR is more reliable; however, additional field verification was completed on all sites where fish distribution may be limited by gradients or habitat quality. For the purposes of this assessment, conservative approaches were used in terms of predicting fish distributions (i.e. stream reaches were assumed to be fish bearing in cases where information was limited).

The low number of fish in many creeks within the Project area limits robust statistical assessments of various fish health metrics in several creeks within the LAA and RAA. For example, baseline sampling in Halfway, YT-24 and Latte creeks resulted in the capture of very few fish in all the exposure areas of these watersheds (**Appendix 14-A**). This may limit the ability to assess changes in VC indicators including fish tissue metal concentrations.

During the winter, ice cover over many streams imposes a technical limitation on the ability to sample and document fish presence and habitat usage in some areas during the winter. Novel sampling techniques (e.g., environmental DNA [eDNA] sampling) have been used during baseline studies to assist in determining the presence of fish species during winter months (**Appendix 14-A**); however, this approach is limited to documenting the presence or absence of a given species and cannot inform on the relative abundance or exact location of fish during the winter months. Where possible this information was supplemented by fish sampling.





COFFEE GOLD MINE

**Fish and Fish Habitat Assessment Boundaries**

## Legend

- Stewart River Ice and Barge Crossings
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access Route
- Northern Access Route
- Project Footprint
- Regional Assessment Area
- Local Assessment Area (mine)
- Local Assessment Area (NAR)

## Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

## Sources

1. Sources: Esri, HERE, DeLorme, increment P Corp., NPS, NRCan, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community
2. Project access and infrastructure provided by Goldcorp Inc. (2017).
3. Aquatic study areas developed by EDI Environmental Dynamics Inc. (2016).

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Kilometres

NAD 1983 UTM Zone 7N

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| Figure 1.3-1 | Date: Mar 23, 2017 | Drawn by: HG/MP | Reviewed: MAS/PT |
|---|---|---|---|

GOLDCORP

# 2.0 ASSESSMENT METHODS

This section describes the methods used to identify and assess the potential Project-related and cumulative effects on Fish and Fish Habitat. The methods were developed pursuant to assessment requirements identified in the *Yukon Environmental and Socio-economic Assessment Act* (YESAA) and YESAB guidance documents. The assessment was conducted in accordance with the general methods identified in **Volume I, Section 5.0 Assessment Methodology**. As described in each section of the report, the assessment was informed by input provided during consultation and engagement with Yukon Environment, affected First Nations, the public, and a review of TK, scientific and other information.

The assessment of potential Project-related effects on Fish and Fish Habitat was divided into two sections: the Mine Area, which encompasses all mine infrastructure and receiving drainages (Latte, Coffee, YT-24 and Halfway creeks, as well as the Yukon River from upstream of Coffee Creek to downstream of Halfway Creek) and the NAR, which includes an assessment corridor that begins at north shore of the Yukon River and follows the NAR right-of-way to Sulphur Creek. The assessment was separated for the following reasons: 1) relevant management plans are separate for the Mine Area and NAR, 2) Project activities differ between the two sections thus dividing the sections allows for more detailed description of Project effects related to differing activities and how these activities affect each subcomponent, and 3) there are no temporal or spatial overlap between potential Project-related effects.

## 2.1 HABITAT SUITABILITY

The Project's potential effects on habitat suitability were assessed by a number of different methods. For the Mine Area, the physical footprint will not affect habitat suitability because no fish occur within the mine site footprint; however, construction and operations of the mine site is predicted to have measureable effects on surface water hydrology. As such, the focus of the assessment was on the downstream effects on Fish and Fish Habitat. Flow predictions from the Project's Water Balance and Water Quality Model Report (**Appendix 12-C**) were used to assess the effect of flow changes to Fish and Fish Habitat during each Project phase. In the absence of any Yukon guidelines, resources from nearby jurisdictions were utilized (i.e. Environmental Flow Assessment Methods for Application to Northeastern BC; Hatfield et al. 2013). The NAR footprint interacts with fish habitat and thus required a quantitative and qualitative assessment of the habitat that will be modified or lost.

Potential effects of excessive sediment mobilization and subsequent deposition in stream habitats were also considered for both the Mine Area and NAR.

## 2.2 HABITAT ACCESSIBILITY

The Project's potential effects on habitat accessibility were evaluated by considering the effects of Project infrastructure (including designs /plans) on fish movement and distribution. In the absence of any Yukon guidelines, information on stream crossing structures and fish passage criteria from literature from nearby jurisdictions was reviewed as necessary (e.g. BC FLNRO, 2012). This component focused on the NAR given there is no fish within the proposed mine infrastructure.

### 2.3 CONTAMINANT TOXICITY

Potential effects of the Project on Fish and Fish Habitat were evaluated with respect to predicted changes in water quality (**Appendix 12-B**). Predicted increases to contaminant concentrations in the Mine Area were evaluated in light of spatial and temporal distribution, fish species distribution and seasonality were screened against CCME and BC water quality guidelines for the protection of freshwater aquatic life and Proposed Site-Specific Water Quality Objectives (PSSWQO); applicable guidelines for all parameters were as outlined in **Table 4.2-3** and **Appendix 12-B**.

For the NAR, potential effects of increases in contaminant concentrations associated with sediment mobilization to streams were considered in light of proposed Project activities.

### 2.4 STREAM PRODUCTIVITY

The Project's potential effects of change in stream productivity on Fish and Fish Habitat were assessed for streams where nutrient levels were predicted to change (**Appendix 12-B**; relevant to Mine Area only). The level of change was evaluated in relation to applicable trigger ranges for phosphorus and nitrogen parameters, as established based on the highest monthly 95$^{th}$ percentile level for months of open-water (i.e., April through October, reflecting the biological growing period; **Appendix 12-B**). Trigger ranges are based on phosphorus and nitrogen concentrations in water and define the reference trophic status for a site. If the upper limit of the range is exceeded, or is likely to be exceeded, further assessment is required (CCME 2004).

For the NAR, potential effects of changes to stream productivity (nutrients and TSS) associated with sediment mobilization to streams were considered in light of proposed project activities.

### 2.5 FISH MORTALITY

Assessment of potential Project effects on fish mortality was made based on identification of predicted Project interactions throughout the Mine Area and NAR that could result in fish mortality. Project interactions with the highest potential to result in fish mortality are generally those associated with construction plans and practices that may result in changes to physical habitat and increases in TSS concentrations. Changes to habitat as well as potential for sediment inputs were evaluated to determine the potential for fish mortality in light of project activities.

# 3.0 EXISTING CONDITIONS

This section of the report provides a summary of the Fish and Fish Habitat within the LAA and RAA. This is based on available scientific information, TK and the baseline data collected for the Coffee Gold Mine Project (refer to **Appendix 14-A).** The habitat and fisheries information summarized in this section will form the basis for the assessment of effects in the Fish and Fish Habitat VC and subcomponents.

## 3.1 REGULATORY CONTEXT

### 3.1.1 FISHERIES ACT

Responsibility for the management of Fish and Fish Habitat in the Yukon is shared between Fisheries and Oceans Canada (DFO), the Yukon Government, and local First Nations. Collective involvement is managed through a combination of federal legislation and regulations, territorial and First Nation administration and policy, and delegation of management authority. The federal *Fisheries Act* is the primary legislation for regulating the management of Fish and Fish Habitat in Yukon.

There are a number of federal/territorial agreements in place that define both federal and territorial responsibilities. These include the Canada-Yukon Freshwater Fisheries Agreement (Y.O.I.C. 1989/060) and the Canada/Yukon Memorandum of Understanding on Aquaculture Development (O.I.C 2010/070). Through these agreements, Environment Yukon has been delegated authority for management of freshwater fisheries in the Yukon Territory. DFO is responsible for management of anadromous species (e.g., various types of Pacific salmon) and fish habitat.

There are a number of sections of the *Fisheries Act* that govern development activities and are applicable to the Project:

- Section 20– Fishway Passage and Obstruction – Section 20 outlines the requirement to ensure free passage of fish by ensuring any and all appropriate tools to manage obstructions, and prevent harm to fish that result from the Project.
- Section 35 – Serious Harm to a Fishery – This section refers to a restriction of any work or activity that may result in serious harm to fish that are part of a commercial, recreational or Aboriginal CRA) fishery, or fish that support such a fishery. This applies to Chinook Salmon, Chum Salmon Arctic Grayling, Burbot, Northern Pike and Whitefish in the LAA.
- Section 36 – Pollution to Fish Habitat – Refers to restrictions on the deposition of deleterious substances in water frequented by fish.

### 3.1.2 METAL MINING EFFLUENT REGULATIONS

Pursuant and annexed to the *Fisheries Act*, the *Metal Mining Effluent Regulations* (2002) establishes metal mining discharge criteria. It also outlines the requirements for monitoring of mine water effluent, aquatic biota, and fish health in the vicinity of the proposed mine site.

#### 3.1.3 CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT (CCME) GUIDELINES

The CCME environmental quality guidelines provide goals, derived through scientifically defensible methods that maintain the quality of aquatic and terrestrial ecosystems (CCME 2007a, 2007b and 2007c). Environmental quality guidelines that are applicable to the Fish and Fish Habitat effects assessment include:

- Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007a)
- Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 2007b)
- Tissue Residue Quality Guidelines for the Protection of Wildlife Consumers of Aquatic Biota (CCME 2007c).

#### 3.1.4 FIRST NATION ACTS AND REGULATIONS

There are four First Nations with interests in the area of the Project: Tr’ondëk Hwëch’in (TH), Selkirk First Nation (SFN), First Nation of Na-cho Nÿak Dun (FNNND), and the White River First Nation (WRFN). The WRFN have not signed a Final Agreement with the Government of Canada, and the Project is included in their asserted area. While the WRFN current land use of the area of the Coffee Project is limited, the First Nation has expressed an interest in the area for future use. The remaining three First Nations have Final Agreements negotiated with the Government of Canada:

- First Nation of the Nacho Nyak Dun Final Agreement (GC, FNNND and YG 1993)
- The Selkirk First Nation Self-Government Agreement (GC, SFN and YG 1997), and
- The Tr’ondëk Hwëch’in Final Agreement (GC, TH, YG 1998).

As such, boards and councils have been established under the Umbrella Final Agreement (UFA; GC, CYFN and GY 1993) and Yukon First Nation Final Agreements, which have advisory and management responsibilities related to Fish and Fish Habitat both throughout the Yukon, and within specific First Nation Traditional Territories. There is First Nation representation on all of the management council and boards established through the UFA (**Table 3.1-1**). Through the UFA, First Nations are provided with the ability to draft acts to manage Fish and Fish Habitat on their Settlement Lands. To date, only the TH have established the Tr’ondëk Hwëch’in Fish and Wildlife Act (Tr’ondëk Hwëch’in 2009). The Act provides authority to TH to manage and administer subsistence harvest of fish in the Traditional Territory.

**Table 3.1-1 Fish and Fish Habitat-related Management Boards and Councils Established under the Umbrella Final Agreement**

| Name of Board or Council | Intended Role |
|---|---|
| Yukon Fish and Wildlife Enhancement Trust | Supports restoration and enhancement of Yukon fish populations and their habitats |
| Dawson District Renewable Resource Council | Primary local management instrument Fish and Fish Habitat in the Traditional Territory of the TH. |
| Selkirk Renewable Resources Council | Primary local management instrument for Fish and Fish Habitat in the Traditional Territory of the SFN |
| Mayo District Renewable Resources Council | Primary local management instrument for Fish and Fish Habitat in the Traditional Territory of the FNNND |
| Fish and Wildlife Management Board | Primary instrument of freshwater fish management in Yukon |
| Yukon Salmon Subcommittee | Primary instrument of salmon management in Yukon |

#### 3.1.5 Species at Risk Act

Within the Project's Fish and Fish Habitat LAA and RAA, there are no aquatic species listed under the federal *Species at Risk Act* (SARA; S.C. 2002 c.29), none are under territorial listing. There are no established protected, special management or conservation areas relevant to Fish and Fish Habitat in Project's Fish and Fish Habitat LAA and RAA.

### 3.2 Background Information and Studies

#### 3.2.1 Traditional Knowledge

The purpose of this section is to demonstrate the awareness of TK related to Fish and Fish Habitat within the LAA and RAA, and to incorporate TK into the Fish and Fish Habitat effects assessment. A review of the Project TK database was carried out to obtain TK related to Fish and Fish Habitat. Additional information was obtained from current land use data collected by the Project team. The TK sourced from the Project TK database included information available as of April 6, 2016, and included TK data relating to:

- Environment (Fish)
- Fishing
- Potential Project Interactions (Traditional Land Use)
- General Traditional Knowledge (TK), and
- Traditional Land Use (Fishing).

Site specific TK has been incorporated into the following sections (**Sections 3.2 and 3.3**). In general the use of fish resources in the LAA appears to be most concentrated on the Yukon River and Coffee Creek. The Yukon River in the vicinity of Coffee Creek has long been an important salmon fishing location for First Nations (TH 2012). The Yukon River watershed is of particular interest to affected First Nations and local residents, with regards to providing rearing, migration and spawning habitat for Chinook and Chum Salmon. Traditional Knowledge and current land use speaks to the importance of the watershed for these species (Bates et al. 2014, TH 2012, DRPC 2013; Interview 14, pers. comm. 2016). Other fish species of traditional interest/use that are present in the Yukon River include Arctic grayling, whitefish, northern pike, burbot, inconnu and longnose sucker.

TK was incorporated during the issues scoping of VCs and VC subcomponents (**Sections 1.2** and **1.2.1**), and selection of assessment boundaries (**Section 1.3.1**). Scientific baseline data and TK information both provided valuable information for the identification of Fish and Fish Habitat priorities in the LAA and RAA. The incorporation of TK resulted in the selection of VC subcomponents that were of most interest to First Nations, and were most likely to be affected by the project. The selection of the RAA boundary includes areas of the Yukon River where TK identified Chinook and Chum Salmon fisheries.

### 3.2.2 Scientific and Other Information

The purpose of this section is to demonstrate awareness of existing scientific and other information and its applicability to the assessment of potential Project related effects and cumulative effects on Fish and Fish Habitat. Existing information includes studies conducted within the Fish and Fish Habitat RAA prior to the initiation of the Coffee Project Fish and Fish Habitat baseline studies.

Databases that pertain to Fish and Fish Habitat include the Yukon Fisheries Information Summary System (FISS) database and the Yukon Placer Fish Habitat Suitability mapping. The FISS database is maintained by DFO, and is a searchable database that contains georeferenced data where fish species have been documented in Yukon watersheds. The FISS database provides a link to the primary data sources for each data record. The Yukon Placer Fish Habitat Suitability mapping is administered by the Yukon Placer Secretariat and is a series of maps that defines fish habitat in Yukon streams based on the physical characteristics, proximity to larger watersheds (i.e., rivers), previous disturbance to the stream, and/or culturally and ecologically important areas (YPS 2010).

Within the LAA, scientific information on Fish and Fish Habitat has been collected since 2000. Additional information exists for the RAA, and the following information sources relevant to this project are available:

- Duncan (1997) reviewed historical catch data and Fish and Fish Habitat records for creeks within the Traditional Territory of the Tr’ondëk Hwëch’in. This review included historical fisheries data on Coffee Creek and the Indian River.
- Sparling (2001) conducted Fish and Fish Habitat assessment on 58 creeks on the Yukon River in 2000, including Coffee and Ballarat creeks. Fish sampling was conducted and the habitat quality was documented in the lower reaches of the creek. A spawning survey for Chinook Salmon was conducted in the Yukon River and lower Coffee Creek.
- Laberge and White Mountain (2002) conducted a follow up study to Sparling 2001, and further documented fish habitat in lower Coffee Creek in 2001. Fish and benthic invertebrate sampling was

conducted to characterize aquatic biota in the creek. A spawning survey for Chinook Salmon was conducted in the Yukon River and lower Coffee Creek.

- Miles and Associates (2003) documented the physical characteristics of the Indian River watershed, including Sulphur Creek. This included comparisons of stream characteristics prior to placer activities on each stream.
- Mercer (2005), Osbourne et al. (2003) and Osbourne (2004, 2005) conducted radio tagging and tracking of Chinook Salmon in the Yukon River watershed. These studies included aerial radio tracking flights on the Stewart and Yukon River watersheds.
- Laberge and White Mountain (2012) conducted fish and benthic invertebrate sampling in the lower reaches of Coffee Creek and the Yukon River in the vicinity of the creek confluence in 2010. Various fish capture techniques were employed.
- Palmer Environmental Consulting Group (PECG 2013a) assessed fish habitat and conducted fish sampling in the upper reaches of Coffee Creek in 2010 associated with the Casino Project. This included a detailed assessment of fish habitat at the sampling locations (PECG 2013b).

Pertinent information from these sources can be found in the baseline reports for this project (**Appendix 14-A**).

### 3.2.3 BASELINE STUDIES

Baseline fish and aquatic resources studies were conducted from 2013 to 2016 in watersheds associated with the proposed mine site, and in 2015 for the proposed NAR (**Table 3.2-1**). A preliminary baseline study in the vicinity of the proposed Coffee Project mine site was conducted by Access Consulting Group (AEG) in 2013 (**Table 3.2-1**; AEG 2013). This study focused on describing the fish habitat in the vicinity of the proposed mine site, and documenting potential salmon spawning and the distribution of fish species within the tributary stream of the Yukon River. Sampling included minnow trapping in the tributary streams and collection of standard in situ water quality data (temperature, dissolved oxygen, pH and specific conductivity). During consultation with the TH, adult salmon and salmon spawning in the vicinity of the Project area were identified as an important consideration for the Project. Aerial salmon spawning surveys were conducted via helicopter to document any Chinook and Chum Salmon spawning in the Yukon River in the vicinity of the Project (**Table 3.2-1**).

Additional baseline studies were conducted in 2014 and 2015 by Palmer Environmental Consulting Group (**Table 3.2-1**; **Appendix 14-A**; PECG 2016 and 2017). These included studies that characterized the baseline fish and aquatic resources in the vicinity of the proposed mine site (**Appendix 14-A**; PECG 2017) and in the vicinity of the proposed NAR (**Appendix 14-A**; PECG 2016).

Finally, a baseline update complete with supplementary winter and summer baseline data collection and a synthesis of TK with previously collected scientific data from 2000 to 2016 was completed by EDI Environmental Dynamics Inc. (EDI) in 2017 (**Appendix 14-A;** EDI 2017).

**Table 3.2-1 Summary of Baseline Studies Related to Fish and Aquatic Resources (Appendix 14-A)**

| Study Name | Study Purpose, Duration and Spatial Boundaries |
|---|---|
| Kaminak Coffee 2013 Fisheries Summary Report (AEG 2014) | **Study Purpose:** Investigate fish species presence and fish habitat quality and usage in the vicinity of the proposed mine site.<br>**Duration:** July, August, September and October 2013<br>**Spatial Boundaries:** Fish sampling and habitat investigations in lower reaches of Coffee, Halfway and Independence creeks; salmon spawning survey in a 31 km section of the Yukon River in the vicinity of the Project area and lower Coffee and Independence creeks. |
| Coffee Gold Mine Fish and Aquatic Resources Baseline Report (**Appendix 14-A;** PECG 2017) | **Study Purpose:** Detailed fish and aquatic resources baseline study to characterize pre-development aquatic environment of the Project area in the vicinity of the proposed mine site.<br>**Duration:** August and October 2014; March, June, July and September 2015.<br>**Spatial Boundaries:** Fish and Fish Habitat, aquatic biota and sediment data collected in lower 10 km of Coffee Creek, lower 8 km of Independence Creek, Latte, Halfway, and YT-24 creeks. The spatial boundaries of the salmon spawning surveys included a 31 km section of the Yukon River in the vicinity of the project area and lower Coffee Creek and Independence Creeks. |
| Coffee Gold Mine: Fish and Aquatic Resources Baseline Report: Mine Access Road (**Appendix 14-A**; PECG 2016) | **Study Purpose:** Fish and aquatic resources baseline study to characterize pre-development aquatic environment of the Project area in the vicinity of the NAR.<br>**Duration:** June, July, August and September 2015.<br>**Spatial Boundaries:** 50 m upstream and downstream of all watercourses that would be crossed or could potentially interact with the proposed NAR, as well as proposed barge crossing locations and barge landing locations on the Stewart and Yukon Rivers. Spawning surveys were completed in late July for Chinook near the barge landings. |
| Coffee Gold Mine: Fisheries and Aquatic Resource Baseline Update (**Appendix 14-A**; EDI 2017) | **Study Purpose:** Supplementary baseline data collection and synthesis with traditional and scientific knowledge and previously collected data.<br>**Duration:** March, July, August and October 2016<br>**Spatial Boundaries:** Additional Baseline Sampling on Fish and Fish Habitat including winter studies around Mine Area and summer studies in Mine area and along NAR. Chum spawning surveys in the Yukon and Stewart rivers were completed in October. |

Baseline studies in the Mine Area focused on Coffee, Latte, Halfway, and YT-24 creeks; data was also collected from reference areas including Independence, Los Angeles and upper Coffee creeks. Study design included fish habitat assessments (summer and winter), sampling for fish (summer, fall and winter), environmental DNA (eDNA), benthic invertebrates, periphyton and stream sediments. Fish sampling has included use of standard methods to determine species presence/diversity (electrofishing, minnow trapping, angling and Fyke netting) and triple-pass electrofishing depletion sampling to calculate fish densities (fish/m$^2$) (**Appendix 14-A**; PECG 2017, EDI 2017; **Table 3.2-1**). Winter fish sampling (minnow trapping) was supplemented by using eDNA to detect the presence of Arctic Grayling and Chinook Salmon in streams around the mine. Sampling methods for eDNA followed those described by Hobbs et. al. 2015.

Standard fish health metrics including fork lengths (total lengths for Slimy Sculpin), weights and Fulton condition factors were calculated from collected data. Fish tissue metals concentrations were analyzed in a subset of captured Arctic Grayling, Chinook salmon and Slimy Sculpin. Concentrations of total metals in fish tissues were compared against available tissue guidelines, including those from the CFIA, CCME, BC MOE and EPA (**Table 3.2-2**). Mercury concentrations in Arctic Grayling that could potentially be consumed by humans were compared against the Canadian Food Inspection Agency guideline for total mercury (**Table 3.2-2,** CFIA 2011). Methylmercury ratios (relative to total mercury) were estimated based on empirical data for Arctic Grayling, Chinook Salmon and Slimy Sculpin, using ratios described in Jewett et al. (2003) and Raymond et al. (2005). There are no federally derived tissue guidelines for selenium. However, both the BC MOE and the US EPA have developed tissue guidelines for both whole body and muscle tissue samples (**Table 3.2-2**).

**Table 3.2-2 Referenced guidelines for tissue metals concentrations (fish and benthic invertebrates**

| Guideline Name | Governing Body and Reference | Contaminant | Guideline | Applicability |
|---|---|---|---|---|
| Canadian guidelines for chemical contaminants and toxins in fish and fish products | Canadian Food Inspection Agency (CFIA 2011) | Mercury | 0.5 mg/L | Arctic grayling muscle tissue |
| Tissue Residue Quality for the Protection of Wildlife Consumer of Aquatic Biota | Canadian Council of the Ministers of the Environment (CCME 2007c) | Methylmercury | 33 µg/kg wet weight | All species sampled, all tissue types |
| Aquatic Life Ambient Water Quality Criterion for Selenium – Freshwater 2016 | United States Environmental Protection Agency (US EPA 2016) | Selenium | Muscle tissue - 8.5 mg/kg dry weight<br>Whole body - 11.3 mg/kg dry weight | Muscle and whole body samples from all fish species |
| Ambient Water Quality Guidelines for Selenium Technical Report Update | British Columbia Ministry of the Environment (BC MOE 2014) | Selenium | Muscle tissue - 4 mg/kg dry weight<br>Whole body - 4 mg/kg dry weight | Muscle and whole body samples from all fish species |

Aerial salmon spawning surveys around the Mine were conducted via helicopter to document any Chinook Salmon spawning in the Yukon River, Coffee Creek and Independence Creek (AEG 2014, PECG 2016, EDI 2017**; Table 3.2-1**) aerial surveys for Chum were completed on the Yukon and Stewart Rivers (EDI 2017).

Benthic invertebrate, periphyton and sediment samples were collected from Independence, Latte, Coffee, Halfway and YT-24 creeks in August 2014 and late July 2015 (12 sites). Benthic invertebrate sampling and analysis followed Canadian Aquatic Biomonitoring Network (CABIN; Environment Canada 2012a) protocols and standard metrics (**Appendix 14-A**; PECG 2016a). Periphyton sample collection followed standard methods and collected data were analyzed for chlorophyll-a concentrations and algal ash-free dry mass (AFDM). Stream sediment samples were collected following guidelines described in the B.C. Ministry of Environment water and air baseline monitoring guidance document for mine proponents and operators (BC MOE 2012). Samples were analyzed for grain size distribution as well as concentrations of metals, total organic carbon and nutrients. Metals concentrations in sediment samples were compared against the Canadian Council of the Ministers of the Environment (CCME) sediment quality guidelines for protection of aquatic life (**Table 3.2-3**; CCME 2007b; **Appendix 14-A;** PECG 2017).

**Table 3.2-3 Applicable Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 2007b)**

| Parameter | Interim Sediment Quality Guideline (µg/kg dry weight) | Probably Effects Level (µg/kg dry weight) |
|---|---|---|
| Arsenic | 5,900 | 17,000 |
| Cadmium | 600 | 3,500 |
| Chromium | 37,300 | 90,000 |
| Copper | 35,700 | 197,000 |
| Lead | 35,000 | 91,300 |
| Mercury | 170 | 486 |
| Zinc | 123,000 | 315,000 |

Additional periphyton sample collection was completed in 2016 and followed standard methods and collected data were analyzed for chlorophyll-a concentrations and AFDM (EDI 2017; **Appendix 14-A**). Benthic invertebrate tissue samples were collected during 2016 (EDI 2017; **Appendix 14-A**) via kick-netting and whole body samples were frozen onsite and submitted for analysis for total metals concentrations. Benthic invertebrate methylmercury tissue concentrations were compared against the CCME methylmercury guideline for the protection of piscivorous wildlife (CCME 2007a). Methylmercury concentrations (relative to total mercury) were estimated based on ratios described in empirical data for multiple benthic invertebrate taxa described in Tremblay and Lucotte (1997). Data for other contaminants of potential concern (CoPC) were collected, and in the absence of applicable guidelines, can be used for post-Project comparison.

Drainages along the portion of the NAR that will be upgraded were assessed for Fish and Fish Habitat during the summer of 2015 and 2016 (**Appendix 14-A**; EDI 2017, PECG 2016). Fish habitat along the proposed NAR was assessed in the field using the BC Resource Inventory Standards Committee (RISC) Site Card and BC's Fish Stream Identification Guidebook (BC MOF 1998.). Fish sampling followed standard methods, and included minnow trapping and electrofishing. Fish species diversity and relative abundance were documented at each sampled watercourse and fork lengths and weights were measured from captured fish. Aerial salmon spawning surveys were conducted via helicopter to document any Chinook and Chum Salmon spawning in the Yukon River and the Stewart River, in the vicinity of the proposed barge crossing and landing locations. No sampling for aquatic biota was completed for the road crossings as there is no pathway to an effect.

### 3.3 Existing Conditions

This section provides a description of existing conditions (i.e., conditions prior to interaction with the Project) for Fish and Fish Habitat, specifically in the LAA with supplemental information on the RAA where relevant. Existing conditions are then described in the following paragraphs (at the VC subcomponent level) in the context of indicators including habitat suitability and accessibility, contaminant toxicity, stream productivity and fish mortality. The quality and reliability of the data and uncertainty and knowledge gaps are described as they relate to each indicator, and natural and human caused trends that may be affecting the VC or VC subcomponent are discussed where applicable.

Available fish sampling data documents a diverse assemblage of fish species that are known to inhabit the Yukon River watershed (FISS 2016). A total of 14 species of fish can be found within the streams in the LAA including two species of salmon and 12 species of resident freshwater fish species. The majority of these species are found only in the Yukon and Stewart rivers with three of these species documented in the small/medium sized streams downstream of the proposed mine site (**Table 3.3-1; Figure 3.3-1).** These species include Slimy Sculpin, Arctic Grayling, and juvenile Chinook Salmon. These three species were also the most common species encountered along the NAR **(Figure 3.3-2**; **Table 3.3-2, Appendix 14-A**; EDI 2017, PECG 2016).

**Table 3.3-1 Summary of Fish Species Documented in the Streams in the LAA near the Mine Site**

| Common Name | Scientific Name | Yukon River | Coffee Creek | Latte Creek | YT-24 Creek | Halfway Creek |
|---|---|---|---|---|---|---|
| Chum Salmon | *Oncorhynchus keta* | ✓ | | | | |
| Chinook Salmon | *O. tshawytscha* | ✓ | ✓ | | | ✓ |
| Longnose Sucker | *Catostomus catostomus* | ✓ | | | | |
| Lake Whitefish | *Coregonus clupeaformis* | ✓ | | | | |
| Broad Whitefish | *C. nasus* | ✓ | | | | |
| Least Cisco | *C. sardinella* | ✓ | | | | |
| Lake Chub | *Couesius plumbeus* | ✓ | | | | |
| Slimy Sculpin | *Cottus cognatus* | ✓ | ✓ | ✓ [1] | ✓ [1] | |
| Northern Pike | *Esox lucius* | ✓ | | | | |
| Arctic Lamprey | *Lethenteron camtschaticum* | ✓ | | | | |
| Burbot | *Lota lota* | ✓ | | | | |
| Round Whitefish | *Prosopium cylindraceum* | ✓ | | | | |
| Inconnu | *Stenodus leucichthys* | ✓ | | | | |
| Arctic Grayling | *Thymallus arcticus* | ✓ | ✓ | ✓ | | ✓ |

[1] Captured near mouths of streams only, at the confluence with Coffee Creek and the Yukon River, respectively.

**Table 3.3-2 Summary of Fish Species Documented in the Streams in the LAA along the NAR**

| Common Name | Scientific Name | Stewart River | Indian River | Sulphur Creek | Maisy May Creek | Barker Creek | Ballarat Creek | Hunker Creek |
|---|---|---|---|---|---|---|---|---|
| Chum Salmon | *Oncorhynchus keta* | ✓ | | | | | | |
| Chinook Salmon | *O. tshawytscha* | ✓ | ✓ [1] | | ✓ | ✓ | ✓ | ✓ |
| Longnose Sucker | *Catostomus catostomus* | ✓ | ✓ | | | | | ✓ |
| Lake Whitefish | *Coregonus clupeaformis* | ✓ | | | | | | |
| Lake Chub | *Couesius plumbeus* | ✓ | ✓ | | | | | |
| Slimy Sculpin | *Cottus cognatus* | ✓ | ✓ | | ✓ | | ✓ | ✓ |
| Northern Pike | *Esox lucius* | ✓ | | | | | | |
| Arctic Lamprey | *Lethenteron camtschaticum* | ✓ | | | | | | |
| Burbot | *Lota lota* | ✓ | | | ✓ | | | ✓ |
| Round Whitefish | *Prosopium cylindraceum* | ✓ | ✓ | ✓ | | | | ✓ |
| Inconnu | *Stenodus leucichthys* | ✓ | | | | | | |
| Arctic Grayling | *Thymallus arcticus* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

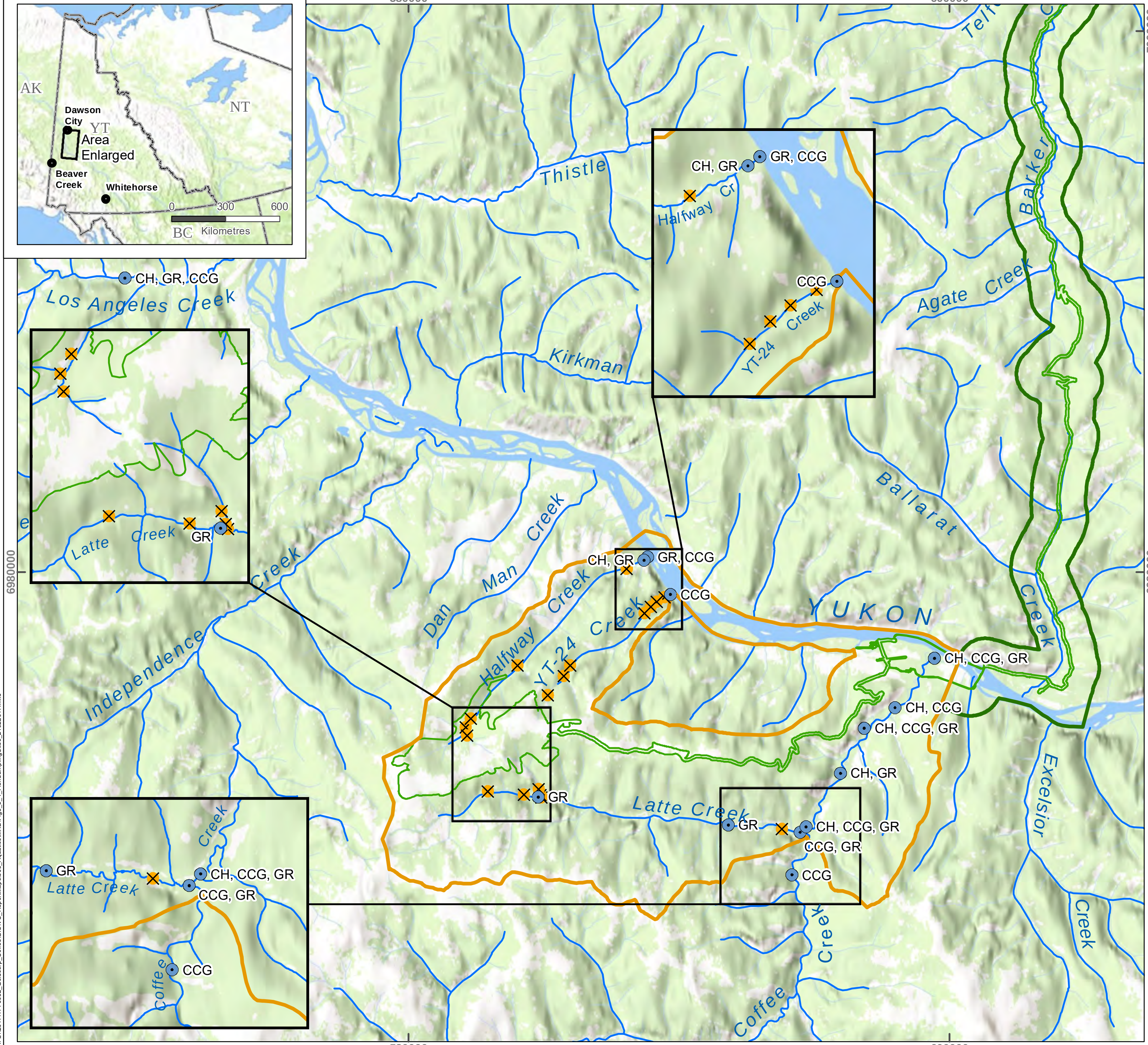
[1] Chinook have been historically documented in the Indian River downstream of the LAA (PECG 2016).

The Yukon and Stewart rivers within the LAA are large rivers with a diverse assemblage of fish species. These rivers are migratory corridors for both Chinook and Chum Salmon and spawning areas for Chum Salmon have been documented within the LAA on the Yukon River and downstream of the LAA on the Stewart River (**Section 3.3.3**). During the summer these rivers are turbid affecting the overall quality of rearing habitat; however, they clear up in the fall/winter and provide stable overwintering habitat for many fish species. Traditional Knowledge (TK) identifies Round Whitefish, Burbot, Northern Pike, Arctic Grayling and Chinook and Chum Salmon as fish species in the Yukon River in the vicinity of the LAA (Bates et al. 2014, Tr'ondëk 2012).

Other than recent mining exploration for the Project, the LAA watersheds associated with the Mine site, Coffee, Halfway and YT-24, have not been subject to development and as such the streams/watersheds are in an unaltered state (**Appendix 14-A**). Fish habitat quality varies between and within these watersheds, with the most complex and high quality habitat being located in Coffee Creek. Coffee Creek provides year round fish habitat for Arctic Grayling, juvenile Chinook Salmon and Slimy Sculpin. Latte Creek, a tributary to Coffee Creek, provides summer rearing habitat for sub-adult and adult Arctic Grayling. Some summer rearing habitat has been documented in the lower portion of Halfway Creek. No fish have been captured in the higher gradient, upper portions of the Latte, Halfway and YT-24 watersheds in the Mine footprint (**Figure 3.3-1**).

The proposed alignment of the NAR includes many watercourses that have been affected by historical or active, ongoing placer mining operations (**Appendix 14-A**). These include the named tributaries to the Stewart and Yukon rivers – Indian River, Sulphur, Eureka, Maisy May, Barker and Ballarat creeks. These watersheds at minimum provide rearing habitat in the lower sections; habitat values at individual crossing sites can be found in **Appendix 14-A** (PECG 2016).

Not including the Yukon or Stewart rivers, 56 drainages were assessed along the NAR. Fish were captured or were previously documented in eight streams (**Figure 3.3-2**, **Appendix 14-A**; EDI 2017). An additional eight streams were determined to be potentially fish bearing due to suitable habitat and the lack of downstream barriers to fish passage. Nineteen of the watercourses assessed along the proposed NAR were considered non-fish bearing due to poor habitat and/or downstream barriers to fish passage. An additional 21 locations did not have consistent stream channel characteristics and were determined to be unclassified drainages having no fish values.




COFFEE GOLD MINE

**Fish and Fish Habitat Sampling Results in the Coffee Gold Mine Portion of the LAA**

## Legend

- City/Town
- Project Footprint
- Local Assessment Area (mine)
- Local Assessment Area (NAR)

**Fish Sampling Sites**

- Fish Captured
- No Fish Captured

## Fish Sampling Codes

GR – Arctic Grayling
CCG – Slimy Sculpin
CH – Chinook Salmon

## Sources

1. Sources: Esri, HERE, DeLorme, increment P Corp., NPS, NRCan, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community
2. Project access and infrastructure provided by Goldcorp Inc. (2017).

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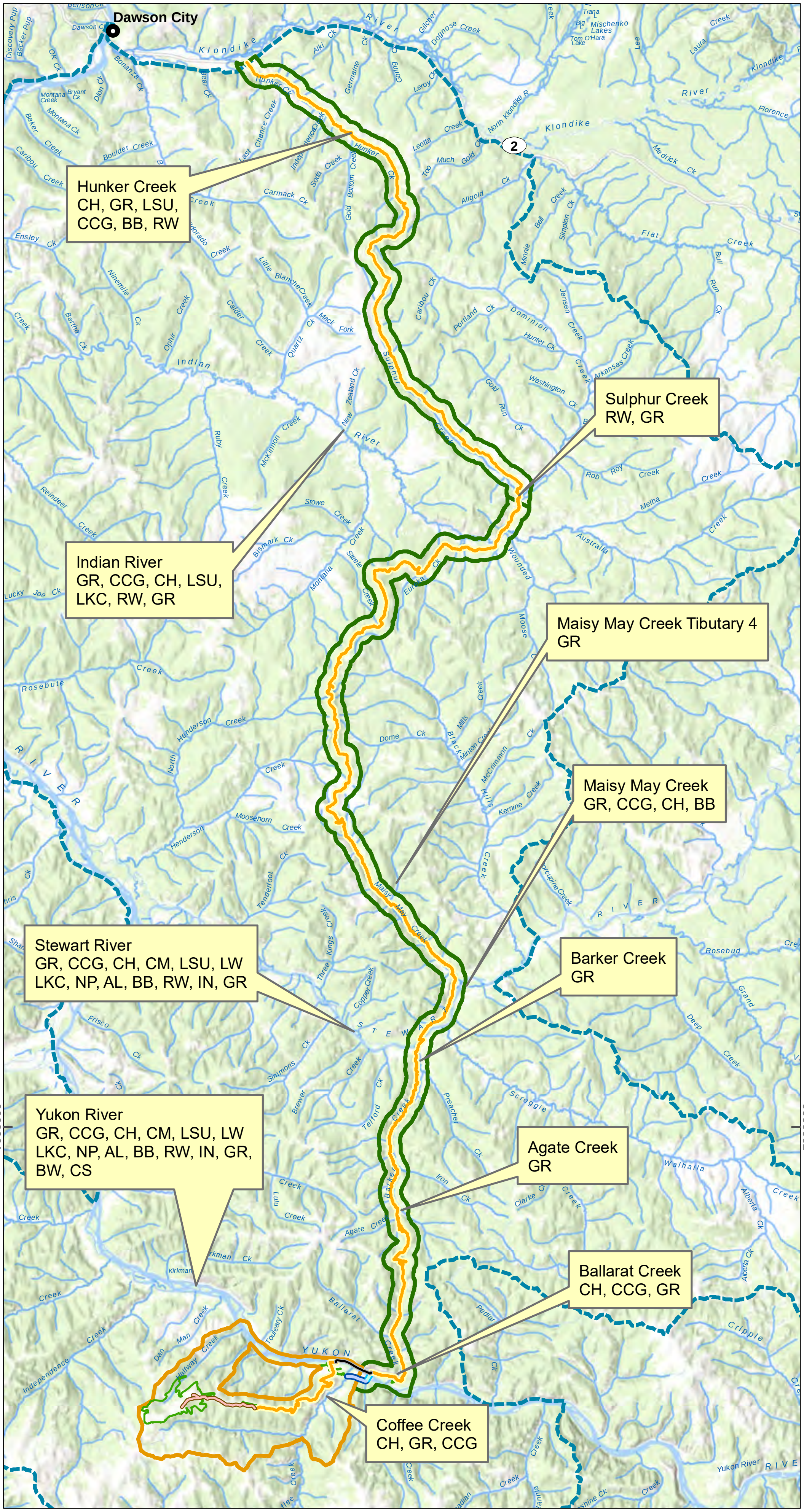


# COFFEE GOLD MINE

## Known Fish Presence in Streams in the NAR Portion of the LAA


### Legend

- Stewart River Ice and Barge Crossings
- Yukon River Barge Route
- Yukon River Ice Road
- Winter Road
- Mine Site Access Route
- Northern Access Route
- Project Footprint
- Regional Assessment Area
- Local Assessment Area (mine)
- Local Assessment Area (NAR)

### Fish Species Codes

GR - Arctic Grayling
CCG - Slimy Sculpin
CH - Chinook Salmon
CH - Juvenile Chinook Salmon
CM - Chum Salmon
LSU - Longnose Sucker
LW - Lake Whitefish
RW - Round Whitefish
BW - Broad Whitefish
CS - Least Cisco
LKC - Lake Chub
NP - Northern Pike
AL - Arctic Lamprey
BB - Burbot
IN - Inconnu

### Notes

1. This map is not intended to be a “stand-alone” document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

### Sources

1. Sources: Esri, HERE, DeLorme, increment P Corp., NPS, NRCan, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community
2. Project access and infrastructure provided by Goldcorp Inc. (2017).

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Benthic invertebrate total abundance and taxa diversity quantify the existing abundance and diversity of food sources available to fish. Benthic invertebrate sampling was restricted to watercourses in the area surrounding the mine site including Independence, Los Angeles, Latte, Coffee, Halfway and YT-24 creeks. Mean total abundance of benthic invertebrates ranged from 247 to 3,885 individuals per kick-net in the Independence, Latte, Coffee, Halfway and YT-24 creek watersheds in the vicinity of the proposed mine site. Independence Creek displayed the highest total abundance followed by YT-24, Coffee Creek, Latte Creek, and Halfway Creek (**Appendix 14-A**; PECG 2017). Total abundance generally increased in an upstream direction within watersheds. Ephemeroptera-Plecoptera-Trichoptera (EPT) abundances within the study area demonstrated similar patterns to overall abundance. Dipterans were the most dominant benthic invertebrate group, making up approximately 50% of the overall community composition. The second and third most dominant groups were the mayflies (Ephemeroptera) and stoneflies (Plecoptera), which contributed approximately 26% and 21% to the overall community composition, respectively. Small percentages of ringed worms (Annelids), and caddisflies (Trichoptera) were also present at the majority of sites. In Coffee and Independence creeks, EPT organisms typically dominated sites higher in the watershed; Dipteran species dominated further downstream. Data on fish food sources (benthic invertebrates) was collected following the CABIN protocols and is of high quality and reliability; no knowledge gaps have been identified in regards to benthic invertebrates.

Existing conditions relating to primary productivity quantify the abundance and diversity of primary producers, which support benthic invertebrates and (by extension) fish. Primary productivity sampling was completed in the Mine LAA including Latte, Coffee, Halfway and YT-24 creeks as well at reference sites (Independence, Los Angeles and upper Coffee creeks). Mean chlorophyll-a was very low in all watersheds in the Mine Area (**Appendix 14-A**; PECG 2017, EDI 2017), which is typical of northern, nutrient poor aquatic habitats. Ash-free dry mass (AFDM) values ranged from 0.38 to 1.07 mg/cm² in these watersheds. There was little variation among chlorophyll–a and AFDM values between sites and there was no relationship between chlorophyll-a and ash-free periphyton mass. Community composition included blue-green algae (Cyanophyta), which comprised approximately 80% of the overall community composition and was the most dominant algal group in the study area; diatoms were the second most dominant group, followed by small percentages of green algae (Chlorophyta). Blue-green algae tended to dominate at higher elevation sites in watershed within the LAA, whereas higher proportions of diatoms were present further downstream, at lower elevations. Recommended holding times were missed for chlorophyll-a samples in 2014 and 2015, and while this was not believed to have significantly affected results, additional sampling was completed in 2016; 2016 sampling met all lab holding times and requirements. The 2016 data indicated higher concentrations of chlorophyll-a throughout the sampling locations when compared with 2014 and 2015 data. The 2016 data indicated that chlorophyll-a was lowest in samples collected farthest upstream in each of the watersheds, and increased in downstream locations. This trend existed in Latte Creek, with values of 0.13 mg/cm² at the upstream sampling location (LC9.9), and 0.26 mg/cm² closer to the confluence

(LC2.7), in Coffee Creek ( 0.57 and 0.88 mg/cm²) at the upstream and downstream sites, respectively, and in YT-24 (0.61 and 0.76 mg/cm²) and Halfway creeks (0.30 and 0.69 mg/cm²) as well.

Stream sediment metals concentrations provide baseline data regarding potential pathways of contaminant toxicity in the aquatic environment, through uptake at lower trophic levels (primary producers) and bioaccumulation into benthic invertebrates and fish. Sediment sampling was restricted to watercourses in the area surrounding the mine site including Latte, Coffee, Halfway and YT-24 creeks (**Appendix 14-A**; PECG 2017); sediment was not sampled along the NAR (streams along the NAR will not receive any mine effluents, and any additional metal loading associated with road construction is predicted to be negligible). Analyses of metals concentrations in sediments collected in Latte, Coffee, Halfway and YT-24 creeks all had arsenic and chromium at concentrations that exceed the CCME interim Freshwater Sediment Quality Guidelines (CCME 2007b; **Table 3.2-3**). Concentrations of copper, cadmium and mercury were found to exceed the applicable guidelines in only a small number of samples, all located in the Coffee Creek watershed. Data on stream sediment metal concentrations was collected following standard data collection and QA/QC protocols, and is of high quality and reliability; no knowledge gaps have been identified in regards to benthic invertebrates.

Climate change trends may influence Fish and Fish Habitat during the lifespan of the Project (inclusive of all Project phases). Fish and Fish Habitat are predicted to be generally affected by an increasing temperature, increasing precipitation and increased sediment loading in the aquatic environment due to changes in the Yukon's climate (Streiker 2016). The predicted effects of climate change may result in potential beneficial (e.g., increase in available habitat due higher discharges) or adverse effects (e.g., thermal stresses to fish due to higher water temperature) to Fish and Fish Habitat. These trends are generally expected to affect all VC subcomponents in a similar manner.

### 3.3.1 Arctic Grayling

Arctic Grayling are an important recreational fish species in the Yukon River watershed, and are an important First Nations food source that has been harvested traditionally (Bates et al. 2014) and currently (Interview 14, pers. comm. 2016) in the LAA. Arctic Grayling have been captured in Coffee Creek and in the lower reaches of Halfway and Latte creeks (**Figure 3.3-1; Appendix 14-A**; PECG 2017). While grayling have not been captured in YT-24, there is potential summer rearing habitat present in the lower 400 m. Within the portion of the LAA along the proposed NAR, Arctic Grayling have been captured in Maisy May (**Appendix 14-A**; PECG 2016), Ballarat (Sparling 2001; PECG 2013), and Barker creeks (EDI 2017) and are known to reside in the Stewart, Yukon and Indian rivers and historically in Sulphur Creek (**Figure 3.3-2**). Smaller tributary streams along the NAR also have potential to provide summer rearing habitat for Arctic Grayling.

The temporal characteristics of Arctic Grayling life-history include seasonal migrations between overwintering, spawning, and summer rearing habitats with the largest individuals often being found the furthest upstream during the summer months (McPhail 2007). Spawning typically occurs during the spring shortly after ice-out and typically takes place in larger creeks or small rivers over substrates dominated by gravels and cobbles (McPhail 2007). Eggs incubate in the gravel for less than a month before hatching. In terms of sensitivities, deposition of fine sediments over the spawning grounds can result in habitat alteration and/or covering or smothering of eggs (mortality) during the incubation period.

Presence of young of the year (YOY) Arctic Grayling can be used to assist in determining the locations and area of spawning habitat that could potentially be directly or indirectly affected by Project activities. During the baseline studies, YOY Arctic Grayling were only captured in the lower reaches of Black Hills and Independence creeks, both of which are located outside of the LAA (**Appendix 14-A**; PECG 2017 and 2016). All Arctic Grayling captured in any creeks in the LAA (mine and NAR) were larger than YOY size, and there was no evidence of Arctic Grayling spawning within the LAA (**Appendix 14-A**; PECG 2017 and EDI 2017); however, spawning cannot be ruled out in the larger creeks along the NAR.

Summer rearing habitat for Arctic Grayling is typically widespread and includes the use of clear water creeks/rivers including small tributary streams for summer feeding and rearing (Hughes and Reynolds 1994). Food items taken by Arctic Grayling include a wide variety of aquatic and terrestrial insects and may include small fish and/or eggs (McPhail 2007, McPhail and Lindsey 1970). Stomach content analysis of Arctic Grayling captured in Coffee Creek in 2015 indicated that Arctic Grayling fed primarily on dipterans, and mayflies and caddisfly larvae. None of the Arctic Grayling that were sampled in Coffee Creek were piscivorous (PECG 2017).

Rearing Grayling are sensitive to changes in habitat suitability, accessibility and stream productivity/food sources. Summer rearing by Grayling in the LAA was documented in several small streams without overwintering habitat (including Latte and Halfway) and mid-sized streams with overwintering potential (Coffee and Maisy May). Arctic Grayling use the streams within the LAA primarily for summer rearing. This species has been found during summer season sampling in streams downstream of the mine site and in watercourse crossings along the NAR (PECG 2017, EDI 2017). No fish have been documented in the portions of the stream within the mine footprint including the upper reaches of YT-24, Halfway or Latte creeks (including Latte Creek Tributary C; **Appendix 14-A**).

Arctic Grayling typically overwinter in larger streams and/or areas with groundwater inputs. Winter 2016 fish and eDNA sampling in creeks in the vicinity of the proposed mine site confirmed Arctic Grayling overwintering in Coffee Creek and the Yukon River, but not in any other streams within vicinity of the mine site (EDI 2017). Overwintering on the NAR was not investigated; however, is likely limited to the larger streams such as Maisy May Creek and the Indian River.

Analysis of Arctic Grayling tissue metal concentrations was conducted on samples collected in the vicinity of the proposed mine site in the summer of 2014 and 2015 (PECG 2017), and in 2016 (EDI 2017). Arctic grayling were captured in Coffee, Latte, and Halfway creeks, and at reference sites in Independence and Los Angeles creeks. In all streams where samples were collected, baseline total mercury concentrations in all sampled Arctic grayling muscle tissue did not exceed the Canadian Food and Inspection Agency (CFIA) guideline (0.5 µg/g ww; **Table 3.2-2**; **Appendix 14-A**). In contrast, estimated methylmercury concentrations (95% of total mercury concentrations, Jewett et. al. 2003) in nearly all Arctic grayling sampled in Coffee, Latte, Independence, and Los Angeles creeks (both muscle tissue and whole body samples) exceeded the Canadian Council for the Ministers of the Environment (CCME) guideline for the protection of piscivorous wildlife (0.033 µg/g ww; **Table 3.2-2**). Mean concentrations were lowest in Halfway (the only grayling captured in Halfway Creek had a mean methylmercury concentration below the guideline), Los Angeles, and Independence creeks, while higher methylmercury concentrations were noted in Coffee and Latte creeks. Selenium concentrations in Arctic grayling muscle tissue did not exceed the EPA's interim guideline for fish muscle tissue (11.3 µg/g dw; US EPA 2016), however, nearly all samples from all sites, with the exception of five Arctic grayling from Latte Creek exceeded the BC tissue and whole body guidelines for selenium (which are both set at 4 µg/g dw, BC MOE 2014).

### 3.3.2 CHINOOK SALMON

Chinook Salmon are an anadromous fish species and are an important First Nations food source that has been traditionally (Bates et al. 2014, DRPC 2013) and currently harvested (Interview 14, pers. comm. 2016) in the LAA (Yukon River). In the Yukon River watershed, the temporal characteristics of Chinook Salmon life-history includes usage of freshwater habitats by YOY, juveniles, and adults (spawning only). Chinook Salmon spawn from late July to late August in clear water, fast flowing streams and rivers, where large and clean cobble substrates are present. Eggs are deposited in stream gravels and hatch in winter as alevin. Chinook Salmon alevin remain in the gravels through the duration of the winter, and live off stored energy reserves during this time before emerging as fry in late spring (May/June). Juvenile Chinook Salmon rear in freshwater streams for up to one year after emerging from the stream gravels. Juvenile Chinook Salmon can migrate many kilometres as juveniles in order to find high quality rearing habitat; this can include use of both natal and non-natal streams. Juvenile Chinook Salmon generally leave rearing habitats in the early spring in the year after emergence, spend three to five years in the ocean, and return to spawn in the Yukon River watershed as 4 to 6 year olds.

As indicated by Traditional Knowledge (TH 2012), the Yukon River in the vicinity of Coffee Creek has long been an important salmon fishing location for First Nations. Many documented Chinook spawning areas are located in the Yukon River watershed upstream of the LAA. No Chinook Salmon spawning has been documented in the Yukon or Stewart rivers within the LAA. Traditional Knowledge (TH 2012) indicates Chinook spawned historically in Coffee Creek, however, Chinook Salmon spawning has not been observed in any of the creeks in the vicinity of the proposed mine site during baseline aerial spawning surveys

(Sparling 2001, Laberge and White Mountain 2002, AEG 2014, **Appendix 14-A**; PECG 2017 and EDI 2017). Habitat quality is generally of poor quality for Chinook Salmon spawning in the vicinity of watercourse crossings along the route of the proposed NAR and no Chinook spawning has been documented in any portion of the LAA in the vicinity of the NAR (**Appendix 14-A**; PECG 2016).

Juvenile Chinook Salmon use the larger streams in the LAA as non-natal rearing habitat. They were captured during the summer months in Coffee Creek (**Appendix 14-A**; PECG 2017), in the lower portion of Halfway Creek (August 2016 only; **Appendix 14-A**; EDI 2017) and in lower Maisy May Creek in the vicinity of the NAR (**Appendix 14-A**; PECG 2016). Potential rearing habitat was inferred by PECG based on suitable habitat in portions of Maisy May, Barker and Ballarat creeks in the vicinity of the proposed NAR. Year round use by juvenile Chinook Salmon has been confirmed in Coffee Creek during winter through direct fish capture (minnow trapping) and via eDNA sampling in March 2016 (**Appendix 14-A**). Juvenile Chinook have been captured in the lower 200 m of Halfway Creek on one occasion (Aug 2016, despite being sampled multiple times); however, this stream does not provide overwintering habitat (**Appendix 14-A**; EDI 2017)

Analysis of juvenile Chinook Salmon tissue metal concentrations was conducted on samples collected in March and August 2016 (**Appendix 14-A;** EDI 2017). Samples were collected from Coffee Creek at CF0.5 and CF2.3, and from Halfway Creek at HF0.2. Juvenile Chinook Salmon tissue samples from both Coffee Creek sites in both March and August 2016 had estimated baseline concentrations of methylmercury that exceeded CCME guidelines for the protection of piscivorous wildlife (0.033 µg/g ww; **Table 3.2-2**). However, all samples collected from Halfway Creek were below the guideline; samples from Halfway Creek had a mean methylmercury concentration of 0.024 µg/g. The CFIA tissue concentration guideline for total mercury does not apply to juvenile Chinook Salmon as they are not consumed by humans. Selenium concentrations in juvenile Chinook salmon muscle tissue in Coffee Creek did not exceed the EPA guideline for muscle tissue (11.3 µg/g dw; US EPA 2015; **Table 3.2-2**) at any sampled stations. Only one sample from Halfway Creek exceeded the BC selenium tissue guideline (4.0 µg/g dw, BC MOE 2012; **Table 3.2-2**).

Chinook Salmon populations in the Yukon River watershed have been experiencing a general trend of declining returns in the number of adults that return to the spawning grounds in the Canadian portion of the Yukon River (JTC 2015), as well as a decreasing trend in the ratio of recruits to spawners (i.e., for each fish that successfully spawns, how many fish return in the subsequent generation). This trend is generally understood to relate to fishing pressures and external environmental pressures outside the RAA. If this trend persists, it will generally have an adverse effect on the number of Chinook Salmon in the Project's RAA. In regards to Project effects, Chinook Salmon would be sensitive to changes in habitat suitability, accessibility, food availability, contaminant toxicology and stream productivity.

### 3.3.3 CHUM SALMON

Chum Salmon are an anadromous fish species and are an important First Nations food source that has been harvested traditionally (Bates et al. 2014, DRPC 2013) and currently (Interview 14, pers. comm. 2016) in the LAA. In contrast to other VC subcomponents, Chum Salmon life-history characteristics restrict the Chum Salmon use of the LAA and RAA to adult spawning and egg/alevin development only. Chum Salmon emerge after completing the alevin life stage, and head directly downstream to the ocean as fry and therefore do not rear in Yukon freshwater environments.

In the Yukon River watershed, Chum spawning occurs from September to November and is almost exclusively associated with areas of upwelling groundwater discharge. Chum Salmon spawning has been documented in the Yukon River main stem sloughs and side channel habitats from the White River to Tatchun Creek (near Carmacks). As with Chinook Salmon, the eggs hatch as alevin during the winter and remain in the gravel until emergence during the spring. Chum Salmon in the Yukon River typically spend three to four years in the ocean before returning as adults to spawn.

Chum Salmon spawning has been documented in the Yukon River within the LAA on multiple occasions (AEG 2014, **Appendix 14-A**; PECG 2017), with confirmed spawning locations generally located on the south side of the Yukon River, in small side channels and sloughs that appear to be groundwater fed which is consistent with the preferred spawning areas for this species in the Yukon River watershed. Chum spawning in the Stewart River has been documented in similar groundwater fed side channels approximately 10 km and 18 km downstream of the LAA (EDI 2017 and Rivest Pers. Comm. 2016). Chum Salmon also migrate through the portions of the Yukon and Stewart Rivers in the LAA to reach spawning areas further upstream. No Chum Salmon spawning has been documented in any of the smaller creeks (or near these stream mouths) within the LAA (**Appendix 14-A**; PECG 2017), nor has any spawning been documented in the immediate vicinity of the proposed barge crossing locations or barge landing areas on the Yukon and Stewart rivers (**Appendix 14-A**; PECG 2016). Sensitivities to Chum Salmon include changes to spawning habitat suitability (i.e. via increases to sediment) and physical covering of incubating eggs (mortality). As this species is only present in large rivers where contaminant levels will not be affected by the Project (**Appendix 12-B**), there is no pathway to changes in contaminant toxicology for chum salmon.

Chum Salmon in the Yukon River watershed have been experiencing a general trend of declining returns in the number of adults that return to the spawning grounds in the Canadian portion of the Yukon River (JTC 2015), as well as a decreasing trend in the ratio of recruits to spawners (i.e., for each fish that successfully spawns, how many fish return in the subsequent generation). This trend is generally understood to relate to fishing pressures and external environmental pressures outside of the RAA. If this trend persists, it will generally have an adverse effect on the number of Chum Salmon in the Project's RAA.

# 4.0 ASSESSMENT OF PROJECT-RELATED EFFECTS

This section identifies potential Project interactions, evaluates potential Project-specific effects and describes proposed mitigation actions to reduce or eliminate effects. Based on the anticipated effectiveness of these measures, residual changes and potential effects to Fish and Fish Habitat are characterized. For Fish and Fish Habitat, the significance and likelihood of each predicted residual effect is identified. The analysis of change and assessment of effects involved the following steps:

- **Section 4.1**: Identification of potential Project-related interactions on the Fish and Fish Habitat VC, with reference to interactions for subcomponents
- **Section 4.2**: Introduction to potential Project-related effects on the Fish and Fish Habitat VC
- **Section 4.3**: Identification of mitigation measures relevant to all Fish and Fish Habitat VC subcomponents
- **Section 4.4.1 - 4.4.2**: Presentation of residual effects characteristics and definitions for significance
- **Section 4.4.3 - 4.4.7**: An assessment of potential effects, subcomponent specific mitigation measures, and residual effects
- **Section 4.4.5**: Summary of Project-related residual effects by subcomponent.

The effects assessment for Fish and Fish Habitat is conducted for the VC as a whole, with attention drawn to the subcomponents Arctic Grayling, Chinook Salmon and Chum Salmon, under each indicator included in the assessment. Within the aquatic environment, changes to surface hydrology, water quality, and physical stream characteristics are applicable to all subcomponents.

## 4.1 POTENTIAL PROJECT-RELATED INTERACTIONS WITH FISH AND FISH HABITAT

This section focusses the assessment on those Project interactions of greatest potential consequence to Fish and Fish Habitat and its subcomponents. The potential for interactions between Fish and Fish Habitat and identified Project activities were considered (**Table 4.1-2**). Each interaction was ranked as either: No Interaction, Negligible Interaction or Potential Interaction, as defined in **Table 4.1-1**.

Most interactions were assessed at the overall Fish and Fish Habitat level because subcomponents are expected to experience similar effects in similar ways. When a potential interaction applies uniquely to a particular Fish and Fish Habitat subcomponent, it is indicated in **Table 4.1-2** (i.e., right hand column, "Nature of Interaction and Potential Effect"). The potential effects of these interactions are discussed further in **Section 4.2** (**Potential Project-Related Effects**) and in **Section 4.4 (Residual Effects Characteristics and Significance of Residual Effects)**.

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**Table 4.1-1 Definitions of Potential for an Interaction between Fish and Fish Habitat and the Project**

| Term | Definition |
|---|---|
| No Interaction | Project activity will not interact with the Fish and Fish Habitat. |
| Negligible Interaction | Interaction with the Project activity will not have a substantive influence on the short- or long-term integrity of Fish and Fish Habitat (i.e., not measurable / not detectable using the identified indicator(s)). |
| Potential Interaction | Interaction between the Project activity and Fish and Fish Habitat may have a substantive influence on the short- or long-term integrity of Fish and Fish Habitat (i.e., measurable or detectable using the identified indicator). The potential effect(s) of the interaction is considered further in the effects assessment. |

**Table 4.1-2 Potential Project Interactions with Fish and Fish Habitat**

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Construction** | | | | |
| **Overall Mine Site** | C-0 | Confirmatory geotechnical drilling in select areas at the mine site, as necessary | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | C-1 | Mobilization of mobile equipment and construction materials | Potential interaction | Sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat potential affecting contaminant toxicity. |
| | C-2 | Clearing, grubbing, and grading of areas to be developed within the mine site | Potential interaction | Changes in surface water hydrology may affect habitat suitability<br>Sediment transport associated with removal of riparian vegetation, erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat potential affecting contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | C-3 | Material handling | Potential interaction | Sediment transport associated with atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat potential affecting contaminant toxicity. |
| **Open Pits** | C-4 | Development of Latte pit and Double Double pit | Potential interaction | Changes in surface water hydrology may affect habitat suitability<br>Changes in water quality including elevated TSS, nutrients and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), nitrogen blasting residues (if blasting required) may affect contaminant toxicity, overall stream productivity, fish mortality and habitat suitability. |
| | C-5 | Dewatering of pits (as required) | Potential interaction | Changes in surface water hydrology may affect habitat suitability<br>Changes in water quality including elevated TSS and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), disturbed mine materials and leachate may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Waste Rock Storage Facilities** | C-6 | Development and use of Alpha WRSF | Potential interaction | Changes in surface water hydrology may affect habitat suitability<br>Changes in water quality including elevated TSS, nutrients and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), nitrogen blasting residues (if blasting required), and groundwater and surface water interactions and seepage may affect contaminant toxicity, overall stream productivity, fish mortality and habitat suitability. |
| **Stockpiles** | C-7 | Development and use of temporary organics stockpile for vegetation and topsoil | Potential interaction | Changes in surface water hydrology may affect habitat suitability<br>Changes in water quality including elevated TSS and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), disturbed mine materials and leachate may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | C-8 | Development and use of frozen soils storage area | Potential interaction | Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | C-9 | Development and use of run-of-mine (ROM) stockpile for temporary storage of ROM ore | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Crusher System** | C-10 | Construction and operation of crushing circuit | Potential interaction | Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| | C-11 | Construction and operation of crushed ore stockpile | Potential interaction | Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Heap Leach Facility** | C-12 | Staged heap leach facility (HLF) construction, including associated event ponds, rainwater pond, piping, and water management infrastructure | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), nitrogen blasting residues (if blasting required), and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | C-13 | Heap leach pad loading | Potential interaction | Changes in surface water hydrology may affect habitat suitability |
| **Plant Site** | C-14 | Construction and operation of process plant | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | C-15 | Construction and operation of reagent storage area and on-site use of processing reagents | Potential interaction | Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), nitrogen blasting residues (if blasting required), and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity fish mortality and habitat suitability.<br>Cyanide usage could affect contaminant toxicity, stream productivity, and fish mortality, however, inadvertent release or spill is not anticipated unless as a result of accident or malfunction (**Section** Error! Reference source not found.). |
| | C-16 | Construction and operation of laboratory, truck shop, and warehouse building | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | C-17 | Construction and operation of power plant | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | C-18 | Construction and operation of bulk fuel/LNG storage and on-site use of diesel fuel or LNG | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Camp Site** | C-19 | Construction and operation of dormitories, kitchen, dining, and recreation complex buildings; mine dry and office complex; emergency response and training building; fresh (potable) water and fire water use systems; and sewage treatment plant | Potential interaction | Treated sewage and domestic waste water may contain elevated concentrations of nutrients (nitrogen and phosphorus species) which may affect stream productivity. |
| | C-20 | Construction and operation of waste management building and waste management area | Potential interaction | Incineration operation may result in atmospheric deposition (dust fall) leading to elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity and stream productivity. |
| **Bulk Explosive Storage Area** | C-21 | Construction of storage facilities for explosives components and on-site use of explosives | Potential interaction | Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), nitrogen blasting residues (if blasting required), and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity fish mortality and habitat suitability. |
| **Mine Site and Haul Roads** | C-22 | Upgrade, construction, and maintenance of mine site service roads and haul roads | Potential interaction | Sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Site Water Management Infrastructure** | C-23 | Development and use of sedimentation ponds and conveyance structures, including discharge of compliant water | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), nitrogen blasting residues (if blasting required), potential leaching of disturbed mine materials/waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | C-24 | Initial supply of HLF process water | Potential interaction | Changes in surface water hydrology may affect habitat suitability |
| | C-25 | Ongoing use of site contact water (i.e., precipitation, stored rainwater) as HLF process water | Potential interaction | Changes in surface water hydrology may affect habitat suitability |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Ancillary Components** | C-26 | Upgrade of existing road sections for Northern Access Route (NAR), including installation of culverts and bridges | Potential interaction | Improper crossing selections could create barriers to fish movements and alter habitat, resulting in affects to fish accessibility. There is also the potential to improve fish passage at existing crossings.<br>Short-term increases in sediment transport associated with erosion and atmospheric deposition (dust fall), and nitrogen blasting residues (if blasting required) could result in elevated TSS, nutrients, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability.<br>In-stream construction activities could result in direct fish mortality. |
| | C-27 | Construction of new road sections for NAR, including installation of culverts and bridges | Potential interaction | Improper crossing selections could create barriers to fish movements and alter habitat, resulting in affects to fish accessibility. There is also the potential to improve fish passage at existing crossings.<br>Short-term increases in sediment transport associated with erosion and atmospheric deposition (dust fall), and nitrogen blasting residues (if blasting required) could result in elevated TSS, nutrients, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability.<br>In-stream construction activities could result in direct fish mortality. |
| | C-28 | Development, operation, and maintenance of temporary work camps along road route | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | C-29 | Vehicle traffic, including mobilization and re-supply of freight and consumables | Potential interaction | Increases in sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | C-30 | Development, operation, and maintenance of barge landing sites on Yukon River and Stewart River | Potential interaction | Barge landings will require habitat alteration resulting in changes to habitat suitability.<br>Blasting near fish bearing waters, resulting in short-term noise, and vibrations and nitrogen blasting residues could result in fish mortality. |
| | C-31 | Barge traffic on Stewart River and Yukon River, including barge mobilization of equipment for NAR construction | Negligible interaction | Changes to surface water quality from this activity are anticipated to be localized (main channel edges) and within existing ranges. It is not considered further in this assessment. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| | C-32 | Annual construction, operation, maintenance, and removal of Stewart River and Yukon River ice roads | Potential Interaction | Changes in surface water hydrology associated with water withdrawals during lower winter discharges may affect habitat suitability.<br>Risk of fish mortality associated with water withdrawal pumps. |
| | C-33 | Annual construction and operation of winter road on the south side of the Yukon River | Potential Interaction | Changes in surface water hydrology associated with water withdrawals during lower winter discharges may affect habitat suitability.<br>Short-term increases in sediment transport associated with clearing of riparian vegetation and erosion could result in elevated TSS, nutrients, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity and stream productivity.<br>Risk of fish mortality associated with water withdrawal pumps. |
| | C-34 | Construction, operation, and maintenance of permanent bridge over Coffee Creek | Potential interaction | Short-term increases in sediment transport associated with clearing of riparian vegetation, erosion and atmospheric deposition (dust fall), could result in elevated TSS, nutrients, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity and stream productivity. |
| | C-35 | Construction and maintenance of gravel airstrips | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | C-36 | Air traffic | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | C-37 | Use of all laydown areas | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | C-38 | Use of Coffee Exploration Camp | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Operation** | | | | |
| **Overall Mine Site** | O-1 | Material handling | Potential interaction | Sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat potential affecting contaminant toxicity. |
| | O-2 | Excavation of contaminated soils followed by on-site treatment or temporary storage and off-site disposal | Potential interaction | This applies only where contaminated soils are located/transported near watercourses. If so, sediment transport associated with erosion and atmospheric deposition (dust fall during excavation) may result in elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-3 | Progressive reclamation of disturbed areas within mine site footprint | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching of HLF residues, and groundwater and surface water interactions and seepage may result in elevated TSS, nutrients, cyanide species, and associated total and dissolved metals which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Open Pits** | O-4 | Development of Kona pit and Supremo pit and continued development of Double Double pit and Latte pit | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of potential leaching of mine waste materials and nitrogen blasting residues, and groundwater and surface water interactions and seepage may result in elevated nutrients (from blasting residues), and total and dissolved metals, this may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-5 | Cessation of mining at Double Double pit, Latte pit, Kona pit, and Supremo pit | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of potential leaching of mine waste materials and nitrogen residue leaching, and groundwater and surface water interactions and seepage may result in elevated nutrients, and total and dissolved metals, this may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-6 | Partial backfill of Latte pit and Supremo pit | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of potential leaching of mine waste materials and nitrogen residue leaching, and groundwater and surface water interactions and seepage may result in elevated nutrients, and total and dissolved metals, this may alter contaminant toxicity, stream productivity, fish mortality and habitat suitability. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| | O-7 | Backfill of Double Double pit and Kona pit | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Sediment transport could affect the quality of physical habitats in downstream areas.<br>Changes in water quality as a result of potential leaching of mine waste materials and nitrogen residue leaching, and groundwater and surface water interactions and seepage may result in elevated nutrients, and total and dissolved metals, this may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-8 | Dewatering of pits (as required) | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Waste Rock Storage Facilities** | O-9 | Continued development and use of Alpha WRSF | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-10 | Development and use of Beta WRSF | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Stockpiles** | O-11 | Continued use of temporary organics stockpile for vegetation and topsoil | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| | O-12 | Continued use of frozen soils storage area | Potential interaction | Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-13 | Continued use of ROM stockpile for temporary storage of ROM ore | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching from disturbed mine waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Crusher System** | O-14 | Crusher operation | Potential interaction | Sediment transport associated with atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat and affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-15 | Continued use of crushed ore stockpile | Potential interaction | Sediment transport associated with atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat and affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Heap Leach Facility** | O-16 | Continued staged HLF construction, including related water management structures and year-round operation | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, and groundwater and surface water interactions and seepage may result in elevated TSS, nutrients, cyanide species, and associated total and dissolved metals may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-17 | Progressive closure and reclamation of HLF | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), leaching of nitrogen residues from blasting, leaching of HLF residues, and groundwater and surface water interactions and seepage may result in elevated TSS, nutrients, cyanide species, and associated total and dissolved metals which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Plant Site** | O-18 | Process plant operation | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | O-19 | Continued on-site use of processing reagents | Potential interaction | Cyanide usage could affect contaminant toxicity, stream productivity, and fish mortality, however, inadvertent release or spill is not anticipated unless as a result of accident or malfunction (**Section** Error! Reference source not found.). |
| | O-20 | Continued on-site use of diesel fuel or LNG | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| **Camp Site** | O-21 | Continued use of facilities | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| **Bulk Explosive Storage Area** | O-22 | Continued on-site use of explosives | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| **Mine Site and Haul Roads** | O-23 | Use and maintenance of mine site service roads and haul roads | Potential interaction | Increases in sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Site Water Management Infrastructure** | O-24 | Continued use of sedimentation ponds conveyance structures | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), nitrogen blasting residues (if blasting required), potential leaching of disturbed mine materials/waste, and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-25 | Ongoing use of site contact water (i.e., precipitation, stored rainwater) as HLF process water | Potential interaction | Changes in surface water hydrology may affect habitat suitability |
| | O-26 | Installation and operation of water treatment facility for HLF rinse water | Potential interaction | Changes in surface water hydrology may affect habitat suitability<br>Changes in water quality including elevated TSS, nutrients, and associated total and dissolved metals as a result of increased sediment transport associated with erosion and atmospheric deposition (dust fall), nitrogen blasting residues (if blasting required), and groundwater and surface water interactions and seepage may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Ancillary Components** | O-27 | NAR road maintenance (e.g., aggregate re-surfacing, sanding, snow removal) | Potential interaction | Short-term increases in sediment transport associated with clearing of riparian vegetation, erosion and atmospheric deposition (dust fall), could result in elevated TSS, nutrients, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity and stream productivity. |
| | O-28 | NAR vehicle traffic, including mobilization and re-supply of freight and consumables | Potential interaction | Increases in sediment transport associated with atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | O-29 | Operation and maintenance of barge landing sites on Stewart River and Yukon River | Potential interaction | Barge landings will require habitat alteration resulting in changes to habitat suitability.<br>Blasting near fish bearing waters, resulting in short-term noise, and vibrations and nitrogen blasting residues could result in fish mortality. |
| | O-30 | Barge traffic on Stewart River and Yukon River | Negligible interaction | Changes to surface water quality from this activity are anticipated to be localized (main channel edges) and within existing ranges. It is not considered further in this assessment. |
| | O-31 | Annual construction, operation, maintenance, and removal of Stewart River and Yukon River ice roads | Potential Interaction | Changes in surface water hydrology associated with water withdrawals during lower winter discharges may affect habitat suitability.<br>Risk of fish mortality associated with water withdrawal pumps. |
| | O-32 | Annual construction and operation of winter road on the south side of the Yukon River | Potential Interaction | Changes in surface water hydrology associated with water withdrawals during lower winter discharges may affect habitat suitability.<br>Short-term increases in sediment transport associated with clearing of riparian vegetation and erosion could result in elevated TSS, nutrients, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity and stream productivity.<br>Risk of fish mortality associated with water withdrawal pumps. |
| | O-33 | Operation and maintenance of gravel air strips | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | O-34 | Air traffic | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | O-35 | Use of all laydown areas | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | O-36 | Use of Coffee Exploration Camp | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Reclamation and Closure** | | | | |
| **Overall Mine Site** | R-1 | Reclamation of disturbed areas within mine site footprint | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Increases in sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat, which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | R-2 | Excavation of contaminated soils followed by on-site treatment or temporary storage and off-site disposal | Potential Interaction | This applies only where contaminated soils are located/transported near watercourses. If so, sediment transport associated with erosion and atmospheric deposition (dust fall during excavation) may result in elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Open Pits** | R-3 | Reclamation of Double Double pit, Latte pit, Supremo pit, and Kona pit | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of potential leaching of mine waste materials and groundwater and surface water interactions and seepage may result in elevated total and dissolved metals, which may affect contaminant toxicity and stream productivity. |
| **Waste Rock Storage Facilities** | R-4 | Reclamation of Alpha WRSF | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Increases in sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat, which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | R-5 | Reclamation of Beta WRSF | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Increases in sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat, which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Stockpiles** | R-6 | Reclamation of temporary organics stockpile, frozen soils storage area, and ROM stockpile | Potential interaction | Changes in water quality as a result of erosion and sedimentation, potential leaching of mine waste materials and leaching of nitrogen residues from blasting may result in elevated TSS, nutrients, and total and dissolved metals, which may affect contaminant toxicity and stream productivity, fish mortality and habitat suitability. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Crusher System** | R-7 | Dismantling and removal of crusher facility and stockpile | Potential interaction | Changes in water quality as a result of erosion and sedimentation, potential leaching of mine waste materials and leaching of nitrogen residues from blasting may result in elevated TSS, nutrients, and total and dissolved metals, which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Heap Leach Facility** | R-8 | Closure of HLF and related water management structures | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of erosion and sedimentation, potential leaching of mine waste materials and leaching of nitrogen residues from blasting, leaching of HLF residues, and groundwater and surface water interactions and seepage may result in elevated TSS, nutrients, cyanide species, and total and dissolved metals, which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| **Plant Site** | R-9 | Dismantling and removal of process plant, reagent storage area, laboratory, truck shop and warehouse building, power plant, and bulk fuel storage | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| **Camp Site** | R-10 | Dismantling and removal or dormitories and kitchen, dining, and recreation complex buildings, mine dry and office complex, emergency response and training building, fresh (potable) water and fire water systems, sewage treatment plant, and waste management building | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| **Bulk Explosive Storage Area** | R-11 | Dismantling and removal of explosives storage facility | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| **Mine Site and Haul Roads** | R-12 | Decommissioning and reclamation of mine site service roads and haul roads | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| **Site Water Management Infrastructure** | R-13 | Decommissioning and reclamation of selected water management infrastructure, construction of long-term water management infrastructure, including water deposition to creek systems | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result erosion and sedimentation and leaching of nitrogen residues from may result in elevated TSS, nutrients, and total and dissolved metals, which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | R-14 | Operation and maintenance of HLF water treatment facility | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of leaching of HLF residues may result in elevated nutrients, cyanide species, and total and dissolved metals, which may affect contaminant toxicity, stream productivity and fish mortality. |
| | R-15 | Decommissioning and removal of HLF water treatment plant | Potential interaction | Changes in surface water hydrology may affect habitat suitability.<br>Changes in water quality as a result of leaching of HLF residues may result in elevated nutrients, cyanide species, and total and dissolved metals, which may affect contaminant toxicity, stream productivity and fish mortality. |
| **Ancillary Components** | R-16 | NAR road maintenance (e.g., aggregate re-surfacing, sanding, snow removal) | Potential interaction | Increases in sediment transport associated with erosion and atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | R-17 | NAR vehicle traffic | Potential interaction | Increases in sediment transport associated with atmospheric deposition (dust fall) could result in elevated TSS, and associated total and dissolved metals in downstream habitat which may affect contaminant toxicity, stream productivity, fish mortality and habitat suitability. |
| | R-18 | Operation and maintenance of barge landing sites on Stewart River and Yukon River | Negligible interaction | Changes to surface water quality/fish habitat from this activity are anticipated to be localized and within existing ranges. It is not considered further in this assessment. |
| | R-19 | Annual resupply of consumables and materials for active closure via barge on the Yukon River | Negligible interaction | Changes to surface water quality/fish habitat from this activity are anticipated to be localized and within existing ranges. It is not considered further in this assessment. |
| | R-20 | Annual construction, maintenance, and decommissioning of Stewart River and Yukon River ice roads | Potential Interaction | Changes in surface water hydrology associated with water withdrawals during lower winter discharges may affect habitat suitability.<br>Risk of fish mortality associated with water withdrawal pumps. |

| Project Component | Project Activities | | Interaction Rating | Nature of Interaction and Potential Effect on Wildlife |
|---|---|---|---|---|
| | # | Description | | |
| | R-21 | Decommissioning of new road portions | Negligible interaction | Changes to surface water quality/fish habitat from this activity are anticipated to be localized and within existing ranges. It is not considered further in this assessment. |
| | R-22 | Air traffic | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | R-23 | Decommissioning and reclamation of airstrip | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| | R-24 | Re-opening and operation of pre-existing Yukon River exploration camp and airstrip to support post-closure monitoring activities | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |
| **Post-Closure** | | | | |
| **Overall Mine Site** | P-1 | Long-term monitoring | No interaction | No change to Fish and Fish Habitat is anticipated to result from this activity. |

## 4.2 POTENTIAL PROJECT-RELATED EFFECTS

Project-related interactions have the potential to result in effects to Fish and Fish Habitat (**Table 4.1-2**). This section describes the nature of the potential Project effects considered with respect to Fish and Fish Habitat. This section will review how Project-related effects may affect the habitat suitability and accessibility, contaminant toxicity, stream productivity, and fish mortality. Key interactions for each are highlighted below and unless specified are relevant to all phases of the project (Construction, Operation, Reclamation and Closure, Post-closure):

- **Habitat Suitability -** including flow changes in Latte, Halfway and YT-24 creeks, changes to habitat from sediment deposition in streams throughout the Project area and habitat alteration from Project infrastructure (specific to NAR only).
- **Habitat Accessibility** – includes changes in accessibility associated with NAR infrastructure during the Construction Phase.
- **Contaminant Toxicity** – includes changes in water quality resulting from Project activities (predicted changes to Latte, Halfway and YT-24 creeks and potential changes associated with NAR).
- **Stream Productivity** – includes changes in nutrient inputs (including predicted changes to Latte, Halfway and YT-24 creeks) and potential changes to suspended sediment concentrations associated with NAR.
- **Fish Mortality** - from habitat infilling, blasting or high suspended sediment concentrations and/or long durations or sediment deposition over incubating eggs.

### 4.2.1 HABITAT SUITABILITY

Changes in habitat suitability are associated with predicted flow changes in Latte, Halfway and YT-24 creeks, from sediment deposition in streams throughout the LAA and habitat alteration from Project infrastructure (NAR). Flow changes are presented in **Section 4.2.1.1** and habitat alteration is presented in **Section 4.2.1.2**. Sediment mobilization and subsequent deposition in fish habitat can occur throughout the LAA (Mine and NAR) and as such is discussed in this section.

Sediments entering streams are typically suspended in water and can be deposited in slower moving areas such as pool habitat. While sediment mobilization/deposition is a natural process, elevated levels of suspended sediments related to development/disturbance can lead to excessive deposition and ultimately habitat alteration. Many studies have demonstrated the negative effects of excessive sediment deposition on fish habitat, including the changing of stream bed material composition, infilling of pool habitat, and covering/changing of spawning habitat (e.g. Robertson et. al. 2006 and Birtwell 1999).

#### *4.2.1.1 Mine Site*

Streams reaches that will be directly affected by the mine infrastructure are non-fish bearing (**Appendix 14-A**); as such, the physical Mine footprint will not directly affect habitat suitability. The Project will not have any measurable effects on the existing stream flow regimes in Coffee Creek or Yukon River (**Appendix 8-B**); therefore, habitat suitability for Chum Salmon is not expected to be affected by Project effects on surface water hydrology.

Construction and operation of the mine site is predicted to have measurable effects on surface water hydrology in Latte, Halfway and YT-24 creeks (**Appendix 8-B**), which include areas of known or suspected of providing summer rearing habitat for Arctic Grayling and in the case of Halfway Creek, occasional summer habitat for juvenile Chinook Salmon (**Section 3.3.1 and Section 3.3.2**). Changes in stream flows can affect the frequency of flushing and channel forming flows, and cause changes in hydraulic habitat variables (i.e., width, depth, and/or velocity), thereby affecting the quantity of suitable habitat for fish and aquatic invertebrates in the areas where flow volumes are changed. The analysis of habitat suitability takes the conservative approach of evaluating effects to Fish and Fish Habitat in both mid to lower Halfway Creek and lower YT-24 , two of these sites are upstream of documented fish use. Mid Halfway is >5 km upstream of documented fish presence and fish use is very unlikely at this site and the YT-24 site is 200 m upstream of documented fish presence; however, this area could be occasionally used by fish.

The Surface Hydrology IC report (**Appendix 8-B**) uses a detailed site-wide water balance model (WBM; **Appendix 12-C**) to estimate effects of the Project on the surface water hydrology of streams within the LAA. The WBM predicts flows during three project phases: i) end-of-operations (2027 to 2032), ii) closure (2033 to 2042) and iii) long term monitoring (2043 to 2100).Without a detailed year by year mine plan it was not possible for the WBM to accurately estimate hydrology for earlier project phases (i.e., construction and early operations). However, the largest effects of the project on stream flow are predicted to occur once the project footprint is near its maximum, which is predicted to occur in approximately 2027 (i.e., the start of the "end-of-operations" phase). Therefore, the results of the WBM should provide a reasonable estimate of the project's largest effects on stream hydrology and the related effects on Fish and Fish Habitat.

With the implementation of mitigation measures, the NAR is not anticipated to result in residual effects on hydrology while residual effects of the mine site are predicted to be largely confined to the headwater drainages of Latte, Halfway and YT-24 creeks (**Table 4.2-1**). The primary mechanisms by which the mine site affects surface water hydrology are the interactions between the increased run-off from mine infrastructure (i.e., diversions around pits, stockpiles, and waste rock storage facilities) and the decreased run-off that results from water abstraction for ore wetting in the heap leach facility, and to the ponds that will form in the mined out open pits. Inflows from non-effect drainage areas increase with distance downstream from the mine site, and consequently no measurable changes to surface water hydrology are anticipated for Coffee Creek (**Table 4.2-1**) or the Yukon River.

The predominant residual effects of the mine site on hydrology are predicted to be decreases in flow in Latte Creek and increases in flow for Halfway and YT-24 creeks (**Table 4.2-1**). For sites in Latte Creek, the predicted decreases in mean annual discharge (MAD) were negligible in magnitude (i.e., less than the 5% error bounds of the WBM) but could be attributed to the diversion of water for the heap leach and dust suppression activities during operations (**Figure 4.2-1**) and for pit infilling during closure (**Appendix 8-B**). The predicted increases in flow for Halfway and YT-24 creeks varied between the both streams and project phases (**Table 4.2-1**). During the end-of-Operation Phase, low to moderate magnitude (8 to 11%) increases in MAD were predicted in both Halfway and YT-24 creeks (**Table 4.2-1, Figure 4.2-2**, and **Figure 4.2-3**) due primarily to increased run-off coefficients in waste rock dumps and dewatered pits (**Appendix 8-B**). During the Closure Phase, while the process of infilling pits with water was predicted to diminish the increases in MAD for YT-24 Creek to a negligible level (3% above natural levels), moderate (10 to 14%) increases in MAD were predicted to continue for Halfway Creek (**Table 4.2-1**) due to increased receipt of water from both Kona pit spillage and the water treatment plant (during its operation) (**Appendix 8-B**). During the Post-Closure Phase, pits will be predominately spilling rather than infilling, and sites in both Halfway and YT-24 creeks were predicted to have moderate (10 to 15%) increases in MAD (relative to natural conditions, **Table 4.2-1**) due to a combination of factors including increased run-off coefficients, passive releases of treated heap leach water to Halfway Creek, and an increase in the watershed area for upper YT-24 (**Appendix 8-B**).

**Table 4.2-1 Predicted Change in Mean Annual Discharge (MAD), Between Baseline and Mine Conditions, as Simulated for Sites in the WBM (Appendix 8-B)**

| Predicted Change in Mean Annual Discharge ($m^3/s$) between Baseline and Mine Conditions | | | | |
|---|---|---|---|---|
| Site | Scenario | Project Phase | | |
| | | End of Operations | Reclamation and Closure | Post-Closure |
| Upper Latte Creek (CC-1.5) | Baseline | 0.177 | 0.176 | 0.195 |
| | Mine | 0.170 | 0.171 | 0.195 |
| | Difference | -0.007 (-4%) | -0.005 (-3%) | 0.000 (<1%) |
| Lower Latte Creek (CC-3.5) | Baseline | 0.330 | 0.328 | 0.357 |
| | Mine | 0.325 | 0.326 | 0.359 |
| | Difference | -0.005 (-2%) | -0.002 (-1%) | 0.002 (1%) |
| Lower Coffee Creek (CC-4.5) | Baseline | 2.839 | 2.823 | 3.134 |
| | Mine | 2.834 | 2.821 | 3.136 |
| | Difference | -0.005 (<1%) | -0.002 (<1%) | 0.002 (<1%) |
| Mid Halfway Creek (HC-2.5) | Baseline | 0.085 | 0.084 | 0.094 |
| | Mine | 0.094 | 0.096 | 0.108 |
| | Difference | 0.009 (11%) | 0.012 (14%) | 0.014 (15%) |
| Lower Halfway Creek (HC-5.0) | Baseline | 0.137 | 0.137 | 0.151 |
| | Mine | 0.149 | 0.151 | 0.168 |
| | Difference | 0.012 (9%) | 0.014 (10%) | 0.017 (11%) |
| Lower YT 24 Creek (YT-24) | Baseline | 0.036 | 0.036 | 0.039 |
| | Mine | 0.039 | 0.037 | 0.043 |
| | Difference | 0.003 (8%) | 0.001 (3%) | 0.004 (10%) |

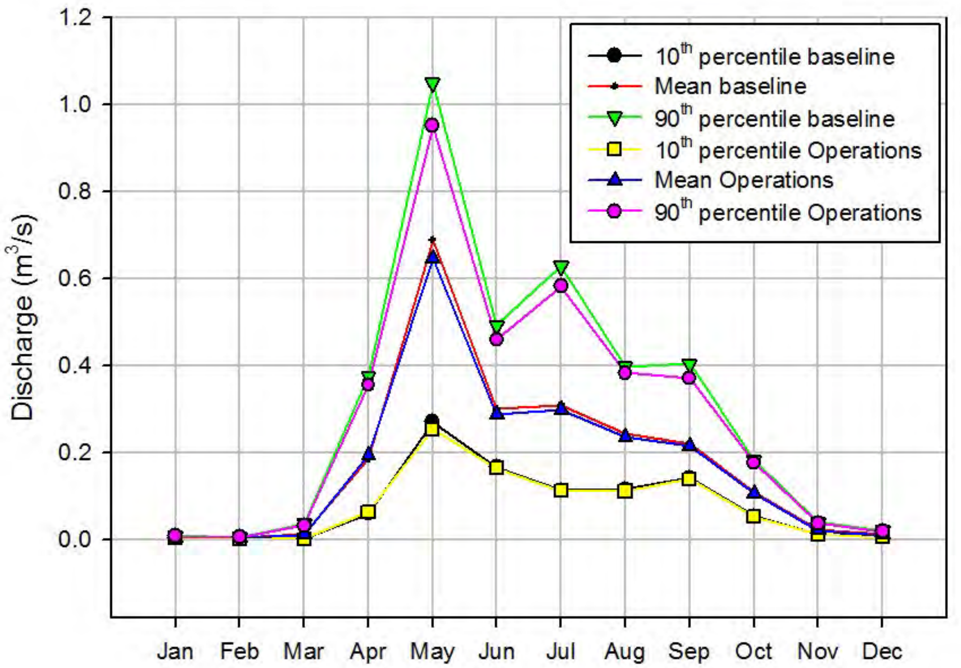



**Figure 4.2-1 Predicted monthly discharges in upper Latte Creek (Site CC-1.5) for the end-of-Operation Phase (Figure from Appendix 8-B)**

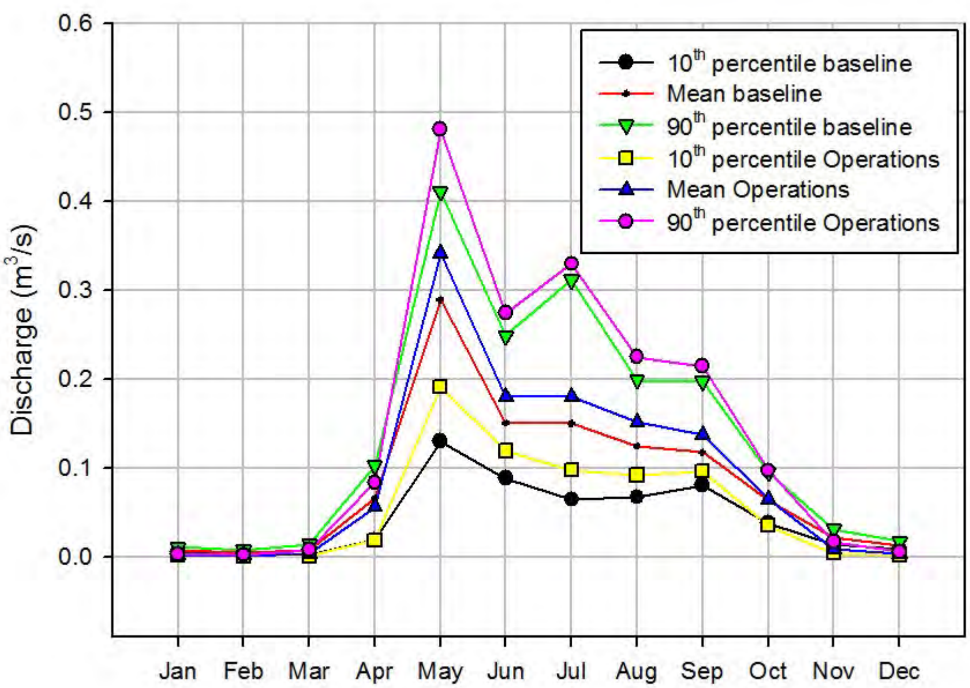



**Figure 4.2-2 Predicted monthly discharges in mid Halfway Creek (Site HC-2.5) for the end-of-Operation Phase (Figure from Appendix 8-B)**

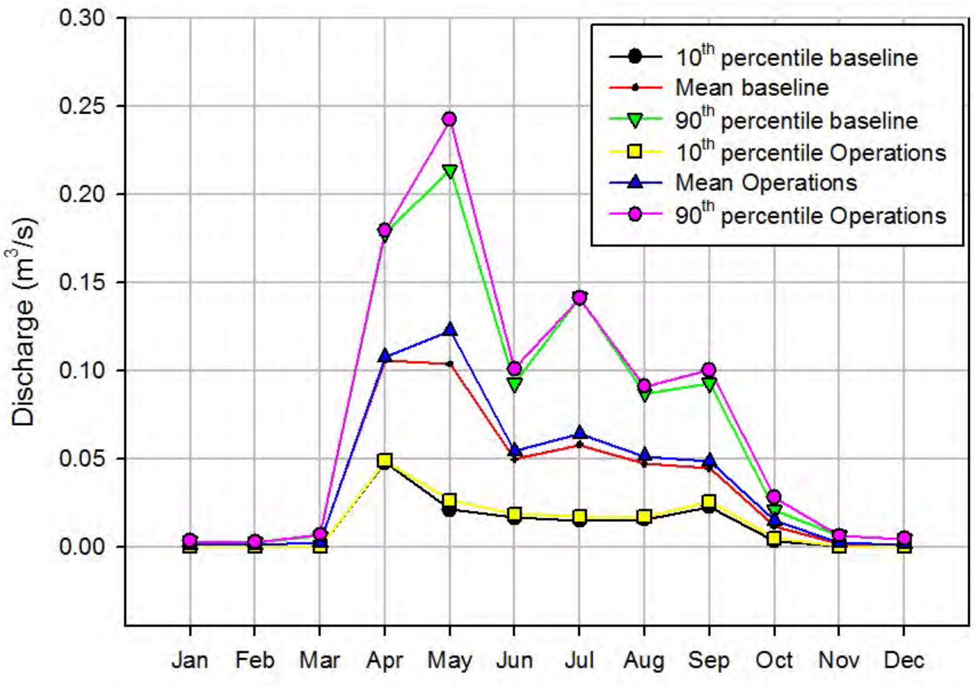



**Figure 4.2-3 Predicted monthly discharges in lower YT-24 Creek for the end-of-Operation Phase (Figure from Appendix 8-B)**

Flow alterations can affect the frequency of both flushing and channel forming flows. Mine site processes that will tend to attenuate high flow events include diversion of water for pond infilling or addition to the heap leach facility, water infiltration through waste rock dumps, and short term water detention in sediment treatment ponds. Insufficient flushing flows can lead to infilling of substrate interstices by fine sediment, which has a detrimental effect on fish and aquatic invertebrates. Flushing flows are considered to be flows above 200% MAD (Tennant 1976), which should occur at least annually to ensure fines are flushed out of larger substrates, and transported downstream, and there is some mobility of the larger substrate (Wald 2009, Robinson 2007). Channel forming flows are often defined as being discharges greater than 400% MAD (Hatfield *et al*. 2003), which are capable of eroding and transporting larger sediment particles, recruiting gravel and LWD, and preventing encroachment from riparian vegetation. Guidelines for Washington State recommend channel forming flows occur at least once every ten years (Wald 2009) though these are defined by higher instantaneous flood return periods and not as a percentage of MAD.

Changes in stream flow result in changes to wetted width, depth and water velocity in stream ecosystems. These changes alter the quantity and characteristics of available habitat in affected stream sections with the nature of this alteration varying by species and life-stage and by the magnitude and timing of hydrological alterations. For summer rearing by Arctic Grayling, juveniles tend to prefer low to moderate water velocities (<0.5 m/s) and depths (0.3 to 0.8 m) while adults prefer moderate water velocities (0.25 to 0.90 m/s) and depths (0.5 to 1.3 m; Larocque et al. 2014). Juvenile Chinook salmon prefer low to moderate velocities (0.1 to 0.55 m/s) and moderate to high depths (>0.2 m; BC Ministry of Environment and the Washington State Department of Ecology (Beecher et al. 2016)) for summer rearing. Changes in the quantity or quality of habitat could lead to effects on fish productivity in terms of fish population numbers, distribution, or fish condition.

#### *4.2.1.2 Northern Access Route*

Arctic Grayling and juvenile Chinook Salmon are present in some of the larger streams crossed by the NAR. Chum Salmon habitat is found in the large rivers and chum spawning occurs in small side channels of the Yukon River within LAA with groundwater inputs.

The physical footprints of road developments have the potential to affect fish habitat suitability. Roads and associated infrastructure (stream crossing structures, barge landings) may encroach and/or require modification of fish habitat in streams, lakes or wetlands. The portion of the NAR that will be upgraded includes 37 stream crossings, plus two barge crossings and encroaches on a 300 m section of a back channel associated with the Stewart River. Of the 37 crossings, 15 are existing fords and 7 have existing structures in place (all existing structures will be upgraded). No lakes are present in the LAA and the NAR does not intersect major wetlands.

Barge crossings will be used on the Yukon and Stewart rivers and will require the construction of barge landings on both banks of the Yukon and Stewart rivers. The barge landings require ramp construction and armouring of the river banks as outlined in Access Route Construction Management Plan (**Appendix 31-A**) and will result in habitat encroachment/alteration in these areas. The barge landings will alter the river bank and armour (riprap) and ramps will encroach to a small extent on the river channel (**Table 4.2-2**).

**Table 4.2-2 Summary of Fish Habitat Encroachment / Alteration Areas Associated with the NAR**

| Location | Length of Encroachment | Area of Encroachment Based on High Water Mark (ha) |
|---|---|---|
| North Stewart Barge Landing | 57 | 0.0385 |
| South Stewart Barge Landing | 123 | 0.1354 |
| North Yukon Barge Landing | 93 | 0.0569 |
| South Yukon Barge Landing | 150 | 0.1243 |
| Stewart River Back Channel | 300 | 0.1734 |
| **Totals** | **723** | **0.5285** |

The other location where the road encroaches on fish habitat is a 300 m section on the northern side of the Stewart River. Due to physical constraints in this area, the road parallels the channel and will require the removal of riparian vegetation and placement of riprap within the high water mark. Specifically, 0.1734 ha will be affected in a location that is only wetted during high flows. This back channel was sampled for fish and assessed for habitat during the summer of 2015 (PECG 2016, **Appendix 14-A**). No fish were captured and the dissolved oxygen concentration was low; however, fish use of the back channel was not ruled out. In October 2016, the channel was dry and provided no fish habitat (EDI 2017). No spawning or high quality rearing habitat for Arctic Grayling, Chinook Salmon or Chum Salmon was documented; however, this back channel likely provides refuge habitat for other fish species in the Stewart River during high water. To mitigate the effect of the riprap works, the design includes incorporation of woody debris to provide cover for fish.

### 4.2.2 HABITAT ACCESSIBILITY

The connectivity of fish habitats is important to supporting the abundance of fish species and their life stages found in fresh water habitats (Parker 2000). Access to fish habitat is important for accessing summer rearing areas (Arctic Grayling), non-natal rearing areas (Chinook Salmon) as well as ensuring genetic diversity in areas where resident fish spend their entire life cycle. The construction of mine infrastructure and roads has the ability to change fishes' ability to access habitats. Specifically, structures within a fish bearing stream that change water velocities and/or create physical barriers (i.e. waterfalls) can pose barriers to some or all species/life stages of fish.

The stream reaches directly affected by mine pits and waste rock storage facilities do not provide useable fish habitat; therefore, affecting accessibility is not a concern at the mine.

Habitat accessibility can be affected by construction activities along the Northern Access Road. There are several streams are crossed by the NAR that have been shown to contain fish or have the potential to contain fish. Habitat accessibility can be greatly influenced by road construction practices. Poor road construction practices, particularly with respect to the sizing and placement of culverts, can create barriers to fish movements and cut off access to large sections of stream habitat. For example, the Forest Practices Board (2009) reviewed over 1,100 stream crossings on fish bearing streams in British Columbia and found less than half of them were likely to allow fish to pass through without problems. Creation of barriers at road crossings can have a significant negative effect on fish populations, particularly species such as Arctic Grayling and juvenile Chinook Salmon, that undertake migratory movements.

Road construction may have a positive effect on Fish and Fish Habitat. The NAR, south of Sulphur Creek, will be upgraded and utilizes predominantly existing roads and trails. Palmer (2016b; **Appendix 14-A**) identified a number of existing crossing structures that are barriers to fish movements (improper culvert placement/design causing high velocities and/or falls at the outlet). The Project will upgrade the existing crossings to meet the Project road design standards (refer to Access Route Construction Management Plan [**Appendix 31-A**]), which will provide an opportunity to remove these barriers and re-establish fish access to the portions of the streams upstream of the NAR.

### 4.2.3 CONTAMINANT TOXICITY

Effects of contaminant toxicity have the potential to reduce fish population health, as measured through sub-lethal effects including growth and reproduction rates, and increases in mortality rates (**Section 4.2.5**). Changes in contaminant toxicity can be associated with Project-related changes in water quality, which can translate to changes in sediment quality, tissue concentrations of contaminants in food sources such as aquatic biota, and ultimately tissue concentrations of exposed fish species.

Project-related activities including development and operation of the NAR, open pits, HLF, WRSFs, stockpiles, and sediment ponds may release sediment into downstream environments and runoff from mine operations may contain metals, cyanide, nutrients, sulphates and other constituents that may flow or seep into fish bearing watercourses during all Project phases. These discharges have the potential to affect downstream water and sediment quality, and ultimately affect aquatic biota, including fish, through direct acute or chronic toxic effects.

Potential residual effects to Fish and Fish Habitat associated with contaminant toxicity were assessed using the generic water quality guidelines (GWQG)[2] derived from existing CCME and BCMOE guidelines derived for the protection of aquatic life (BCMOE 2006, CCME 2007a; **Appendix 12B; Table 4.2.3**), as well as Proposed Site-Specific Water Quality Objectives (SSWQO) developed for the Project area (**Appendix 12-B**). For the purposes of the Fish and Fish Habitat assessment the contaminants of potential concern (CoPC) were determined based on those parameters that are anticipated to increase during any Project phase when compared to baseline or predicted natural case. Further, the anticipated trends in CoPC concentrations were compared with known fish presence and habitat usage in the LAA. The CoPCs that exceed applicable guidelines, and have elevated concentrations during time periods with known fish presence and habitat usage will be determined to cause potential residual effects.

2 CCME WQGs were used as the default standards against which predictions were screened, unless the BC WQG for the corresponding parameter was more appropriate. A detailed description of the rationale for each guideline by parameter is presented in Appendix 12-A, Appendix A.

**Table 4.2-3 Proposed Water Quality Objectives for the Assessment of Surface Water Quality (from Appendix 12-B)**

| Parameter | Unit | Regulatory Source for Guideline | Proposed Water Quality Objectives | | | | |
|---|---|---|---|---|---|---|---|
| | | | Latte Creek | YT-24 | Halfway Creek | Coffee Creek (CC-4.5)[a] | Yukon River (YUK-5.0)[a] |
| $NH_3$-N | mg/L | BC | 1.63[b] | 1.91[b] | 1.91[b] | 0.04 | 0.03 |
| $NO_2$-N | mg/L | BC | 0.02[c] | 0.02[c] | 0.02[c] | 0.05 | 0.05 |
| $NO_3$-N | mg/L | BC | 3 | 3 | 3 | 0.6 | 0.2 |
| P | mg/L | CCME | 0.1[d] | 0.1[d] | 0.1[d] | – | – |
| $SO_4$ | mg/L | BC | 309[e] | 218[e] | 218[e] | 77 | 25 |
| WAD-CN | mg/L | BC | 0.005 | 0.005 | 0.005 | Non-detectable | Non-detectable |
| **Total Metals and Metalloids** | | | | | | | |
| Ag | mg/L | CCME | 0.00025[e] | 0.00025[e] | 0.00025[e] | 0.000007 | 0.00002 |
| As | mg/L | CCME | 0.005 | 0.005 | 0.005 | 0.0006 | 0.0013 |
| Cd | mg/L | CCME | 0.00013[e] | 0.0001[e] | 0.00011[e] | 0.00005 | 0.00021 |
| Cr | mg/L | CCME | 0.001[f] | 0.001[f] | 0.001[f] | – | – |
| Cu | mg/L | CCME | **0.003** | **0.0034** | **0.003** | 0.0042[g] | 0.0055[g] |
| Fe | mg/L | CCME | 1 | 1 | 1 | 0.349 | 2.066[g] |
| Hg | mg/L | CCME | 0.000026 | 0.000026 | 0.000026 | 0.00001 | 0.00001 |
| Mn | mg/L | BC | 0.89[e] | 0.97[e] | 0.86[e] | – | – |
| Mo | mg/L | CCME | 0.073 | 0.073 | 0.073 | 0.00074 | 0.0013 |
| Ni | mg/L | CCME | 0.082[e] | 0.061[e] | 0.069[e] | 0.0015 | 0.0046 |
| Pb | mg/L | CCME | 0.0025[e] | 0.0015[e] | 0.0018[e] | 0.00021 | 0.0011 |
| Sb | mg/L | BC | 0.009 | 0.009 | 0.009 | 0.00014 | 0.0002 |
| Se | mg/L | BC | 0.002 | 0.002 | 0.002 | 0.0001 | 0.00056 |
| Tl | mg/L | BC | 0.0008 | 0.0008 | 0.0008 | – | – |
| U | mg/L | CCME | **0.031** | 0.015 | **0.086** | 0.0036 | 0.001 |
| Zn | mg/L | CCME (draft) | 0.015[e] | 0.011[e] | 0.013[e] | 0.0052 | 0.0017[g] |
| **Dissolved Metals and Metalloids** | | | | | | | |
| Ag | mg/L | – | – | – | – | 0.000005 | 0.000005 |
| Al | mg/L | BC | **0.351** | **0.205** | **0.403** | 0.263[g] | 0.045 |
| As | mg/L | – | – | – | – | 0.00049 | 0.00054 |

| Parameter | Unit | Regulatory Source for Guideline | Proposed Water Quality Objectives | | | | |
|---|---|---|---|---|---|---|---|
| | | | Latte Creek | YT-24 | Halfway Creek | Coffee Creek (CC-4.5)[a] | Yukon River (YUK-5.0)[a] |
| Cd | mg/L | – | – | – | – | 0.000031 | 0.00006 |
| Cu | mg/L | – | – | – | – | 0.0033 | 0.0017 |
| Fe | mg/L | BC | 0.35 | 0.35 | 0.35 | 0.203 | 0.059 |
| Hg | mg/L | – | – | – | – | 0.00001 | 0.00001 |
| Mo | mg/L | – | – | – | – | 0.00068 | 0.00125 |
| Ni | mg/L | – | – | – | – | 0.0013 | 0.0017 |
| Pb | mg/L | – | – | – | – | 0.000055 | 0.00006 |
| Sb | mg/L | – | – | – | – | 0.00012 | 0.00012 |
| Se | mg/L | – | – | – | – | 0.00012 | 0.0005 |
| U | mg/L | – | – | – | – | 0.0038 | 0.001 |
| Zn | mg/L | – | – | – | – | 0.0022 | 0.0028 |

**Notes:**

CCME = Canadian Council of Ministers of the Environment (CCME 2014); BC = British Columbia Ministry of Environment (B.C MOE 2015a,b); dash (–) indicates not proposed.

Values in bold font represent Proposed Site Specific Water Quality Objective (SSWQO). Other values are either based on the generic water quality guidelines (BC or CCME) or non-degradation objectives.

a. Non-degradation objective; all values calculated as 90$^{th}$ percentile of corresponding baseline dataset unless otherwise noted.

b. Guidelines calculated using assumed temperature of 7°C and 25$^{th}$ percentile pH from corresponding baseline dataset.

c. Chloride dependent; value shown assumes Cl > 2 mg/L.

d. Proposed seasonal limit based on CCME trophic trigger range; applied during months of open water (April to October).

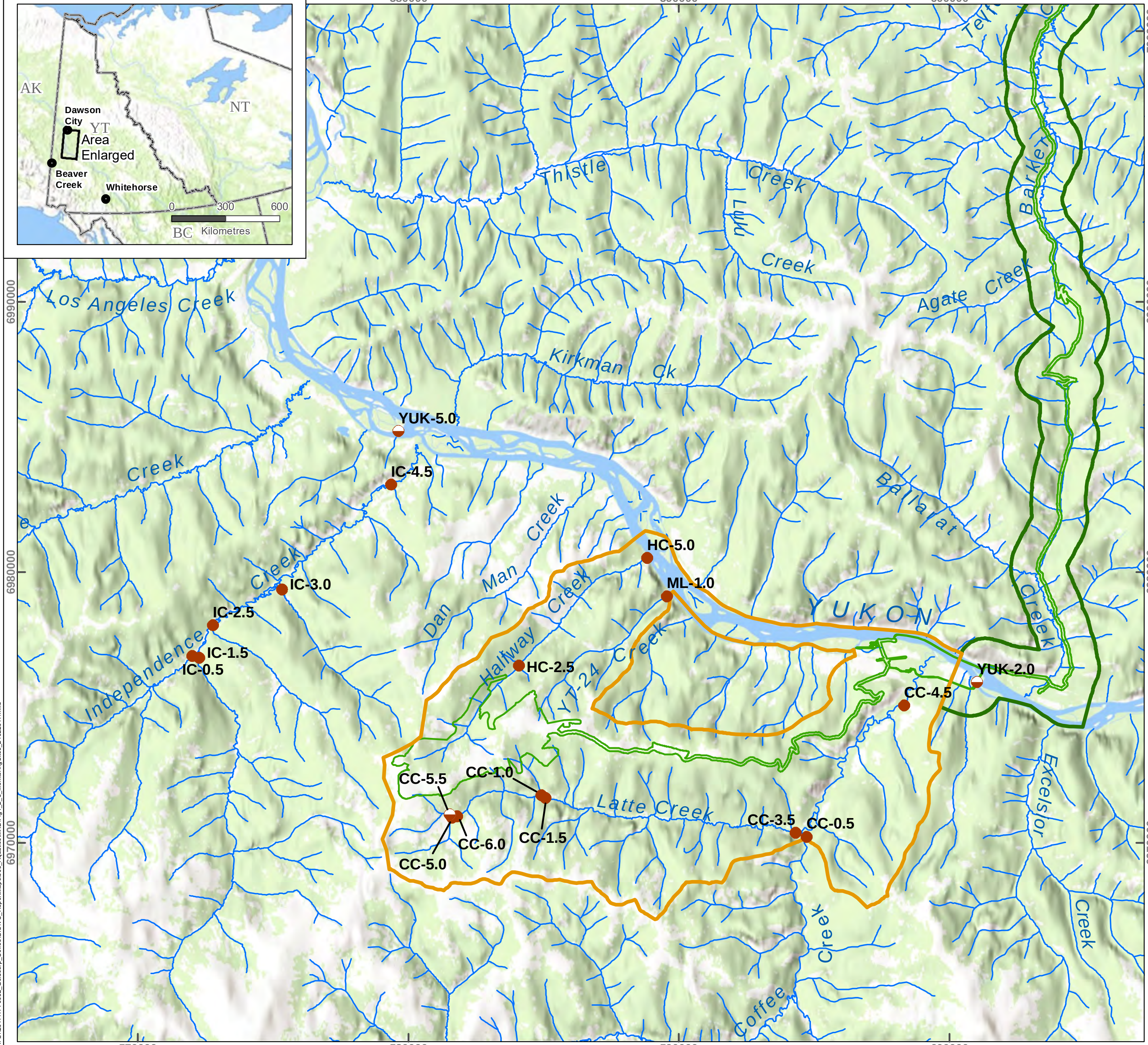
e. Hardness-dependent; values shown assume 25$^{th}$ percentile hardness from corresponding baseline dataset.

f. CCME water quality guideline for Cr(VI).

g. 95th percentile from baseline dataset.

The aquatic biota communities and fish habitat usage in each of the watersheds are unique. Coffee Creek is the largest creek in the LAA and provides summer rearing and overwintering habitat for Arctic Grayling and juvenile Chinook Salmon. Latte Creek, a tributary to Coffee Creek, is significantly smaller, and provides summer rearing habitat for Arctic Grayling. Halfway Creek provides documented summer use by Arctic Grayling and juvenile Chinook salmon within the lower 350 m While YT-24 appears to have some suitable summer habitat in the lower 400 m, it does not appear to be used by fish (no fish have been captured upstream of the stream mouth despite numerous sampling events; **Appendix 14-A**; EDI 2017). Regardless of the fish sampling results in Halfway and YT-24, the analysis of contaminant toxicity takes the conservative approach of evaluating effects to Fish and Fish Habitat in both mid to lower Halfway Creek and lower YT-24 (both upstream of documented fish use).

Baseline water quality data collection occurred throughout the Project area watercourses (**Appendix 12-A**, **Figure 4.2-4**). Results indicated that a number of water quality parameters were periodically present at concentrations that exceeded the GWQG (**Appendix 12-A**). In upper and lower Latte Creek the concentrations of dissolved and total aluminum exceeded the BCMOE guideline for protection of aquatic life during periods of high flow (open water season), and the total copper concentrations periodically exceeded the CCME hardness dependent guideline for protection of aquatic life (**Appendix 12-A**, BCMOE 2006, CCME 2007a). The total uranium concentrations in mid to lower Latte Creek were elevated during the winter season, coinciding with baseflow conditions, and seasonally exceeded the CCME guideline (**Appendix 12-A**, CCME 2007a). In Coffee Creek the dissolved aluminum and total copper concentrations exceeded the BCMOE guideline during the open water season. The upper Coffee Creek total uranium concentrations were elevated during the winter season, coinciding with baseflow conditions, and exceeded the CCME guideline; lower Coffee Creek did not have elevated concentrations of uranium (**Appendix 12-A**, CCME 2007a). In mid to lower Halfway Creek the concentrations of dissolved aluminum exceeded the BCMOE guideline during periods of high flow (open water season), and the total copper concentrations periodically exceeded the CCME guideline (**Appendix 12-A**, BC MOE 2006, CCME 2007a). The total uranium concentrations in Halfway Creek were elevated during the winter season, coinciding with baseflow conditions, and seasonally exceeded the CCME guideline (**Appendix 12-A**, CCME 2007a). In YT-24 the concentrations of dissolved aluminum were periodically elevated above the BCMOE guideline; high concentrations were associated with high flows and elevated TSS concentrations. Also the total copper concentrations exceeded the CCME guideline through the open water season. Uranium concentrations in YT-24 did not exceed any applicable guidelines. This assessment will review all anticipated changes in the concentrations of all parameters associated with Project interactions, and thereby evaluating effects of the Project, and not effects associated with current conditions.




# COFFEE GOLD MINE

## Surface Water Monitoring Stations

### Legend

- City/Town
- Surface WQ Monitoring Stations
- Surface and Hydrology Monitoring Stations
- Project Footprint
- Local Assessment Area (mine)
- Local Assessment Area (NAR)

### Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

### Sources

1. Sources: Esri, HERE, DeLorme, increment P Corp., NPS, NRCan, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community
2. Project access and infrastructure provided by Goldcorp Inc. (2017).

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| Fig 4-2-4 | Mar 22, 2017 | Drawn by: HG/MP | Reviewed: MAS/PT |
|---|---|---|---|

GOLDCORP

Predictions of changes to water quality caused by the Project were modelled by Lorax and the complete results are presented in **Appendix 12-C**. The evaluation of effects on Fish and Fish Habitat associated with contaminant toxicity are based on these predictions.

There are a number of CoPCs associated with Project interactions in the Latte Creek watershed (**Table 4.2-4**); these parameters include dissolved aluminum, arsenic, copper, molybdenum, antimony, thallium, uranium, and zinc. With the exception of uranium, while there is an expected increase in concentrations of these parameters from natural case, anticipated concentrations of these CoPCs during all Project phases do not exceed the GWQG. Therefore, in the Latte Creek watershed, uranium is the only parameter with the potential to result in a residual effect to Fish and Fish Habitat.

In upper Latte Creek (CC-1.5), the maximum uranium concentrations occur during the winter months under baseflow conditions. There are no anticipated changes to baseflow (winter) uranium concentrations; concentrations of uranium in water will continue to exceed the GWQG (0.015 mg/L; **Table 4.2-3; Appendix 12-B**), but rarely exceed the SSWQG (0.031 mg/L). However, the uranium concentrations during the open water season are projected to increase, beginning during the Operations Phase, and continuing through Closure and Post-Closure phases, however, open water concentrations are not anticipated to exceed the GWQG. In lower Latte Creek the trends are the same, but the magnitude much lower, only winter concentrations are projected to exceed the GWQG, and at no time are concentrations projected to exceed the SSWQG.

Water quality projections for lower Coffee Creek (CC-4.5, downstream of the confluence with Latte Creek) indicate there are no CoPCs with anticipated concentrations that increase over natural conditions, or are predicted to exceed the most applicable guideline (**Appendix 12-B**).

**Table 4.2-4 Contaminants of Potential Concern in the Latte Creek Watershed**

| Contaminant | Sites with Projected Change from Natural Case | Trend Projection | Residual Effect Determination |
|---|---|---|---|
| Dissolved Aluminum<br>(D-Al) | CC-1.5 (upper Latte Creek)<br>CC-3.5 (lower Latte Creek) | Slight decrease over natural case during all Project phases.<br>Concentrations during the open water season exceeded the GWQG in both natural case and in projected concentrations during all Project phases (0.05 mg/L;**Table 4.2-3**; **Appendix 12-B**), but not the SSWQG (0.351 mg/L). | No residual effects; projected concentrations are lower than natural case concentrations. |
| Arsenic (As) | CC-1.5 (upper Latte Creek)<br>CC-3.5 (lower Latte Creek) | Increase over natural case during Operations, Closure and Post-Closure phases<br>No concentrations projected to exceed the GWQG (0.005 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |
| Copper (Cu) | CC-1.5 (upper Latte Creek)<br>CC-3.5 (lower Latte Creek) | Slight decrease over natural case during all Project phases.<br>Concentrations during the open water season exceeded the GWQG in both natural case and in projected concentrations during all Project phases (0.002 mg/L; **Table 4.2-3**; **Appendix 12-B**), but not the SSWQG (0.003 mg/L) | No residual effects; projected concentrations are lower than natural case concentrations. |
| Molybdenum (Mo) | CC-1.5 (upper Latte Creek)<br>CC-3.5 (lower Latte Creek) | Slight increase in concentration through Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.073 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |
| Antimony (Sb) | CC-1.5 (upper Latte Creek)<br>CC-3.5 (lower Latte Creek) | Slight increase in concentration through Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.009 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |
| Thallium (Tl) | CC-1.5 (upper Latte Creek)<br>CC-3.5 (lower Latte Creek) | Slight increase over natural case during Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.0008 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |
| Uranium (U) | CC-1.5 (upper Latte Creek)<br>CC-3.5 (lower Latte Creek) | Increase over natural case during open water season concentrations during later Operations, Closure and Post-Closure phases. There are no predicted changes in winter concentrations.<br>As under baseline conditions, the winter concentrations in Latte Creek will continue to exceed the GWQG (0.015 mg/L; **Table 4.2-3**; **Appendix 12-B**), but rarely exceeded the SSWQG (0.031 mg/L). Open water concentrations are anticipated to remain below the GWQG. | Potential residual effects |
| Zinc (Zn) | CC-1.5 (upper Latte Creek)<br>CC-3.5 (lower Latte Creek) | Slight increase over natural case during Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.015 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |

There are a number of CoPCs associated with Project interactions in the Halfway Creek watershed at water quality sites HC-2.5 (mid Halfway Creek) and at HC-5.0 (lower Halfway; 200 m upstream of mouth **Table 4.2-5).** Parameters discussed here are those for which water quality projections indicated a change from natural case conditions (**Appendix 12-B**): these parameters include nitrate, nitrite, sulphate, WAD CN, arsenic, chromium, molybdenum, antimony, selenium, thallium, uranium and zinc. The CoPCs at mid and lower Halfway Creek are the same, however, in general the magnitude of the anticipated concentrations are higher at the mid Halfway Creek site. The anticipated base case concentrations were compared with the GWQG, as defined in **Table 4.2-3** and **Appendix 12-B**, to determine if there is a potential for a residual effect associated with contaminant toxicity. In the Halfway Creek watershed, the only parameters with the potential to result in a residual effect to Fish and Fish Habitat are nitrate and uranium.

The nitrate concentration in mid and lower Halfway Creek is anticipated to increase during the open water season through Operations, remain steady through Reclamation and Closure, and increase further during the open water season in late Closure and Post-Closure. Concentrations at HC-2.5 are anticipated to exceed the GWQG during late Closure and Port-Closure phases (3.0 mg $NO_3$-N/L, **Table 4.2-5; Appendix 12-B**).

In Halfway Creek the uranium concentration is anticipated to increase during the Operations Phase, and remain constant through Reclamation and Close and Post-Closure. Uranium concentrations in mid Halfway Creek (HC-2.5) are anticipated to exceed the GWQG of 0.015 mg/L year round, while further downstream at HC-5.0, the uranium concentration is anticipated to exceed the GWQG during the open water season (**Table 4.2-5; Appendix 12-B**). Uranium concentrations are projected to exceed the SSWQG (0.086 mg/L; **Table 4.2-3**) only during baseflow conditions at HC-2.5 (mid Halfway Creek).

### Table 4.2-5 Contaminants of Potential Concern in the Halfway Creek Watershed

| Contaminant | Sites with Projected Change from Natural Case | Trend Projection | Residual Effect Determination |
|---|---|---|---|
| Nitrate ($NO_3$-N) | HC-2.5<br>HC-5.0 | Increase over natural case during Operations, Closure and Post-Closure phases during the open water season<br>Concentrations projected to exceed GWQG beginning in second half of Closure Phase (3 mg/L; **Table 4.2-3**; **Appendix 12-B**) | Potential residual effects |
| Nitrite ($NO_2$-N) | HC-2.5<br>HC-5.0 | Increase over natural case during Operations, Closure and Post-Closure phases during the open water season.<br>No concentrations projected to exceed GWQG (0.02 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |
| Sulphate ($SO_4$) | HC-2.5<br>HC-5.0 | Change in peak concentration timing during Operations and into Closure phases. Increase over natural case during Closure and Post-Closure phases during the open water season.<br>No concentrations projected to exceed GWQG (218 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |
| Cyanide, Weak Acid Dissociable (WAD-CN) | HC-2.5<br>HC-5.0 | Slight increase over natural case during Operations, Closure and Post-Closure phases during the open water season.<br>No concentrations projected to exceed the GWQG (0.005 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |
| Arsenic (As) | HC-2.5 | Slight increase over natural case during Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.005 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |
| Chromium (Cr) | HC-2.5<br>HC-5.0 | Slight decrease in concentration during Operations and Closure phases, and slight increase during Post-Closure Phase.<br>Peak concentrations projected to exceed the GWQG during late Closure and Post Closure phases (0.001 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects; natural case exceeds the guideline, and there is minimal projected increase in the peak concentrations. |
| Molybdenum (Mo) | HC-2.5<br>HC-5.0 | Successive increase in concentration through Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.0073 mg/L; **Table 4.2-3**; **Appendix 12-B**) | No residual effects |

| Contaminant | Sites with Projected Change from Natural Case | Trend Projection | Residual Effect Determination |
|---|---|---|---|
| Antimony (Sb) | HC-2.5<br>HC-5.0 | Successive increase in concentration through Operations, Reclamation and Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.009 mg/L; **Table 4.2-3**; **Appendix 12-B**). | No residual effects |
| Selenium (Se) | HC-2.5<br>HC-5.0 | Successive increase over natural case during Operations, Reclamation and Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.002 mg/L; **Table 4.2-3**; **Appendix 12-B**). | No residual effects |
| Thallium (Tl) | HC-2.5<br>HC-5.0 | Slight increase over natural case during Operations, Reclamation and Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.0008 mg/L; **Table 4.2-3**; **Appendix 12-B**). | No residual effects |
| Uranium (U) | HC-2.5<br>HC-5.0 | Increase in open water season concentrations during Operations, Closure and post-Closure phases.<br>Year-round concentrations at HC-2.5 and open water concentrations at HC-5.0 are predicted to exceed the GWQG (0.0015 mg/L; **Table 4.2-3**; **Appendix 12-B**), but only winter concentrations at HC-2.will exceed the SSWQG (0.086 mg/L). | Potential residual effects |
| Zinc (Zn) | HC-2.5<br>HC-5.0 | Increase in open water concentrations during Operations, Closure and post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.013 mg/L; **Table 4.2-3**; **Appendix 12-B**). | No residual effects |

There are a number of CoPCs associated with Project interactions in YT-24 (**Table 4.2-6**). Parameters discussed here are those for which water quality projections indicated a change from natural case conditions (**Appendix 12-B**): these parameters include arsenic, cadmium, copper, molybdenum, antimony, selenium, thallium, uranium, and zinc. The CoPC with the potential to result in a residual effect is arsenic.

The arsenic concentration is projected to be highest during the Operations Phase, exceeding the GWQG (0.005 mg/L; as per **Table 4.2-3** and **Appendix 12-B**) through the open water season. Concentrations are then anticipated to decrease below the GWQG during late Operations, Closure and Post-Closure phases (**Appendix 12-B**).

**Table 4.2-6 Contaminants of Potential Concern in the YT-24 Watershed**

| Contaminant | Trend Projection | Residual Effect Determination |
|---|---|---|
| Arsenic (As) | Increase over natural case during the Operations Phase, lesser increase through Closure and Post-Closure phases.<br>Concentrations projected to exceed the GWQG (0.005 mg/L; **Table 4.2-3**; **Appendix 12-B**) during the open water season during Operations Phase. | Potential residual effects |
| Cadmium (Cd) | Increase over natural case during the Operations Phase, lesser increase through Reclamation and Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.0001 mg/L; **Table 4.2-3; Appendix 12-B**) | No residual effects |
| Copper (Cu) | Slight decrease over natural case during all Project phases.<br>Concentrations during the open water season exceeded the GWQG in both natural case and in projected concentrations during all Project phases (0.002 mg/L; **Table 4.2-3; Appendix 12-B**), concentrations are not projected to exceed the SSWQG (0.0034 mg/L) | No residual effects; projected concentrations are lower than natural case concentrations. |
| Molybdenum (Mo) | Increase over natural case during the Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.073 mg/L; **Table 4.2-3; Appendix 12-B**) | No residual effects |
| Antimony (Sb) | Increase over natural case during the Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.009 mg/L; **Table 4.2-3; Appendix 12-B**) | No residual effects |
| Selenium (Se) | Slight increase over natural case during the Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.002 mg/L; **Table 4.2-3; Appendix 12-B**) | No residual effects |
| Thallium (Tl) | Slight increase over natural case during the Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.0008 mg/L; **Table 4.2-3; Appendix 12-B**) | No residual effects |
| Uranium (U) | Increase over natural case during the Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.015 mg/L; **Table 4.2-3; Appendix 12-B**) | No residual effects |
| Zinc (Zn) | Increase over natural case during the Operations, Closure and Post-Closure phases.<br>No concentrations projected to exceed the GWQG (0.011 mg/L; **Table 4.2-3; Appendix 12-B**) | No residual effects |

The water quality in the Yukon River is not projected to change appreciably from the baseline or natural case projections due to the volume of inputs from Coffee Creek, Halfway Creek and YT-24. (**Appendix 12-B**) Therefore, there are no predicted Project-related effects associated with contaminant toxicity in the Yukon River.

In addition to surface water quality, baseline tissue metal data was collected. Throughout Coffee, Latte, Independence and Los Angeles creeks, Arctic Grayling muscle tissue samples had estimated baseline concentrations of methylmercury that exceeded CCME guidelines for the protection of piscivorous wildlife (0.033 µg/g ww; CCME 2007c; **Section 3.3.1**). Also, Chinook Salmon tissues from Coffee Creek had baseline concentrations of methylmercury that exceeded CCME guidelines for the protection of piscivorous wildlife, though concentrations in Chinook tissues from Halfway Creek did not exceed the guideline. Mercury has a high potential for bioaccumulation as well as biomagnification (CCME 2007c), therefore it can be found in elevated tissue concentrations in areas where water concentrations meet applicable guidelines and standards. Additionally, some Slimy Sculpin samples collected from Coffee Creek at CF3.9 and CF10.0 were found to have selenium tissue concentrations that were elevated over the US EPA draft guideline for whole body concentrations (8.5 µg/g dw, US EPA 201).6 and the BC MOE whole body tissue guideline (4 mg/kg dw, BC MOE 2014) Changes in concentrations of metals in the water column throughout the LAA could result in the increase in tissue metal concentrations in sediment as well as fish and other biota. However, the baseline tissue concentrations of mercury and selenium are not anticipated to change as the Project does not expect to result in increased concentrations of mercury or selenium in the effluent in Coffee, Latte, Halfway, YT-24 or any of the creeks along the NAR during any of the Project phases (**Appendix 12-B**).

Arctic Grayling are the most wide-spread fish species throughout the Project area; therefore, they would be most affected by changes to contaminant concentrations which could result in higher tissue concentrations and potentially affect growth or reproduction.

Juvenile Chinook Salmon are found in Coffee Creek year round, where there is little predicted change in contaminant concentrations (**Appendix 12-B**) and occasionally in the lower portion of Halfway Creek during the summer. It is expected that there will be minimal contaminant toxicity effects to juvenile Chinook Salmon.

The Project has no potential to alter the contaminant loading of large rivers including the Yukon River and the Stewart River. Therefore, there are no effects to Chum Salmon that are likely to occur associated with changes in contaminant toxicity.

#### 4.2.4 STREAM PRODUCTIVITY

Stream productivity, defined as changes in food supply including benthic invertebrates and periphyton (aquatic biota) is affected by many different parameters including changes in water quality resulting in nutrient enrichment, changes in sedimentation, and changes in riparian vegetation via clearing. Increased sedimentation can result from upslope development and/or erosion of stream bank soils, and can result in the input of nutrient materials, affect water clarity, light penetration, water temperatures and/or primary and secondary productivity growth.

Increased sedimentation can affect benthic invertebrates by interfering with filter feeding and respiration, as well as smothering physical habitats, decreasing interstitial spaces, ultimately resulting in a decrease in invertebrate abundance (Wood and Armitage 1997). Increased sedimentation can also increase invertebrate drift as biota searches for more appropriate habitat.

One of the primary factors driving changes in stream productivity is the clearing of riparian vegetation (Broadmeadow and Nisbet 2004). Clearing of riparian vegetation results in increased sunlight exposure, and potential stream temperature changes, and alters inputs of food and nutrients to the watercourse. Riparian vegetation provides food sources and nutrients to the aquatic food web via falling insects and leaf litter. Additionally woody debris provides a source of organic carbon as well as substrate habitat for aquatic biota, including aquatic insects, an important source of food for salmonids (Keely and Slaney 1996). Therefore, the alteration or removal of riparian vegetation affects food source quality and quantity as well as nutrient inputs. Increases in water temperature can alter the growth of primary productivity, including phytoplankton and algae, as well as aquatic vegetation. Nutrient-enriched run off from Project infrastructure or from blasting activities can affect stream productivity at the level of primary productivity through increases in nitrogen and phosphorus.

Project interactions with stream productivity include clearing and grubbing throughout the Project area, including the mine site and the NAR, changes in water quality associated with changing surface water flow patterns, and effluent characteristics including development and closure of open pits, WRSFs, HLFs, crushing and processing facilities, material stockpiles, development of water management systems, and the development, operation and maintenance of roads (including the NAR).

Any of the above activities that require blasting, which produces nitrogen-rich blast residues, can potentially introduce nutrient-enriched runoff to downstream watercourses. The development of the alpha WRSF will alter headwater ephemeral drainages in the mid Halfway Creek watershed; however, this area is not fish bearing and provide little habitat for periphyton and invertebrate communities.

CCME released a guidance framework for the management of phosphorus in freshwater systems; it describes ‘trigger’ concentrations for total phosphorus (**Table 4.2-7;** CCME 2004). A trigger range is a desired concentration range; when the upper limit is exceeded, it can be indicative of a potential environmental problem that warrants further investigation (CCME 2004). A classification system for trophic levels referencing nitrogen was developed in 1998 (Dodds et al.1998), and further validated in 2006 (Alexander and Smith 2006).

**Table 4.2-7 Trigger Ranges for Total Phosphorus and Total Nitrogen in Canadian Lakes and Rivers**

| Trophic Status | Canadian Trigger Ranges for Total Phosphorus (mg P/L) | Canadian Trigger Ranges for Total Nitrogen (mg N/L) |
|---|---|---|
| | Water Bodies (CCME 2004) | (Alexander and Smith 2006) |
| Ultra-oligotrophic | <0.004 | -- |
| Oligotrophic | 0.004-0.010 | <0.70 |
| Mesotrophic | 0.010-0.020 | -- |
| Meso-eutrophic | 0.020-0.035 | <1.5 |
| Eutrophic | 0.035-0.100 | -- |
| Hyper-eutrophic | >0.100 | -- |

The trophic status of the watercourses in the LAA may change as a result of nitrogen and phosphorus enrichment associated with Project activities including blasting, development of event ponds, and run off from WRSF and other infrastructure. Any potential changes in trophic status could negatively affect the biotic integrity of streams including growth and health of aquatic biota communities (Miltner and Rankin 1998). Baseline phosphorus and nitrogen concentrations in Latte, Coffee and Halfway creek are indicative of ultra-oligotrophic to oligotrophic conditions, and YT-24 baseline nutrient concentrations are indicative of oligotrophic conditions (**Appendix 12-A**).

Nutrient concentrations in Coffee Creek are projected to remain comparable with baseline conditions. Projections during all of the Project phases in upper and lower Latte Creek indicate that phosphorus concentrations will remain largely unchanged through Operation and Closure phases, and increase slightly during the Post-Closure Phase. All concentrations are anticipated to remain below the CCME oligotrophic trigger (0.01 mg/L; **Table 4.2-7**). Nitrogen concentrations are also projected to increase in Latte Creek, but all nitrogen parameters will remain below CCME guidelines for oligotrophic systems (**Appendix 12-B; Table 4.2-7**).

Phosphorus concentrations in mid Halfway Creek (HC-2.5) are projected to increase by only a slight amount, and never above the CCME oligotrophic trigger (0.01 mg/L; **Table 4.2-7; Appendix 12-B**). Anticipated phosphorus concentrations in lower Halfway Creek show similar trends. Nitrate and nitrite concentrations in Halfway Creek are predicted to increase through all Project phases; and nitrate concentrations during the open water season are anticipated to exceed the BC water quality guideline during Closure and Post-Closure phases (3 mg/L, **Table 4.2-3**; **Appendix 12-B**). However, given that the system is phosphorus-limited, and phosphorus concentrations are to remain within oligotrophic trigger ranges, there is no predicted change to trophic status.

There are minimal changes to phosphorus or nitrogen concentrations in YT-24 (**Appendix 12-B**). There are some slight anticipated increases in phosphorus concentrations in YT-24 during the Operations phase, and nitrate and nitrite concentrations may slightly decrease. At no time are concentrations of these parameters anticipated to exceed applicable guidelines or ‘trigger’ values.

Periphyton and benthic invertebrate communities are continually exposed to in situ stream conditions, and the health of their populations is reflective of the overall aquatic ecosystem health. Measureable changes in stream productivity will result in changes to the abundance and diversity of periphyton and benthic invertebrate communities. Periphyton, chlorophyll-a and taxonomic composition and abundance are useful in determining potential changes in aquatic ecosystems. They are sensitive to changes in stream productivity and as such can be used to predict changes to benthic invertebrate and fish populations. Increased nutrient inputs can result in excessive periphyton growth, which can result in negative effects to benthic invertebrate communities, via changes to physical habitat, and changes to water quality including dissolved oxygen concentrations (Horner et al. 1983). Benthic invertebrates consume smaller aquatic biota and plants, and assist in the decomposition of organic material in addition to being a main source of food for fish and other larger biota. Therefore, changes in benthic invertebrate diversity and abundance, as well as contaminant concentrations, as a result of Project interactions can have a direct effect on fish, and in turn birds and other wildlife that consume fish.

Arctic Grayling are the most wide-spread fish species throughout the Project area including downstream of the mine site and along the NAR; therefore, they would be most affected by changes to stream productivity, which could result in altered food sources and/or physical habitat.

Juvenile Chinook Salmon are found year round in Coffee Creek, where there is little predicted change to stream productivity because there is little to no predicted change to nutrient concentrations (**Appendix 12-B**), riparian vegetation clearing, or resulting suspended sediment loadings. It is expected that there will be minimal to no effects to juvenile Chinook Salmon in Coffee Creek. However, they are also occasionally found in Halfway Creek, where there is some predicted increase in nitrogen concentrations. There exists the potential for effects to juvenile Chinook Salmon in Halfway Creek due to changes in stream productivity associated with altered food sources and/or physical habitat.

The Project has no potential to alter the productivity of large rivers including the Yukon River and the Stewart River. Therefore, there are no effects to Chum Salmon that are likely to occur associated with changes in stream productivity.

#### 4.2.5 FISH MORTALITY

Fish mortality includes direct loss at any life stage; it is measured by assessing changes in fish species diversity and abundance metrics including the number of fish species present, fish catch-per unit effort, total abundance and density. Each of these metrics is further described in the Fish and Aquatic Habitat Management Plan (**Appendix 31-I**). Fish mortality may potentially occur both indirectly and directly as a result of Project-related interactions. Indirectly, fish mortality may occur as the final link in a potential chain of effects resulting from changes in one or all Project indicators that are fully described in the previous subsections, including decreases in fish habitat suitability and accessibility (**Section 4.2.1,** and **Section 4.2.2**), and increases in contaminant toxicity sufficient to result in acute, fatal, toxic effects (addressed in **Section 4.2.3**) and significant changes in stream productivity (addressed in **Section 4.2.4**).

Potential Project-related interactions leading to fish mortality may occur in all Project phases. The nature of fish mortality and the type of effect is the same for Arctic Grayling, Chinook Salmon and Chum Salmon; however, all three VC subcomponents are not present in the Fish and Fish Habitat LAA at all life stages. Arctic Grayling and Chinook Salmon are present in the LAA as juveniles and adults (Chinook only present as adults for spawning), while Chum Salmon are present in the LAA as adults (for spawning only), eggs and alevins. Upon reaching the fry stage, Chum Salmon migrate directly towards estuarine habitats (McPhail 2007), and thus are not present in the LAA as juveniles.

Potential Project-related interactions that may directly cause fish mortality include sediment and contaminants transported downstream from mine/road operations. Increased sediment loads have the potential to affect spawning substrates by smothering developing eggs and depriving them of oxygen (Grieg et. al. 2005). In rare cases excessive levels of TSS and/or contaminants can also result in fish mortality. Direct fish mortality from TSS is associated with excessive levels of TSS for a given duration of time. Newcombe and Jensen (1996) outline modelled durations and exposure times for lethal and para-lethal effects. A number of contaminants, if present at excessive concentrations, can have acute toxic effects.

At the egg stage, Chum Salmon mortality may occur directly due to increased sediment transport affecting spawning substrates. At the alevin stage, Chum Salmon are found in the spawning areas where they developed as eggs (McPhail 2007). Given that Chum Salmon spawn in groundwater fed side channels of the Yukon River that appear to be isolated from main river flows during the incubation period (i.e. when water levels are low; **Appendix 14-A**), there is no pathway for increased sediment transport (e.g. from barge operation or other Project activities) to occur in these areas.

There is no pathway for Chum Salmon eggs or alevin being affected by contaminants as a result of the Project. Water quality modelling (**Appendix 12-B**) shows there will not be any changes to metal concentrations in the Yukon River.

Indirect mortality of juvenile Arctic Grayling or Chinook Salmon can occur due to localized decreases in water quality or quantity, increases in contaminant toxicity or increases in stream productivity (eutrophic conditions resulting in low oxygen concentrations), which are described in **Section 4.2.3** and **Section 4.2.4**.

Blasting near fish bearing waters has the potential to cause barotrauma injuries in fish that are near the blast. Fish mortality is caused by rupturing of gas filled organs, particularly the swim bladder; however, kidney, liver, spleen and heart may also be affected (Wright 1982). Fish eggs and alevins may also be killed by blasting related barotrauma injuries (Wright 1982). DFO guidelines for the use of explosives in or near Canadian fisheries waters specify a distance of 150.9 m from the center of a detonation of confined explosive to avoid damage to fish eggs, and 50.3 m to avoid damage to other fish life stages (Wright and Hopky 1998). The only location where blasting will occur within this distance of a fish bearing stream is the north barge landing on the Stewart River and a portion of the adjacent NAR as it ascends away from the Stewart River after leaving the Maisy May River valley.

The nearest known salmon spawning location documented on the Stewart River is ~10 km downstream of the barge location (in a groundwater fed side channel) and 15 km downstream of portion of the NAR where blasting is required. There are no similar habitats (groundwater fed side channels) in the near vicinity of these locations (EDI 2017). As such, Salmon egg incubation occurs beyond the range where potential blasting related effects could occur (Wright and Hopky 1988). Blasting near fish bearing waters has the potential to affect Arctic Grayling and juvenile Chinook Salmon (and other species) that may be within 50 m of potential blasting sites (Wright and Hopky 1988) in the vicinity of barge landing locations.

Mortality can occur associated with water withdrawals on fish bearing streams. Unscreened water pumps can remove fish from streams/lakes; however this can be avoided by proper use of screens (DFO 1995).

### 4.3 MITIGATION MEASURES

This section describes mitigation measures, or actions that can be taken to decrease or prevent the effects that may be a consequence of activities related to the Project. Mitigation measures comprise any practical means taken to manage potential adverse effects and may include applicable standards, guidelines, and Best Management Plans/Practices (BMPs) supported by specific guidance documents.

The selection of mitigation measures for Fish and Fish Habitat was informed by a review of mitigation measures and follow-up programs undertaken for past projects and through input by regulators. Mitigation measures to address potential adverse effects to Fish and Fish Habitat are described below and summarized in **Table 4.3-1**. The final column in the table identifies whether or not there is the potential for a residual effect. Potential residual effects are carried forward to assessment for determination of significance. While this section highlights the mitigation measures applicable to reducing potential effects on Fish and Fish Habitat, details of process, implementation and responsibilities and schedules will be provided in the Fish and Aquatic Habitat Management Plan (currently in development for Project licensing).

To reduce or eliminate the effects to the Fish and Fish Habitat and number of mitigation measures will be undertaken. The approach to mitigating Project related effects will follow the mitigation hierarchy of elimination, mitigation and offsetting of residual effects. In general, this approach involves redesign and relocation of Project components to eliminate effects, and application BMPs to mitigate effects. The potential effects remaining after mitigation will be carried through the residual effects assessment.

Mitigation measures are illustrated in the following sections. More detailed descriptions of application of the mitigation measures are described in the various environmental management plans that are found in the various plans for the Project (**Appendices 31-A to F**). Project mitigation is based on professional experience, industry norms (e.g., BMPs), known regulatory expectations for works affecting water quality and fish habitat (e.g., DFO PoE) and reducing effects to VC subcomponents. The objectives of the mitigation incorporated to address Fish and Fish Habitat VC are to:

- Reduce effects to Fish and Fish Habitat in general
- Reduce effects to VC and VC subcomponents, and
- Minimize the residual effects that may require offsetting.

### 4.3.1 PROJECT DESIGN

#### *4.3.1.1 Mine Site Design and Operation*

The location and nature of the Project has eliminated many of the PoE to Fish and Fish Habitat commonly associated with the mining activities. The mine site is located high up in watersheds in areas that do not support fish. The only part of the Project that directly contacts fish habitat is the NAR, at the stream and river crossings and a 300 m section of road within the high-water mark of a back channel adjacent to the Stewart River.

The Project Design includes mitigation measures to reduce potential effects to surface water quality, which mitigates potential effects of Fish and Fish Habitat. One key project design element is associated with the heap leach facility. Two technologies were evaluated: ridgetop (conventional) and valley fill. Valley fill was rejected because of the higher rates of liner leakage and the higher risk of containment failure – both of which would have effects to water quality (**Volume 1, Section 2.9**). Specific Project Design mitigation measures associated with effects on surface water quantity and quality including waste rock storage facilities, backfills, management of potential ARD, processing and water management facilities are discussed in **Appendix 31-D and Appendix 31-E**.

#### *4.3.1.2 Northern Access Route Design*

Potential negative or adverse effects of the NAR on fish habitat suitability and accessibility will be mitigated through the selection of appropriately sized/designed culverts and bridges to prevent constriction of the stream channels and facilitate fish passage. This will minimize the risk of fish passage barriers from developing over time (e.g., hanging culverts) or changes in flows and bedload that cause degradation of the stream bed immediately below the road crossing. In addition, the choice of using barge/ice road crossings of the major rivers (i.e., Stewart and Yukon) eliminates the instream footprint of a large bridge.

Clear span bridges will be used for crossing moderate and smaller sized fish bearing streams with valuable fish habitat characteristics. Many of these bridges are located at existing ford crossings that lack existing riparian vegetation; riparian clearing at new crossing sites will be limited to what is required to construct the bridge. All bridges are designed in a manner that does not encroach on the stream channel (Access Route Construction Management Plan, **Appendix 31-A**). As such, bridges pose a negligible negative effect on fish habitat and their presence/use will eliminate negative effects associated with use of fords.

Embedded culverts will be installed at smaller stream crossings that have limited fish habitat. Specifically, this will include seasonal rearing streams and streams where fish have not been documented, but fish presence cannot be ruled out. The construction process will include replacement of existing stream crossings with culverts that are embedded into the stream channel, altering the fish habitat in these locations. Many of the existing crossing sites are located at existing fords; therefore, they are located at sites where the natural stream channel characteristics have already been altered.

The NAR makes use of existing roads and trails along much of its length, reducing the length of new construction required, which has the benefit of reducing the number of new stream crossings required. The use of existing roads and trails will have a positive effect on Fish and Fish Habitat. In the section to be upgraded, there are three existing crossings that are in poor condition or have undersized culverts that have created fish passage issues (**Appendix 14-A**). Nineteen existing crossings are fords where there are potential concerns with sediment mobilization and/or potential habitat alteration from vehicles driving through the streams. As part of the road upgrade work, to bring the roads up to Project design standards, the crossing structures will be upgraded to culverts or bridges that allow for fish passage. This will eliminate existing fish barriers and reconnect portions of the streams currently inaccessible to fish (Sulphur, Eureka, and a tributary to Barker Creek). The elimination of fords on many streams will reduce sediment mobilization and potential habitat effects from disturbance associated with vehicles.

#### 4.3.2 WATER MANAGEMENT PLAN

Water run-off from the mining, processing and Waste Rock Storage Facilities (WSRF) locations can affect water quantity and quality in downstream areas, which can affect fish habitat and fish use of the streams that receive discharges from site. The management of water will be guided by the Water Management Plan (**Appendix 31-E**). The performance objectives for water management at the Coffee Gold Mine are to:

- Minimize alteration to the pre-development drainage network, and the volume of contact water to be managed
- Maintain the physical integrity and stability of the mine site
- Manage water that could potentially be affected by the mine ('contact water') in accordance with industry best management practices
- Ensure that the quantity and quality of contact water discharged from the mine complies with applicable regulatory requirements
- Maintain the physical integrity and stability of slopes and watercourses downstream of the mine site, and
- Minimize any potential effects to surface water and groundwater quantity and quality in the receiving environment.

The water containment systems are more fully discussed in the Project Description (**Volume I, Section 2.0)** and the Water Management Plan (**Appendix 31-E**). The implementation of the Water Management Plan will play a key role in mitigating potential downstream effects on Fish and Fish Habitat suitability, contaminant toxicology, stream productivity and fish mortality. This Plan was designed to assist the Project with maintaining surface water quality downstream of the mine site, preventing increases in TSS concentrations, mitigating increases in total and dissolved metals and associated potential for changes to contaminant toxicity and habitat suitability. It will also assist with maintaining nutrient parameters, including nitrogen and phosphorus, close to acceptable ranges, mitigating changes to the trophic status of the water courses (stream productivity). The Water Management Plan will also ensure that cyanide is not released, thereby mitigating potential downstream toxic effects to fish (fish mortality).

#### 4.3.3 EROSION AND SEDIMENT CONTROL

Increase in TSS concentrations in run-off and sediment transport into fish bearing reaches of the streams that receive discharges from the mining and processing areas has the potential to change habitat and affect fish use of the habitat that exists downstream of the site (e.g., avoidance). In extreme cases, high concentrations of TSS can also result in a range of chronic physiological and behavioural response in fish and can cause lethal effects (Newcombe and Jensen 1996).

The implementation of an Erosion and Sediment Control Plan (currently in development for Project licensing) at the mine will reduce the amount of sediment mobilized from the site and roadways, reducing the TSS that needs to be treated in the sediment ponds, and reduce the risk of downstream TSS exceeding discharge criteria. The goals of the Erosion and Sediment Control Plan will be to:

- Reduce erosion and hence the need for sediment control
- Prevent sediment mobilization into the receiving environment, and
- Establish vegetation on disturbed areas as soon as practical to provide long-term erosion.

The Water Management Plan and the Project design include provisions for sediment settling ponds, which are essential in treating sediment once it has been suspended in water. The site's water management system and its associated sediment ponds will play a critical role in treating TSS in contact water before it leaves the site. The interaction between erosion and water management is essential in maintaining downstream water quality and minimizing TSS related effects on Fish and Fish Habitat.

In terms of the NAR, erosion and sediment control are addressed by the Access Route Construction Management Plan (**Appendix 31-A**) during construction and the Access Route Operational Management Plan (**Appendix 31-B**) during the operational period. The Access Route Construction Management Plan outlines measures for stream crossing installation (i.e. site isolation) and general BMPs for construction near streams as well as upslope areas. The Access Route Operational Management Plan outlines measures for inspection and maintenance to detect and address erosion and sediment issues.

The above mentioned plans and mitigation will play a key role in mitigating potential downstream effects on Fish and Fish Habitat at/near stream crossing sites. By ensuring that TSS concentrations remain within acceptable guidelines, the Project can mitigate effects to the downstream environment including degradation of fish habitat (suitability), chronic physiological and behavioural responses to fish, and in severe cases, fish mortality. Also, by preventing the increase in TSS, the Project is able to mitigate changes in stream productivity and increases in total and dissolved metals and associated toxicity effects to fish.

#### 4.3.4 BEST MANAGEMENT STRATEGIES FOR WORKING AROUND WATER

The stream crossings, barge landing areas, and winter ice bridges will require work activities near water. The Access Route Construction Management Plan and Access Route Operational Plan outline specific practices and BMPs to minimize construction related effects (**Appendix 31-A and 31-B**). Additional BMPs that will be applied to the Project activities are outlined in the following documents:

- DFO's Operational Statement for Ice Bridges and Snow fills (DFO 2007)
- DFO Freshwater Timing Windows Identified for Yukon (DFO 2014)
- DFO Freshwater Intake End-of-Pipe Fish Screen Guideline (DFO 1995)
- Best Management Practices for Works Affecting Water in Yukon (Yukon Environment 2011)

A goal of construction management is to minimize introduction of TSS to fish habitat and mitigate potential effects to habitat suitability, contaminant toxicology, stream productivity and fish mortality. To minimize construction related effects:

- When instream works are required, construction areas will be isolated from stream flows, where possible
- Erosion and sediment control activities will be put in place
- When site isolation is required for any site containing fish, a fish salvage will be carried out to remove fish from the work area
- When possible, instream works will be completed during low flow periods to make it easier to isolate work areas, and
- Water withdrawals required for ice bridges will follow DFO's Operational Statement for Ice Bridges and Snow fills (DFO 2007). The Stewart and Yukon rivers have significant flow volumes and established thresholds/guidelines (DFO 2007) for water withdrawals will be followed so that effects on instream flows are minimized.

### 4.3.5 WATER QUALITY GUIDELINES AND STANDARDS

Where possible, effects to Fish and Fish Habitat associated with changes in contaminant toxicity can be avoided/mitigated by water quality monitoring and management that prevents the release of water that leads to an exceedance water quality guidelines in fish bearing streams. Proposed Site-Specific Water Quality Objectives (PSSWQO) have been developed using applicable standards including Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007c), the BC MOE Water Quality Objectives (BC MOE) and detailed analysis of the background water chemistry of the stream in the Mine LAA (**Appendix 12-B**). Ensuring that water quality in the LAA remains at or below PSSWQO concentrations prevents health and mortality issues to Arctic Grayling, Chinook and Chum Salmon. Water quality monitoring continues through all Project phases, and results can be compared with these guidelines to determine if un-anticipated changes are occurring and if additional treatment or other Project design changes are required.

### 4.3.6 PROGRESSIVE RECLAMATION AND CLOSURE PLAN

Reclamation and closure planning is a key instrument to mitigating the overall effects of mining. The Conceptual Reclamation and Closure Plan (**Appendix 31-C**) outlines steps that will be taken during the Operation and Reclamation and Closure phases to reclaim the mine site. Some key principles and strategies outlined by the plan include:

- Early and ongoing community and regulatory engagement
- Designing for closure, including reclaiming disturbed areas progressively during the Operation Phase
- Reducing affected water and controlling contaminants at source, and
- Planning for long-term monitoring and maintenance, while minimizing long-term operational activities.

The plan includes measures to address waste rock, soil and overburden management, erosion and sediment control, and other measures to protect water quality and the aquatic environment (i.e. works to mitigate habitat suitability, contaminant toxicology, stream productively and mortality).

### 4.3.7 BLASTING MITIGATION

Potential fish mortality associated with blasting near water (particularly for the north Stewart barge ramp and NAR) will be mitigated by the measures described in the Access Route Construction Management Plan (**Appendix 31-A**). Specifically this includes following the requirements outlined in DFO *Guidelines for Use of Explosives In or Near Canadian Fisheries Waters* (Wright and Hopky 1998). These guidelines outline methods, practices and standards (i.e. limits to pressure change) that are designed to protect fish and fish habitat from the destructive forces of explosives.

### 4.3.8 METAL LEACHING/ACID ROCK DRAINAGE MANAGEMENT AND MONITORING PLAN

A Metal Leaching/Acid Rock Drainage Management Plan which will be developed for Project licensing will outline the potential for acid rock drainage and details management, prevention and monitoring strategies to mitigate the effects. Adaptive management and reporting requirements are outlined. The overall plan describes mine waste management and ensures that surface runoff is isolated from, and does not interact with, acid generating material. Therefore, there is a reduced the potential for increased contaminant levels in adjacent streams.

### 4.3.9 SUMMARY OF MITIGATION MEASURES

The Project incorporates many design features that reduce and eliminate effects to Fish and Fish Habitat. This greatly reduces the potential Project interactions with the aquatic environment. Integration of BMPs and proactive environmental planning (e.g., Water Management Plan, Access Route Construction Management Plan, and Access Route Operational Management Plan) into all phases of the Project will reduce the residual effects to the Fish and Fish Habitat VC and its subcomponents. Proposed mitigation measures for each Project component that interacts with Fish and Fish Habitat are listed in **Table 4.3-1** and a determination is made to evaluate if a residual effect remains following such mitigation.

**Table 4.3-1 Summary of Potential Effects and Proposed Mitigation Measures for Fish and Fish Habitat**

| Summary of Potential Effect | Project Components | Contributing Project Activities | Proposed Mitigation Measure | Detectable / Measurable Residual Effect (Yes / No) |
|---|---|---|---|---|
| **Construction Phase** | | | | |
| Habitat Suitability | Overall Mine Site | Construction of open pits, WRSFs, stockpiles, HLF sediment ponds and water management infrastructure. | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Water Management Plan | Yes |
| | Northern Access Road | Upgrade of existing road sections and construction of new road sections and winter roads, including installation of culverts and bridges and barge landings on the Yukon and Stewart rivers. | Project Design (incorporation of fish habitat features)<br>Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Access Route Construction Plan<br>DFO Timing Windows | Yes |
| Habitat Accessibility | Northern Access Road | Upgrade of existing road sections and construction of new road sections, including installation of culverts and bridges | Project Design (i.e. selection of appropriate crossing for fish passage)<br>Access Route Construction Plan | Yes |
| Contaminant Toxicity | Overall Mine Site | Construction of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures. | Water Management Plan<br>Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Project Design | No |
| | Northern Access Road | Upgrade of existing road sections and construction of new road sections and winter roads, including installation of culverts and bridges and barge landings on the Yukon and Stewart rivers. | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Access Route Construction Plan (including blasting mitigation) | No |
| Stream Productivity | Overall Mine Site | Construction of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures. | Water Management Plan<br>Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Project Design, which requires little to no blasting, and resulting nitrogen residues | No |

| Summary of Potential Effect | Project Components | Contributing Project Activities | Proposed Mitigation Measure | Detectable / Measurable Residual Effect (Yes / No) |
|---|---|---|---|---|
| | Northern Access Road | Upgrade of existing road sections and construction of new road sections, including installation of culverts and bridges and barge landings on the Yukon and Stewart rivers. | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Access Route Construction Plan (including blasting mitigation) | No |
| Fish Mortality | Overall Mine Site | Construction of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures. | Water Management Plan<br>Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Project Design (including HLF leak detection system ) | No |
| | Northern Access Road | Upgrade of existing road sections and construction of new road sections and winter roads, including installation of culverts and bridges and barge landings on the Yukon and Stewart rivers. | Erosion and Sediment Control Planning<br>Best Management Strategies for Working Around Water<br>Access Route Construction Plan (including blasting mitigation) | No |
| **Operations Phase** | | | | |
| Habitat Suitability | Overall Mine Site | Operation of open pits, WRSFs, stockpiles, HLF (operation and progressive closure and reclamation), sediment ponds and water management infrastructure. | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Water Management Plan | Yes |
| | Northern Access Route | Road maintenance and vehicle traffic - mobilization and re-supply of freight and consumables. | Best Management Strategies for Working Around Water<br>Access Route Operational Management Plan | No |
| Contaminant Toxicity | Overall Mine Site | Operation of open pits, WRSFs, stockpiles, HLF (operation and progressive closure and reclamation), sediment ponds and water management infrastructure. | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Water Management Plan<br>Water Quality Guidelines | Yes |
| | Northern Access Route | Road maintenance and vehicle traffic - mobilization and re-supply of freight and consumables | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Access Route Operational Management Plan | No |

| Summary of Potential Effect | Project Components | Contributing Project Activities | Proposed Mitigation Measure | Detectable / Measurable Residual Effect (Yes / No) |
|---|---|---|---|---|
| Stream Productivity | Overall Mine Site | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Project Design including HLF water containment and leak detection systems<br>Best Management Strategies for Working Around Water<br>Water Management Plan<br>Erosion and Sediment Control Planning | Yes |
| | Northern Access Route | Road maintenance and vehicle traffic - mobilization and re-supply of freight and consumables | Best Management Strategies for Working Around Water including Access Route Construction Plan and Access Route Operational Management Plan | No |
| Fish Mortality | Overall Mine Site | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Water Management Plan | No |
| | Northern Access Route | Road maintenance and vehicle traffic - mobilization and re-supply of freight and consumables | Best Management Strategies for Working Around Water<br>Access Route Operational Management Plan | No |
| **Reclamation and Closure Phase** | | | | |
| Habitat Suitability | Overall Mine Site | Reclamation and closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Best Management Strategies for Working Around Water<br>Water Management Plan<br>Erosion and Sediment Control Planning | Yes |
| | Northern Access Route | Road maintenance and vehicle traffic - mobilization and re-supply of freight and consumables<br>Annual construction, maintenance, and decommissioning of Stewart River and Yukon River ice roads | Best Management Strategies for Working Around Water<br>Access Route Operational Management Plan | No |

| Summary of Potential Effect | Project Components | Contributing Project Activities | Proposed Mitigation Measure | Detectable / Measurable Residual Effect (Yes / No) |
|---|---|---|---|---|
| Contaminant Toxicity | Overall Mine Site | Reclamation and closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Reclamation and Closure Plan<br>Water Management Plan<br>Water Quality Guidelines | Yes |
| | Northern Access Route | Road maintenance and vehicle traffic - mobilization and re-supply of freight and consumables | Access Route Operational Management Plan<br>Best Management Strategies for Working Around Water | No |
| Fish Mortality | Overall Mine Site | Reclamation and closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Best Management Strategies for Working Around Water<br>Erosion and Sediment Control Planning<br>Water Management Plan<br>Water Quality Guidelines | No |
| | Northern Access Route | Road maintenance and vehicle traffic - mobilization and re-supply of freight and consumables<br>Annual construction, maintenance, and decommissioning of Stewart River and Yukon River ice roads | Best Management Strategies for Working Around Water<br>Access Route Operational Management Plan | No |
| **Post-Closure Phase** | | | | |
| Habitat Suitability | Overall Mine Site | Site closed - long-term monitoring | Reclamation and Closure Plan | Yes |
| Contaminant Toxicity | Overall Mine Site | Site closed - long-term monitoring | Water Quality Guidelines<br>Reclamation and Closure Plan | Yes |
| Stream Productivity | Overall Mine Site | Site closed - long-term monitoring | Reclamation and Closure Plan | Yes |
| Fish Mortality | Overall Mine Site | Site closed - long-term monitoring | Reclamation and Closure Plan | No |

## 4.4 RESIDUAL EFFECTS AND SIGNIFICANCE OF RESIDUAL EFFECTS

After the application of mitigation measures, residual effects (i.e., effects anticipated to occur following the application of mitigation measures) remain for habitat suitability, habitat accessibility, contaminant toxicology and stream productivity. This section describes how these residual effects of the Project are characterized and how the significance of those effects to Fish and Fish Habitat is determined. Residual effects are characterized by the significance, likelihood, and the level of confidence in the information used to predict effects. The determination of significance for potential residual effects is based on a consideration of characteristics and the environmental context for Fish and Fish Habitat and associated subcomponents.

### 4.4.1 RESIDUAL EFFECTS CHARACTERISTICS

Residual effects are characterized based on the criteria defined in **Table 4.4-1**. The effect characteristics are assessed in the context of the mitigation measures and strategies that will be applied to eliminate or minimize the effect on the Fish and Fish Habitat subcomponent and indicator being evaluated. The subcomponent-specific definition of each effect characteristic was derived according to the following hierarchy:

1. A published regulatory or industry standard or criterion that establishes a threshold (e.g., relevant YESAB guidelines, CCME guidelines)
2. A range of values or standards that, while not regulated, are widely recognized and accepted (e.g. based on discussions with and input provided by YESAB staff)
3. Professional judgment based on a review of literature, precedents, TK, scientific and other information provided by learned persons, panels, etc. that support establishment of a threshold. As the thresholds differ for each indicator used for assessment of Fish and Fish Habitat subcomponents, a detailed rationale for effects characterizations is provided where relevant.

**Table 4.4-1 Effect Characteristics Considered When Determining the Significance of Residual Effects to Fish and Fish Habitat**

| Residual Effect Characteristic | Definition | Rating |
|---|---|---|
| Direction | Identifies the long term trend of the residual effect. | • Adverse – a reduction in fish health, habitat or productivity; an increase in the risk of fish mortality<br>• Positive – an increase in fish health, habitat or productivity; a reduction in the risk of fish mortality<br>• Neutral – no change from baseline in fish health, habitat, productivity or risk of fish mortality |
| Magnitude | Size or severity of the residual effect –measured in terms of the proportion and type of the Fish and Fish Habitat affected within the LAA, relative to the range of natural variation. | • Negligible – no measurable adverse effect to the accessibility productivity, or functionality of habitat, stream, or reduction in the health or mortality of Arctic Grayling, Chinook Salmon or Chum Salmon<br>• Low – measurable adverse effect to low sensitive habitat; low risk to health or mortality to Arctic Grayling, Chinook Salmon or Chum Salmon<br>• Moderate – measurable adverse effect on moderately sensitive habitat; moderate risk of heath or mortality effects to a small number Arctic Grayling, Chinook Salmon or Chum Salmon<br>• High – measurable adverse effect to highly sensitive habitat; high risk of health or mortality effects to Arctic Grayling, Chinook or Chum Salmon<br>• Positive – measurable positive effect to Arctic Grayling, Chinook Salmon or Chum Salmon or habitat. |
| Geographic Extent | Spatial scale over which the residual effect is expected to occur. | • Site-specific – effects restricted to a watercourse within the project footprint<br>• Local – effects restricted watersheds in the LAA<br>• Regional - Effects extend to the RAA. |
| Timing | Occurrence of the residual effect with respect to periods of life-history important to the Fish and Fish Habitat. For the purposes of this assessment, sensitive periods of life-history include spawning and overwintering and less sensitive periods include rearing and migration. | • Less Sensitive – Effects occur during less sensitive periods of life-history (e.g., rearing and migration)<br>• Sensitive – Effects occur during sensitive periods of life history (spawning, incubation or overwintering). |
| Frequency | How often the residual effect is expected to occur. | • Infrequent – effect occurs rarely, at irregular intervals throughout the life of the Project<br>• Frequent – effect occurs on a regular basis at regular intervals throughout the life of the Project<br>• Continuous – effect occurs continuously. |
| Duration | Length of time over which the residual effect is expected to persist. | • Short-term - Effect lasts less than typical lifespan of fish species affected.<br>• Long-term - Effect lasts longer than typical age of fish species affected.<br>• Permanent. |

| Residual Effect Characteristic | Definition | Rating |
|---|---|---|
| Reversibility | Whether or not the residual effect can be reversed once the activity causing the residual effect ceases. Irreversible effects are considered to be permanent. | • Fully reversible – fish health, habitat and productivity will recover through natural or assisted processes; loss of only a small number of fish that are part of an established population<br>• Partially reversible (e.g., habitat can be rehabilitated)<br>• Irreversible – loss of habitat, fish health or productivity is permanent; destruction of developing eggs or loss of fish from population at risk. |
| Probability of occurrence | Likelihood that the predicted residual effect will occur. | • Likely<br>• Unlikely |
| Context | The extent to which each subcomponent has been affected by past and present environmental processes and conditions, its potential sensitivity to the Project-related residual effect, and its ability to recover from that effect (i.e., resilience). | • High: subcomponent has a natural resilience and can respond or adapt to the disturbance before an effect can be detected within the population.<br>• Moderate: subcomponent has neutral resilience and may be able to respond or adapt to the disturbance, and low likelihood that an effect can be detected within the population.<br>• Low: subcomponent has low resilience and will not easily adapt to the disturbance, and an effect can be readily detected within the population. |

### 4.4.2 Significance Definition

The Fisheries Protection Policy (DFO 2013) identifies a number of threats to fisheries resources in Canada, the relevant ones for this Project are listed below.

- Habitat degradation or loss, which may occur as a result of the fragmentation of habitat, infilling of lakes or streams, conversion of wetlands or other activities in a watershed such as logging, urbanization, or the clearing of riparian or aquatic vegetation
- Flow alteration, which may alter habitat characteristics or cause the death of fish, and may be caused by dams or other impoundments, water diversion, stream crossings or water extraction for uses such as municipal, industrial, or agricultural uses, and,
- Pollution of many kinds, which may adversely affect water quality and fish health.

The Fisheries Protection Policy Statement (DFO 2013) also outlines at which scale these threats are considered a serious harm to a commercial, recreational or aboriginal fishery and this guidance will be considered when determining significance of residual effects. Each of the ratings used to characterize the residual effect of the Project on the aquatic environment will be rated as “Significant” or “Not Significant.”

***Significant*** Residual effects determined to be “Significant” are those that would result in a measurable effect that would result in one of the following situations.

- Fish mortality at a level that would pose a risk to the persistence and viability of fish populations within the LAA.
- Change in the amount or quality of fish habitat that is available to fish in the LAA. As defined by the Fisheries Act (Government of Canada 2014), a permanent alteration to fish habitat of a spatial scale, duration or intensity that limits or

diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.

- As defined by the Fisheries Act (Government of Canada 2014), the destruction of fish habitat of a spatial scale, duration, or intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.
- Changes in water chemistry that could affect fish health or mortality within the LAA.

***Not Significant*** Residual effects determined to be "Not Significant" are those that do not meet the definition of "Significant".

After considering the characteristics, a confidence rating will be determined and applied that considers the accuracy and application of analytical tools, and understanding of the effectiveness of mitigation measures, and an understanding of known responses of Fish and Fish Habitat subcomponent species to potential Project effects. The level of confidence in the significance determination will be rated as low, moderate, or high as follows:

**Low** A low level of confidence will be assigned to effects predictions with little or no empirical site-specific data and little to no published information on examples from other projects.

**Moderate** A moderate level of confidence will be assigned to effects predictions that are based on published literature and empirical site-specific data from other projects of a similar scale with similar Fish and Fish Habitat-related indicators; however, baseline data may not be entirely sufficient for the Coffee Creek Project.

**High** A high level of confidence will be assigned to effects predictions that have direct, site-specific quantitative data to support the prediction, either from the Coffee Project or other similar projects with similar Fish and Fish Habitat-related indicators. Baseline data is also considered sufficient for the Coffee Creek Project.

### 4.4.3 HABITAT SUITABILITY ASSESSMENT

#### *4.4.3.1 Mine Site*

After the application of mitigation measures including the Water Management Plan residual effects to habitat suitability are predicted for Arctic Grayling in Latte, Halfway and YT-24 creeks and juvenile Chinook Salmon in Halfway Creek due to Project related changes in hydrology. Residual effects of the mine site on fish habitat suitability were characterized for the following two key issues of concern:

- Potential changes in stream channel morphology due to changes in the frequency of flushing and channel forming flows.
- Change in the availability of suitable fish habitat due to changes in the magnitude and seasonal pattern of stream flow during the open water period.

The data source used to characterize residual effects due to these two mechanisms was the detailed site wide water balance model (WMB) described in the Hydrology IC report (**Appendix 8-B**). This hydrology model provided estimates of mean monthly flow at multiple stations along potentially affected streams for each year, under baseline (natural) and mine affected conditions. To account for uncertainty in future climate patterns, the model made separate predictions for each of 28 different climate simulations, all of which accounted for climate change after closure of the project.

The WBM provided flow estimates for three project phases: i) end-of-operations (2027 to 2032), ii) closure (2033 to 2042) and iii) long term monitoring (2043 to 2100).Without a detailed year by year mine plan it was not possible for the WBM to accurately estimate hydrology for earlier project phases (i.e., construction and early operations). However, the largest effects of the project on stream flow are predicted to occur once the project footprint is near its maximum, which is predicted to occur in approximately 2027 (i.e., the start of the "end-of-operations" phase, **Appendix 8-B**). Therefore, the results of the WBM should provide a reasonable estimate of the Project's largest effects on stream hydrology and the related effects on Fish and Fish Habitat.

The locations of hydrology modelling stations utilized for this residual effects assessment were in upper Latte Creek (CC-1.5), lower Latte Creek (CC-3.5), mid Halfway Creek (CC-2.5), lower Halfway Creek (HC-5.0), and lower YT-24 Creek (YT-24). Although the model also provided hydrology data for lower Coffee Creek (CC-4.5), the project is not predicted to have measurable effects on the hydrology of Coffee Creek and so it was excluded from this residual effects assessment.

As a result of mine development, the return period of flushing flows (200% MAD) and channel forming flows (400% MAD) tended to increase (i.e., become less frequent) for Latte Creek and decreased (i.e., become more frequent) for Halfway and YT-24 creeks (**Table 4.4-2** and **Table 4.4-3**). The primary causes for decreased frequency of high flow events for Latte Creek were diversion of water for the heap leach and dust suppression activities during Operations, and for pit infilling during Closure. Increased frequency of high flows in Halfway and YT-24 creeks were due to a combination of factors including increased run-off coefficients for developed areas, releases of treated heap leach water to Halfway Creek, and an increase in the watershed area for upper YT-24. Under both the baseline and mine site scenarios, the mean return period was less than one year for flushing flows and less than five years for channel forming flows, across all sites and Project phases. The frequency of these high flow events would be even greater if the analysis was based on daily rather than monthly flows. Since these return periods are shorter than the minimums recommended for maintenance of channel flushing and forming processes– i.e., at least annually and every ten years, respectively (**Table 4.4-2** and **Table 4.4-3**) – adequate channel flushing and forming processes are expected to be maintained with mine development.

**Table 4.4-2 Comparison of the mean return period of flushing flows (200% MAD) between baseline and mine conditions for each site and Project phase, based on simulated monthly average data (Appendix 8-B)**

| The Mean Return Period (Years) of Flushing Flows (200% MAD) Based on Mean Monthly Flow Estimates | | | | |
|---|---|---|---|---|
| Site | Scenario | Project Phase | | |
| | | End of Operation | Closure | Post-Closure |
| Upper Latte Creek (CC-1.5) | Baseline | 0.60 | 0.60 | 0.53 |
| | Mine | 0.63 | 0.64 | 0.53 |
| | Difference | 0.03 (6%) | 0.03 (6%) | 0 (-1%) |
| Lower Latte Creek (CC-3.5) | Baseline | 0.57 | 0.57 | 0.50 |
| | Mine | 0.58 | 0.57 | 0.49 |
| | Difference | 0 (1%) | 0 (0%) | -0.01 (-1%) |
| Mid Halfway Creek (HC-2.5) | Baseline | 0.63 | 0.64 | 0.58 |
| | Mine | 0.50 | 0.47 | 0.41 |
| | Difference | -0.13 (-21%) | -0.16 (-26%) | -0.17 (-29%) |
| Lower Halfway Creek (HC-5.0) | Baseline | 0.64 | 0.63 | 0.53 |
| | Mine | 0.55 | 0.54 | 0.44 |
| | Difference | -0.09 (-13%) | -0.09 (-15%) | -0.09 (-17%) |
| Lower YT 24 Creek (YT-24) | Baseline | 0.48 | 0.48 | 0.51 |
| | Mine | 0.45 | 0.47 | 0.46 |
| | Difference | -0.03 (-6%) | -0.01 (-3%) | -0.05 (-10%) |

**Table 4.4-3 Comparison of the mean return period of channel forming flows (400% MAD) between baseline and mine conditions for each site and project phase, based on simulated monthly average data (Appendix 8-B).**

| The Mean Return Period (Years) of Channel Forming Flows (400% MAD) based on Mean Monthly Flow Estimates | | | | |
|---|---|---|---|---|
| Site | Scenario | Project Phase | | |
| | | End of Operation | Closure | Post-Closure |
| Upper Latte Creek (CC-1.5) | Baseline | 1.89 | 1.89 | 2.37 |
| | Mine | 2.63 | 2.50 | 2.52 |
| | Difference | 0.74 (39%) | 0.61 (32%) | 0.15 (6%) |
| Lower Latte Creek (CC-3.5) | Baseline | 2.27 | 2.31 | 2.51 |
| | Mine | 2.55 | 2.69 | 2.47 |
| | Difference | 0.28 (12%) | 0.38 (16%) | -0.05 (-2%) |
| Mid Halfway Creek (HC-2.5) | Baseline | 4.54 | 4.67 | 3.22 |
| | Mine | 1.89 | 1.83 | 2.47 |
| | Difference | -2.65 (-58%) | -2.84 (-61%) | -0.75 (-23%) |
| Lower Halfway Creek (HC-5.0) | Baseline | 2.63 | 2.55 | 2.68 |
| | Mine | 1.75 | 1.81 | 2.34 |
| | Difference | -0.88 (-33%) | -0.74 (-29%) | -0.34 (-13%) |
| Lower YT 24 Creek (YT-24) | Baseline | 2.05 | 2.00 | 1.45 |
| | Mine | 1.47 | 1.76 | 1.25 |
| | Difference | -0.58 (-28%) | -0.24 (-12%) | -0.2 (-14%) |

In the absence of Yukon specific guidelines, residual effects on the availability of suitable fish habitat due to effects of the mine site on stream hydrology were assessed using the *Environmental Flow Assessment Methods for Application to Northeastern BC* (Hatfield et al. 2013). These guidelines recommend the use of a performance measure based on a habitat rating curve that provides a habitat rating of zero at zero flow and increases at a constant rate with increasing flow (as indicated by an upward sloping straight line) up to a maximum habitat rating of one, at or above an optimal flow rate. Optimal flow rate is estimated based on stream size and latitude using an equation developed by Hatfield and Bruce (2000) for juvenile salmonids. This equation was developed based on regression analysis of the results of instream flow assessment studies from across western North America (Alaska to California) and so should be applicable to the Yukon, particularly with the equation's correction for latitude.

Since the streams in which flows are predicted to be measurably affected by the mine site (Latte, Halfway, and YT-24 creeks) only provide summer rearing habitat for Arctic Grayling (and juvenile Chinook in Halfway), Project effects on fish habitat suitability were only assessed for the open water period, which was identified as the period of April through October. Although this flow assessment method is ideally meant to utilize mean daily flow data, Hatfield *et al.* (2013) determined that flow assessment results were similar when using monthly average flow data, and that the differences were probably insubstantial when the magnitude of flow alteration was low. They also recommend the adoption of the following categories to assess environmental risk based on the percentage change in the performance measure: ±<10% is low risk, ± 10-20% is moderate risk, and ±>20 is high risk.

Summaries of Project effects on habitat suitability, as indicated by the open water performance measure (OWPM), are provided for effects on average habitat suitability (**Table 4.4-4)**, and for effects on low flow ($10^{th}$ percentile) habitat suitability (**Table 4.4-5)**. For sites in Latte Creek, predicted changes in mean and $10^{th}$ percentile values of the OWPM due to Project effects were low (≤3%), across all three of the modelled Project phases, and could be considered negligible relative to the 5% maximum precision of the underlying WBM. For Halfway and YT-24 creeks, increases in the OWPM were predicted, including low to moderate (4 to 17%) increases in the mean value of the OWPM during all project phases in both creeks, and moderate to high magnitude (10 to 33%) increases in the $10^{th}$ percentile (low flow) values of the OWPM during the Post-Closure phase for Halfway Creek and all phases for YT-24. The increases in habitat availability, as indicated by the predicted increases in the OWPM for Halfway and YT-24 creeks, are consistent with the predicted increases in flows due to Project development for these two creeks (**Section 4.2.1.1**).

**Table 4.4-4 Comparison of the mean value of the open water fish habitat performance measure between baseline and mine conditions for each site and project phase, based on simulated monthly average data (Appendix 8-B)**

| Mean Open Water Habitat Performance Measures (A unit-less score between 0 and 1) | | | | |
|---|---|---|---|---|
| Site | Scenario | Project Phase | | |
| | | End of Operation | Closure | Post-Closure |
| Upper Latte Creek (CC-1.5) | Baseline | 0.653 | 0.650 | 0.696 |
| | Mine | 0.644 | 0.648 | 0.697 |
| | Difference | -0.009 (-1%) | -0.002 (<1%) | 0.001 (<1%) |
| Lower Latte Creek (CC-3.5) | Baseline | 0.734 | 0.729 | 0.756 |
| | Mine | 0.733 | 0.732 | 0.759 |
| | Difference | -0.001 (<1%) | 0.002 (<1%) | 0.003 (<1%) |
| Mid Halfway Creek (HC-2.5) | Baseline | 0.566 | 0.564 | 0.606 |
| | Mine | 0.632 | 0.646 | 0.709 |
| | Difference | 0.066 (12%) | 0.082 (15%) | 0.103 (17%) |
| Lower Halfway Creek (HC-5.0) | Baseline | 0.634 | 0.631 | 0.677 |
| | Mine | 0.679 | 0.687 | 0.741 |
| | Difference | 0.045 (7%) | 0.056 (9%) | 0.064 (9%) |
| Lower YT-24 (YT-24) | Baseline | 0.206 | 0.205 | 0.221 |
| | Mine | 0.227 | 0.213 | 0.239 |
| | Difference | 0.021 (10%) | 0.008 (4%) | 0.018 (8%) |

**Table 4.4-5 Comparison of the 10th percentile of the open water habitat performance measure between baseline and mine conditions for each site and project phase, based on simulated monthly average data (Appendix 8-B)**

| 10th Percentile of the Open Water Habitat Performance Measures (A unit-less score between 0 and 1) | | | | |
|---|---|---|---|---|
| Site | Scenario | Project Phase | | |
| | | End of Operation | Closure | Post-Closure |
| Upper Latte Creek (CC-1.5) | Baseline | 0.234 | 0.230 | 0.318 |
| | Mine | 0.238 | 0.238 | 0.320 |
| | Difference | 0.004 (2%) | 0.008 (3%) | 0.002 (1%) |
| Lower Latte Creek (CC-3.5) | Baseline | 0.279 | 0.274 | 0.336 |
| | Mine | 0.282 | 0.281 | 0.339 |
| | Difference | 0.002 (1%) | 0.007 (2%) | 0.003 (1%) |
| Mid Halfway Creek (HC-2.5) | Baseline | 0.224 | 0.219 | 0.289 |
| | Mine | 0.216 | 0.221 | 0.385 |
| | Difference | -0.008 (-4%) | 0.002 (1%) | 0.096 (33%) |
| Lower Halfway Creek (HC-5.0) | Baseline | 0.237 | 0.235 | 0.323 |
| | Mine | 0.246 | 0.240 | 0.392 |
| | Difference | 0.009 (4%) | 0.005 (2%) | 0.069 (21%) |
| Lower YT-24 (YT-24) | Baseline | 0.035 | 0.034 | 0.045 |
| | Mine | 0.044 | 0.041 | 0.049 |
| | Difference | 0.008 (24%) | 0.007 (20%) | 0.005 (10%) |

Given the proposed mitigation measures (**Section 4.3**), residual effects on habitat suitability due to the mine site development are expected to range from negative to positive in direction and low to high in magnitude (**Table 4.4-6**). Residual effects will be restricted to the LAA and be focused in headwater streams that provide limited rearing habitat for Arctic Grayling (and occasionally juvenile Chinook Salmon in lower Halfway) rather than more sensitive spawning or overwintering habitats. The effects on habitat suitability will be caused by alterations to stream flow hydrology, which will occur continuously throughout the Project. Most residual effects to fish habitat will be reversible to negligible levels following mine closure and rehabilitation. However, some changes to stream flows and fish habitat suitability, including increases in the watershed area of YT-24, will be permanent. Changes in habitat suitability are likely to occur since the mechanism of effects are well understood and the magnitude of residual effects, especially increases in habitat suitability for Halfway and YT-24 creeks, are moderate (>10%) to high (>20%) in magnitude. The context (resilience) for the effects on Arctic Grayling and Chinook Salmon is considered high. Both species are common throughout the Yukon River watershed, including the area adjacent to the LAA. The streams that will be affected have relatively small amounts of habitat that is used on a seasonal basis and therefore population effects are not expected to be detectable.

**Table 4.4-6 Effect Characteristics Ratings for Habitat Suitability due to Effects of the Mine Site**

| Residual Effects Characteristic | Rating | Rationale for Rating |
|---|---|---|
| Direction | Adverse to Positive | Effects on Latte Creek were adverse to neutral while effects to Halfway and YT-24 creeks were predominantly neutral to positive |
| Magnitude | Low | Magnitudes of effects were low for Latte Creek and low to high for Halfway and YT-24 creeks. |
| Geographic Extent | Local | Effects of the mine site on fish habitat suitability are caused by changes in stream flow hydrology, which are predicted to be largely confined to the headwater drainages of Latte, Halfway and YT-24 creeks. |
| Timing | Less Sensitive | Affects only summer rearing habitat and not spawning or overwintering habitat. |
| Frequency | Continuous | The effects from changes to stream flow hydrology will be continuous. |
| Duration | Long-term to Permanent | The underlying effects to stream hydrology are long-term and with some effects continuing even after mine closure and rehabilitation. |
| Reversibility | Partially Reversible | Changes to stream hydrology and fish habitat availability will be partially reversed through site closure and rehabilitation. |
| Probability of Occurrence | Likely | The mechanisms of effect are well understood and the magnitude of some predicted habitat increases are substantial (i.e., >20%), even relative to the precision (>5%) of the hydrology model. |
| Context | High Resilience | Arctic Grayling and Chinook Salmon are prevalent throughout the region and the streams affected by the Project provide a relatively small proportion of such habitat. |

The following is a summary of the key factors influencing the significance of the residual effects of the mine site on fish habitat suitability:

- The frequency of high flow events important in channel forming and flushing processes are expected to decrease only in Latte Creek, during the end-of-operation and Closure phases, and not below the level required to maintain channel flushing and forming processes.
- Due to predictions of low to moderate increases in overall flows for Halfway and YT-24 creeks, predicted changes in fish habitat suitability for these two streams were predominantly positive.
- The only predicted adverse residual effects on habitat availability were very low magnitude (≤1%) decreases in both mean and low flow percentiles for Latte Creek, and a reduction in the low flow percentile for mid Halfway Creek that was both low magnitude (4%) and non-permanent (i.e., occurred only during the end-of-operation) .
- The measurable residual effects will be focused in headwater streams that provide seasonal rearing habitat for Artic Grayling (and juvenile Chinook Salmon in lower Halfway) rather than more sensitive spawning or overwintering habitats.

Based on these considerations, the residual effects of the mine site on habitat suitability are not expected to result in any permanent adverse effects on the ability of Arctic Grayling or Chinook Salmon to carry out their life processes, and so are assessed as not significant. There are no anticipated residual effects to Chum Salmon as they are not present in the Latte, Halfway or YT-24 creeks.

Although Project effects on stream hydrology are likely to cause changes in habitat suitability [i.e., based on the known mechanisms of effect and the substantial (i.e., >20%) magnitude of some predicted effects] our confidence in the determination of non-significance is moderate (rather than high), primarily due to the limitations of the models used to predict both effects of the project on hydrology and the effects of flow alteration on fish habitat. The WBM used to estimate Project effects on hydrology (**Appendix 8-B**) was limited in accuracy, due to inherent inaccuracies in flow measurements and model fitting; could provide only monthly flow estimates; and did not provide flow estimates for years prior to the end-of-operation phase (due to limitations in the degree of detail in the mining plan). The model used to assess effects of flow alteration on fish habitat for this assessment (Hatfield et al. 2013), although based on a peer reviewed and regionally appropriate relationship to predict optimal flow based on stream size and latitude (Hatfield and Bruce 2000), does not utilize Project specific field measurements of flow versus habitat availability (i.e., depth and velocity) or account for other potentially confounding influences such as differences in stream geomorphology or fish communities between streams.

#### *4.4.3.2 Northern Access Route*

After the application of mitigation measures including Best Management Strategies for working around water, including the Access Route Construction and Operations Plans, residual effects to habitat suitability are predicted for Arctic Grayling, Chinook Salmon and Chum Salmon in the Yukon and Stewart Rivers due to habitat alteration at the barge landings, stream crossings (embedded culverts) and back channel along the Stewart River.

Residual effects of the NAR footprint are limited to shoreline modifications at the barge landings, the Stewart River back channel and stream channel alteration at embedded culverts. The habitat that will be altered at the barge landings is typical of the habitats along the main channel of the Yukon and Stewart rivers. No unique habitats are present these locations and value from a fish habitat perspective was for migratory and rearing purposes (PEGC 2016b; **Appendix 14-A**). The design of the ramps and associated bank protection (riprap) will prevent erosion and limit maintenance requirements (unlike barge landings downstream at Dawson City). While there will be some encroachment on habitat, it is limited to 0.36 ha in a river where similar habitat is readily abundant. The use of large riprap along the edge of the stream will also provide unique habitat to this section of river; large riprap can have positive effects on fish rearing in large western Canadian rivers (Long 2007; Quigley and Harper[3], 2004). Overall barge landings are predicted to have a negligible effect on rearing and no effect on migration of fish and; therefore, will not cause serious harm to Fish and Fish Habitat (subcomponents including Arctic Grayling, Chinook Salmon or Chum Salmon). As such, this has been assessed as not significant.

The Stewart River back channel alteration involves the transition of the edge of the channel bank from a natural riparian to riprap bank with woody debris placed into the riprap to provide fish habitat attributes. The encroachment on this back channel is 0.17 hectares along the high water mark. This back channel does not provide any critical fish habitat (i.e. spawning or overwintering), rather it likely provides refuge habitat during high water events in the Stewart River. While the habitat area of this back channel will decrease slightly, the overall fish use or value of this back channel habitat is not expected to change. The wood features incorporated into the riprap design will provide more cover for fish than currently exists. Overall the bank alteration is predicted to have a negligible effect to rearing; therefore, will not cause serious harm to fish or fish habitat (Arctic Grayling, Chinook Salmon or Chum Salmon).

Embedded culverts will be placed at three stream crossings with potential fish habitat (Eureka Creek, Upper Barker Trib 1 and Upper Barker Trib 3); however, these sites do not have any critical habitats such as spawning habitat. Two of these sites (Eureka and Upper Barker Trib. 3) currently have undersized, unembedded culverts that will be removed and replaced. As outlined in **Section 4.2.2**, the replacement of these culverts will restore access to currently inaccessible habitats without creating an additional footprint. Habitat will be altered at the remaining embedded culvert site (Upper Barker Trib. 1) where banks and stream channel disturbance has occurred associated with a log bridge. Additional alternations will be limited to the immediate stream crossing (~15 linear m), removing the log bridge before installing the culvert at this site. At all embedded culvert sites, natural stream bed material will be placed in the culverts to provide

[3] Quigley and Harper found a mix of negative, neutral and positive effects on salmonids. Positive effects were found in late summer and winter in the Thompson River in BC and Fraser River in the winter.

some fish habitat within the culverts (as well as facilitate fish passage). The combination of the minimal change to rearing habitat and the improved access to habitats upstream of three sites results in no measurable effect on Fish and Fish Habitat and thus are assessed as not significant (Arctic Grayling or Chinook Salmon). Confidence in this determination is high given clear knowledge of habitat loss and quality.

The context (resilience) for the effects on Arctic Grayling, Chinook and Chum Salmon is considered high. These species are common throughout the Yukon River watershed, including the area adjacent to the LAA. The streams that will be affected have relatively small amounts of habitat that is used on a seasonal basis; therefore, these species can adapt to the change before an effect can be detected within the population.

**Table 4.4-7 Effect Characteristics Ratings for Habitat Suitability Associated with the NAR for all Subcomponent(s) (related to the Construction Phase only)**

| Residual Effects Characteristic | Rating | Rationale for Rating |
|---|---|---|
| Direction | Adverse | Habitat loss associated with construction at barge landings, Stewart River back channel and embedded culverts. |
| Magnitude | Negligible | No measurable adverse effect to the functionality of habitat. |
| Geographic Extent | Site specific | Limited to sites at barge landings, culverts and Stewart River back channel. |
| Timing | Less Sensitive | Affects only summer rearing habitat and not spawning or sensitive habitat. |
| Frequency | Continuous | The effect from habitat loss will be continuous. |
| Duration | Long-term | Riprapped areas (barge landings and back channel) and embedded culverts are long-term as they are planned to be removed with the channel restored. |
| Reversibility | Partially Reversible | Culverts are to be removed and stream channels restored. Note armouring for barge landings and back channel could be removed; however, may be unlikely. |
| Probability of Occurrence | Likely | Requirement of construction plans. |
| Context | High | Grayling, Chinook and Chum are prevalent throughout the region and areas affected provide a relatively small proportion of such habitat. |

### 4.4.4 Habitat Accessibility Assessment

After the application of mitigation measures, residual positive effects to habitat accessibility are predicted during the Construction Phase for Arctic Grayling along the NAR due to improvement of fish passage. No residual effects (positive or negative) are predicted for Chinook Salmon as there are no current barriers in areas where Chinook have been documented or are likely to occur. Also, all future crossing structures at new and upgraded crossing sites with Chinook Salmon habitat will be designed and installed to allow fish passage. Chum Salmon are not found in any of the streams affected by changes to habitat accessibility, and are therefore not affected positively or negatively by improvements made to fish passage at stream crossings.

Currently the portion of the NAR that will be upgraded has 43 watercourse crossings (Access Route Construction Management Plan [**Appendix 31-A**]), exclusive of the barge crossings. Of these crossings, there are 32 existing crossings and 11 new structures. Of the 32 existing crossings along the route, there are 11 undersized corrugated steel pipes, 19 fords, and two bridges. Many of the existing corrugated steel pipes are in poor condition, are sediment sources and three (Sulphur, Eureka and Upper Barker Trib 3) are considered to be barriers to fish passage.

Replacement and upgrading the crossing structures to the project design standards will have a positive effect on the accessibility of fish habitat in the LAA. The upgrades will improve fish habitat accessibility at three of the stream crossings. Application of the design standards to the other fish stream crossings will significantly reduce the risk that fish barriers will develop during the operational life of the road.

Arctic Grayling, as the most wide-spread species throughout the LAA will be the main beneficiary of increased habitat accessibility. Juvenile Chinook Salmon have not been documented in the vicinity of the crossings where fish passage will be restored; therefore, effects will be neutral to their habitat accessibility. As accessibility will be improved to a considerable amount of stream habitat that is of moderate value to Arctic Grayling, the potential residual effects are considered significant. Confidence in this prediction is high given the clear knowledge of fish passage requirements.

**Table 4.4-8 Effect Characteristics Ratings for Habitat Accessibility for Arctic Grayling Subcomponent**

| Residual Effects Characteristic | Rating | Rationale for Rating |
|---|---|---|
| Direction | Positive | Access route will upgrade stream crossings which are currently fish movement barriers |
| Magnitude | Positive | Measurable positive effect for accessibility to moderate quality habitats. |
| Geographic Extent | Local | Streams in the road portion of the LAA |
| Timing | Less Sensitive | Streams are unlikely to have spawning or overwintering habitat. |
| Frequency | Continuous | Crossings installed during road development. Properly installed crossings will provide fish passage. |
| Duration | Long-term | Crossings in for duration of Project |
| Reversibility | Fully Reversible | Stream crossings can be removed at the end of the project, when the road is no longer required to support closure activities. |
| Probability of Occurrence | Likely | Stream crossings must be constructed as part of the access road development |
| Context | High | Grayling are prevalent throughout the region and area affected provides a relatively small proportion of such habitat. |

#### 4.4.5 CONTAMINANT TOXICITY ASSESSMENT

The mitigation measures applicable to contaminant toxicity are those that prevent increases in suspended sediment into watercourses in the LAA, including those that collect contact water and ensure that it is properly stored, and if necessary, treated, before being released to the downstream environment. These measures include implementation of the Water Management Plan, the Erosion and Sediment Control Plan, best management strategies for working around water, and the application of water quality guidelines. After the application of mitigation measures there is no potential for contaminant toxicity residual effect to Fish and Fish Habitat in Coffee Creek or along the NAR.

After the application of mitigation measures, there is the potential for residual effects to contaminant toxicity associated with uranium concentrations in Latte Creek, nitrate and uranium concentrations in Halfway Creek, and arsenic concentrations in YT-24. Baseline uranium concentrations during winter baseflows are elevated above the GWQG in Latte and Halfway creeks (0.015 mg/L; **Figure 4.4-1; Figure 4.4-2; Figure 4.4-3; Figure 4.4-4; Appendix 12-B**). Therefore, the Project has developed site specific water quality objectives (SSWQO) for both Latte and Halfway creeks. Throughout Latte Creek the uranium concentrations during the open water season are projected to fall below the GWQG. However, while winter, under ice, concentrations are anticipated to remain unaffected by Project activities; the uranium concentrations will remain above the GWQG, but below the SSWQG (0.031 mg/L; Table 4.2-3). Uranium concentrations in mid and lower Halfway Creek during the open water season are anticipated to exceed the GWQG, though not the SSWQG (0.086 mg/L; Table 4.2-3). Winter concentrations in Halfway Creek are anticipated to remain unaffected by Project activities; uranium concentrations at HC-2.5 (mid Halfway Creek) will remain above the GWQG, and periodically exceed the SSWQG. Given the low magnitude of the changes in uranium concentrations combined with seasonal use of Latte and Halfway creeks by fish, any effects associated with changes in contaminant toxicity are expected to be small.

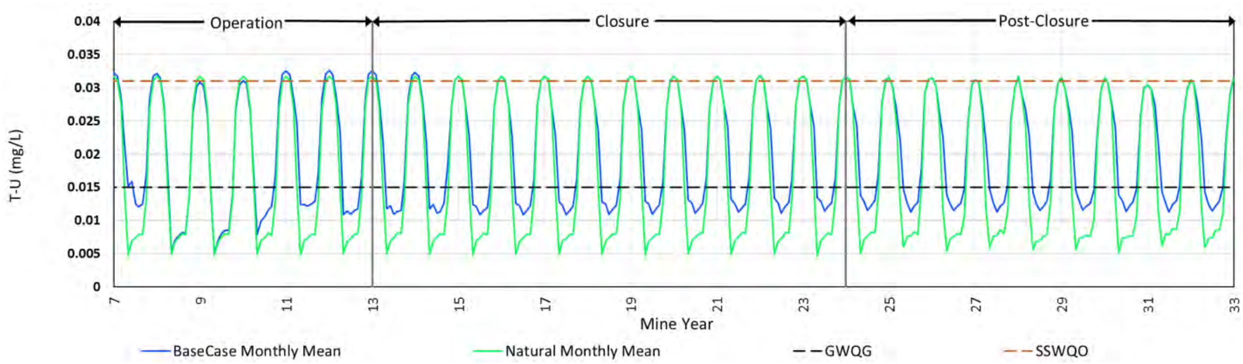


**Figure 4.4-1 Predicted mean monthly uranium concentrations in upper Latte Creek (Site CC-1.5) (Figure from Appendix 12-B)**

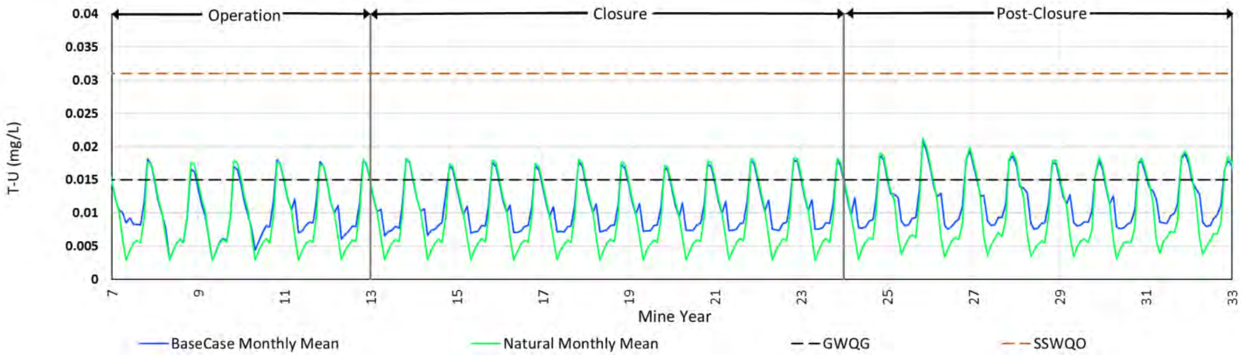


**Figure 4.4-2 Predicted mean monthly uranium concentrations in lower Latte Creek (Site CC-3.5) (Figure from Appendix 12-B)**

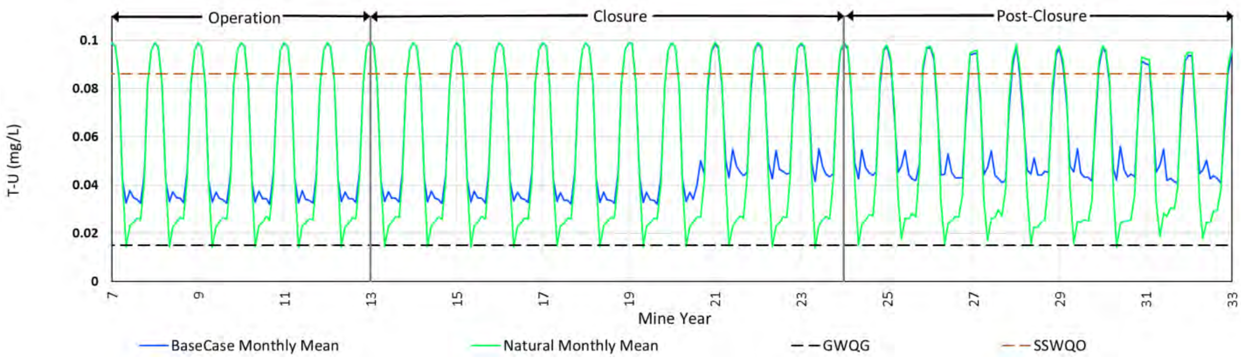


**Figure 4.4-3 Predicted mean monthly uranium concentrations in mid Halfway Creek (Site HC-2.5) (Figure from Appendix 12-B)**

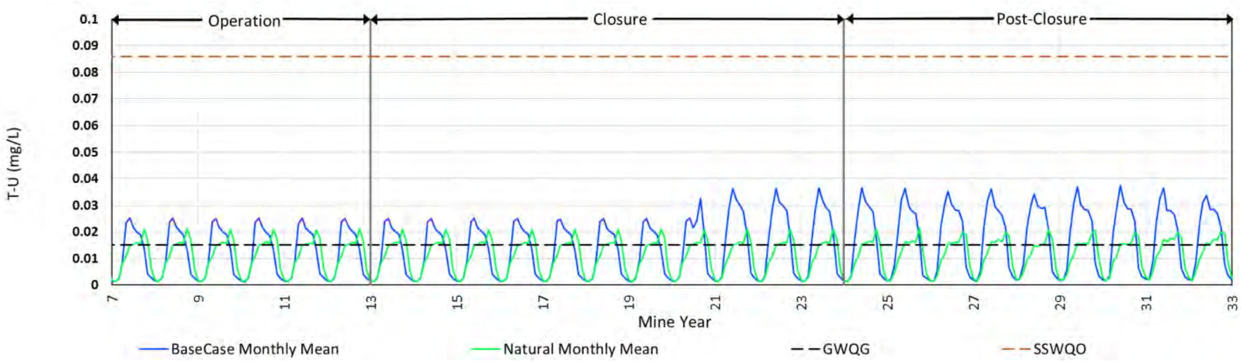


**Figure 4.4-4 Predicted mean monthly uranium concentrations in lower Halfway Creek (Site HC-5.0) (Figure from Appendix 12-B)**

Nitrate concentrations in Halfway Creek are anticipated to increase seasonally during the open water season; they are predicted exceed the GWQG at Halfway Creek (HC-2.5) during the later years of the Closure Phase and the whole of the Post-Closure Phase (3 mg/L; as defined in **Table 4.2.3; Figure 4.4-5; Appendix 12-B**). Concentrations are not anticipated to exceed the guideline at any time in lower Halfway Creek (HC-5.0). Given that fish use has only been documented in lower Halfway Creek, 5 km downstream of the HC-2.5 site, any effects associated with changes in contaminant toxicity are expected to be minimal.

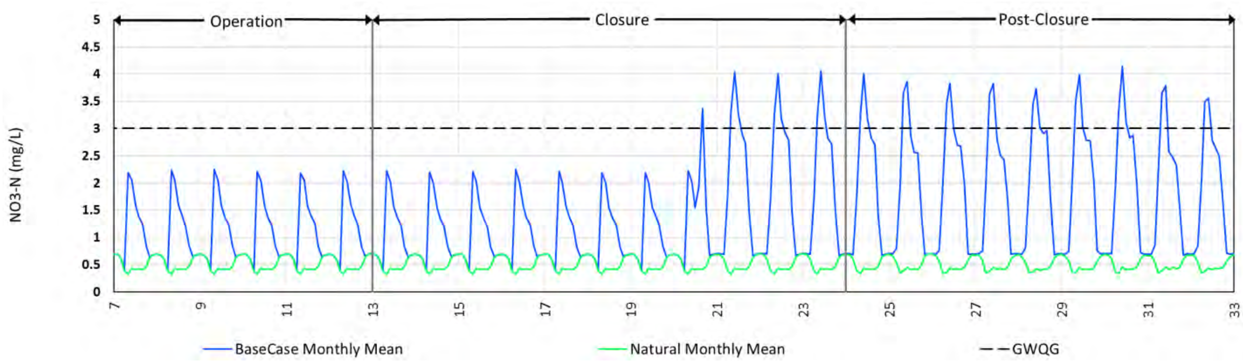


**Figure 4.4-5 Predicted mean monthly nitrate concentrations in Halfway Creek (HC-2.5) (Figure from Appendix 12-B)**

Arsenic concentrations in YT-24 are anticipated to increase during the Operations Phase, periodically exceeding the water quality guideline (0.005 mg/L; **Table 4.2-3; Figure 4.4-6; Appendix 12-B**). Concentrations that exceed the guideline set for the protection of aquatic life are of short duration; these concentrations are associated with freshet and heavy rainfall driven outflows from pit dewatering. Given the temporal natural (less than two months per year) and low magnitude of the increase (less than two times the GWQG) they are not anticipated to provoke an acute or chronic toxic response in aquatic biota present in the LAA. The existing guideline was calculated using the most sensitive species data, for the algae species, *S. obliquus*, which had a 14-day EC50 (growth) of 0.05 mg/L, an order of magnitude higher than the CCME AL guideline, and the anticipated concentrations in YT-24 (Vocke et al. 1980, CCME 1999). Therefore, while there may be a Project effect to arsenic concentrations, existing toxicity literature indicates that it is unlikely that this will translate to a toxic effect to resident fish and aquatic biota, especially considering the short duration of these events.

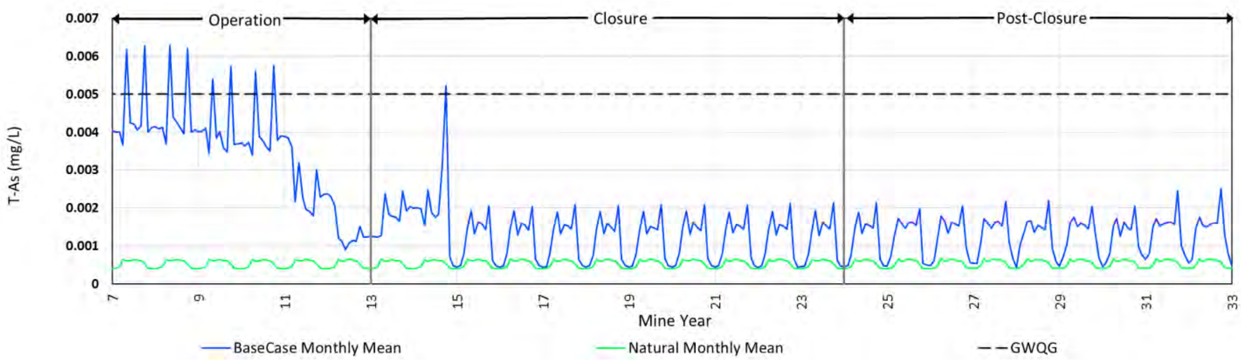


**Figure 4.4-6 Predicted mean monthly arsenic concentrations in YT-24 (Figure from Appendix 12-B)**

Arctic Grayling are widespread through the LAA, including summer rearing use of Latte and Halfway creeks, and the potentially the lower portion of YT-24. Therefore, there is an anticipated effect to Arctic Grayling associated with elevated uranium, nitrate and arsenic concentrations in the LAA. However, given magnitude of anticipated change to the concentrations of these contaminants in water, combined with the limited, seasonal fish use of upper Latte, lower Halfway and YT-24 creeks, this residual effect is deemed not significant and confidence in this prediction is high.

Juvenile Chinook Salmon are found in the LAA in Coffee Creek and occasionally in lower Halfway Creek. As there are no predicted changes in contaminant concentrations from background in Coffee Creek and limited predicted changes to contaminant concentrations in lower Halfway Creek this residual effect is deemed not significant and confidence in this prediction is high.

Chum Salmon are found in the LAA only in the Yukon River, and as such there are no predicted significant effects to Chum Salmon with respect to contaminant toxicity.

Continued monitoring of water and sediment quality as well as the abundance and diversity of aquatic biota, and tissue metal concentrations in the LAA will ensure that any adverse effects with respect to contaminant toxicity are detected and addressed in a timely manner.

**Table 4.4-9 Effect Characteristics Ratings for Contaminant Toxicity for Arctic Grayling and juvenile Chinook Salmon**

| Residual Effects Characteristic | Rating | Rationale for Rating |
|---|---|---|
| Direction | Adverse | Potential for changes in uranium concentrations in Latte Creek, nitrate and uranium concentrations in Halfway Creek, and arsenic concentrations in YT-24 during Operations, Reclamation and Closure and Post-Closure may result in adverse health effects for aquatic biota in Latte and Halfway and YT-24 creeks. |
| Magnitude | Low | While concentrations of uranium concentrations in Latte Creek, nitrate and uranium concentrations in Halfway Creek, and arsenic concentrations in YT-24 are projected to increase during Construction, Reclamation and Post-Closure phases, the Fish and Fish Habitat in YT-24 is of low quality for Arctic Grayling and juvenile Chinook salmon, and no overwintering or spawning habitat is present. |
| Geographic Extent | Site-specific | Any changes to contaminant toxicity are confined to Latte, Halfway, and YT-24 creeks. |
| Timing | Less Sensitive | There is no overwintering or spawning habitat located in Latte, Halfway or YT-24 creeks, where changes in water quality are may result in changes to contaminant toxicity. However, non-sensitive periods including the open water rearing season may be affected. |
| Frequency | Frequent | Changes in uranium, nitrate and arsenic are projected to occur frequently throughout the Operations, Reclamation and Closure and Post-Closure phases. |
| Duration | Long term | Changes in uranium, nitrate and arsenic concentrations are anticipated to last beyond the typical age of Arctic Grayling and juvenile Chinook Salmon |
| Reversibility | Partially reversible | Changes to uranium nitrate and arsenic concentrations may be partially addressed through reclamation and water treatment techniques. |
| Probability of Occurrence | Likely | Changes to uranium, nitrate and arsenic concentrations in Latte, Halfway and YT-24 creeks are highly likely. |
| Context | High | Arctic grayling and juvenile Chinook Salmon are prevalent throughout the region and Latte, Halfway andYT-24 creeks provides a relatively small proportion of such habitat (if any at all), and only on a seasonal basis during open water. |

### 4.4.6 STREAM PRODUCTIVITY ASSESSMENT

After the application of mitigation measures, there remains the potential for residual effects to stream productivity to fish and fish habitat in Halfway Creek due to increases in nitrogen concentrations (nitrate and nitrite) in the water column.

The mitigation measures that are most relevant to effects associated with stream productivity are those that limit increased suspended sediment in streams, and those that limit, or prevent nutrient-rich run off from mine facilities. These include the Water Management Plan, the Erosion and Sediment Control Plan, Best Management Strategies for Working Around Water, including the Access Construction Management Plan and the Access Operation Management Plan, and the Reclamation and Closure Plan.

Stream productivity is controlled by a number of factors including sediment inputs, water temperatures and nutrient enrichment. At the mine, the only riparian vegetation that will be eliminated is in the vicinity of WRSF, and minimal riparian vegetation will be cleared along the NAR watercourse crossings, as per the Access Route Construction Management Plan (**Appendix 31-A**). Limiting the amount of riparian vegetation cleared decreases the risk of sediment-laden run-off entering the streams, as well as limits increased sunlight exposure, and therefore limits increases in water temperatures. The only factor not fully mitigated through applicable management plans is nutrient enrichment associated with blasting and mine effluent.

Nitrate and nitrite concentrations in Halfway Creek are anticipated to increase during the Operations Phase, peaking at the end of the Closure Phase. Nitrate concentrations during the open water season are anticipated to exceed the BC water quality guideline (3 mg/L) during Closure and Post-Closure phases at HC-2.5 (mid Halfway Creek) (**Table 4.2-3; Appendix 12-B**). However, phosphorus concentrations are anticipated to remain very low, well below oligotrophic trigger ranges. Given that the system is phosphorus-limited, and phosphorus concentrations are to remain within oligotrophic trigger ranges, it is unlikely, but possible that changes in nitrogen concentrations would result in changes to trophic status, and ultimately stream productivity.

The residual environmental effects of nutrient enrichment on stream productivity in Halfway Creek, including effects to benthic algae and invertebrate communities, are predicted to be adverse[4], low to moderate in magnitude, frequent (but expressed seasonally), and will occur through all Project phases (long-term). The effect has a moderate likelihood of occurring (given the conservative predictions) and would be partially reversible when discharge ceases. Confidence in this prediction is moderate given that is has been based on water quality models.

Arctic Grayling are most wide spread through the LAA, including summer rearing use of the lower portions of Halfway and Latte creeks and potential use of the lower portion of YT-24. Projected changes to stream productivity associated with nutrient enrichment are considered minor. The context (resilience) of the effect is high because changes in nutrient concentrations will affect a small proportion of grayling habitat in the area. There are no predicted significant effects to Arctic Grayling with respect to changes in stream productivity.

Juvenile Chinook Salmon are found in the LAA only in Coffee Creek and occasionally in the lower portion of Halfway Creek. Projected changes to stream productivity associated with nutrient enrichment in Halfway Creek are considered minor. The context (resilience) of this species is considered high given their limited use of Halfway Creek and the high amount of available habitat in the region.

[4] In low nutrient stream increases in productivity could be considered to be positive for fish by providing more food sources; however, given there is a change from the natural condition it was considered negative.

Chum Salmon are found in the LAA only in the Yukon River, and as such there are no predicted effects to Chum Salmon with respect to changes in stream productivity.

Based on the assessment above, the Project will not result in any significant effects to stream productivity. However, continued monitoring of water quality, with a particular emphasis on in-situ data including temperature and dissolved oxygen, nutrient parameters including total phosphorus, ammonia, nitrate and nitrite, as well as the abundance and diversity of periphyton, benthic invertebrate and fish communities in the LAA will detect any unanticipated adverse effects with respect to changes in stream productivity.

**Table 4.4-10 Effect Characteristics Ratings for Stream Productivity for Arctic Grayling and Chinook Salmon**

| Residual Effects Characteristic | Rating | Rationale for Rating |
|---|---|---|
| Direction | Adverse | Potential for changes in water quality to result change to stream production in Halfway Creek |
| Magnitude | Low to moderate | While concentrations of nitrate and nitrite are anticipated to increase, projected concentration increases are of small enough magnitude that they preclude a change to trophic status, and further effects to primary and secondary stream production. |
| Geographic Extent | Local | Any changes to nutrient concentrations is confined to Halfway Creek |
| Timing | Less Sensitive | There is no overwintering or spawning habitat located in Halfway Creek, where changes in water quality are may result in changes to stream productivity. However, non-sensitive periods including the open water rearing season may be affected. |
| Frequency | Frequent | Changes in nutrient concentrations are projected to occur on a regular basis throughout all Project phases; elevated concentrations follow seasonal trends. |
| Duration | Long term | Changes in nutrient concentrations are anticipated to last beyond the typical age of Arctic Grayling or Chinook Salmon. |
| Reversibility | Partially reversible | Changes to stream productivity may be partially addressed through reclamation and treatment techniques. |
| Probability of Occurrence | Likely | There will be changes nutrient concentrations Halfway Creek, but these changes should not result in significant changes in stream productivity. |
| Context | High | Grayling and Chinook are prevalent throughout the region and area affected provides a relatively small proportion of such habitat. |

#### 4.4.7 FISH MORTALITY ASSESSMENT

After the application of mitigation measures, no residual effects to fish mortality are predicted for Arctic Grayling, Chinook Salmon or Chum Salmon. Direct and indirect mortality is mitigated by best management practices for working around water and adhering to the Water Management Plan (**Appendix 31-E**), the erosion and sediment control best practices and the Access Route Construction and Operational Management plans (**Appendix 31-A and 31-B**).

### 4.5 SUMMARY OF PROJECT–RELATED RESIDUAL EFFECTS AND SIGNIFICANCE

#### 4.5.1 ARCTIC GRAYLING

Arctic Grayling are the most widespread species in the LAA (downstream of the mine and along the NAR) and, as such, residual effects from numerous Project components have been assessed for this species (**Table 4.5-1**). Arctic Grayling are prevalent in the Yukon River watershed and are known to be resilient to disturbance in the region (i.e. are found in areas affected by placer mining); therefore, context is high for this species.

The assessment of alteration to Arctic Grayling habitat suitability indicated that flow changes downstream of the mine site (related to all mine phases) and habitat alteration along the NAR will be affected (related to the Construction Phase). Changes to surface water hydrology in the LAA downstream of the mine site (no changes at streams along the NAR), the frequency of high flows events is not expected to be reduced below the level required to maintain channel flushing and forming processes. Therefore, the residual adverse effects on habitat suitability that were predicted were low in magnitude (less than 10%) for Latte Creek (magnitude for Halfway and YT-24 creeks was neutral to high but positive in direction). The measureable residual effects will be focused in headwater streams that provide limited rearing habitat for Arctic Grayling rather than more sensitive spawning or overwintering habitats. Based on these considerations, the residual effects of the mine site on habitat suitability are not expected to result in any permanent adverse effects on the ability of Arctic Grayling to carry out their life processes, and so are assessed as not significant.

Habitat alteration during the construction stage along NAR is limited to small portions of marginal habitat along the Yukon River and tributary streams where embedded culverts will be installed. The limited amount of area affected and the limited quality of habitat is not anticipated to limit Arctic Grayling in the LAA and was assessed as insignificant.

The assessment of the accessibility of fish habitat indicated that replacement and upgrading the crossing structures to the project design standards will have a positive effect on the accessibility of fish habitat in the LAA along the NAR (**Section 4.4.4**). The upgrades will improve fish habitat accessibility at three of the stream crossings (Sulphur, Eureka and Upper Barker Trib 3). Application of the design standards to the other fish stream crossings will significantly reduce the risk that fish barriers will develop during the operational life of the road. Arctic Grayling, as the most wide-spread species throughout the LAA, will be the main beneficiary of increased habitat accessibility. As accessibility will be improved to a considerable amount of stream habitat that is of moderate to low value to Arctic Grayling, the potential residual effects are considered significant.

The assessment of contaminant toxicity indicated after the application of mitigation measures, residual effects to contaminant toxicity are predicted for Arctic Grayling in the Latte, Halfway and YT-24 creek watersheds. These potential residual effects are associated with increases in uranium, nitrate and arsenic above baseline conditions and both generic and site specific guidelines (GWQG and SSWQO) during the Operations, Reclamation and Closure and Post-Closure phases. Arctic Grayling are widespread through the LAA, including summer rearing use of Latte and Halfway (lower portion) creeks, and the potentially the lower portion of YT-24. Therefore, there is an anticipated effect to Arctic Grayling associated with elevated uranium, nitrate and arsenic concentrations in the LAA. However, given magnitude of anticipated change to the concentrations of these contaminants in water, combined with the limited, seasonal fish use of upper Latte, lower Halfway and YT-24 creeks, this residual effect is deemed not significant and confidence in this prediction is high.

The assessment of stream productivity indicated that the anticipated changes to nutrient enrichments in Halfway Creek may have a residual effect on stream productivity for Arctic Grayling. The residual environmental effects of nutrient enrichment on stream productivity, including effects to benthic algae and invertebrate communities, are predicted to be adverse, low to moderate in magnitude frequent (but expressed seasonally), and will occur through all Project phases (long-term) (**Section 4.4.6**). The effect has a moderate likelihood of occurring (given the conservative predictions) and would be partially reversible when discharge ceases.

There are no predicted residual effects to Arctic Grayling mortality following the application of all appropriate mitigation measures.

**Table 4.5-1 Summary of Potential Residual Effects for Arctic Grayling**

| Potential Residual Effects | Contributing Project Activities | Proposed Mitigation Measures | Residual Effects Characterization (see Notes for details) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction | Magnitude | Geographic Extent | Timing | Frequency | Durations | Reversibility | Probability of Occurrence | Significance | Level of Confidence | Context |
| **Construction Phase** | | | | | | | | | | | | | |
| Habitat Suitability – Mine Site, Latte Creek | Construction of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Erosion and Sediment Control Plan<br>Water Management Plan | A | L | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability – Mine Site, Halfway Creek | Construction of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures. | Erosion and Sediment Control Plan<br>Water Management Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability – Mine Site, YT-24 | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Erosion and Sediment Control Plan<br>Water Management Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability - NAR | Upgrade of existing road sections, and construction of new road sections, including installation of culverts and bridges and barge landings on the Yukon and Stewart rivers. | Project Design (incorporation of fish habitat features)<br>Erosion and Sediment Control Plan<br>Access Route Construction Plan<br>DFO Timing Windows | A | N | S | L | C | LT | P | L | NS | H | H |

| Potential Residual Effects | Contributing Project Activities | Proposed Mitigation Measures | Residual Effects Characterization (see Notes for details) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction | Magnitude | Geographic Extent | Timing | Frequency | Durations | Reversibility | Probability of Occurrence | Significance | Level of Confidence | Context |
| Habitat Accessibility - NAR | Upgrade of existing road sections, and construction of new road sections, including installation of culverts and bridges. | Project Design (i.e. selection of appropriate crossing structure for fish passage)<br>Access Route Construction Plan | P | P | L | L | C | L | F | L | S | H | H |
| **Operations Phase** | | | | | | | | | | | | | |
| Habitat Suitability – Mine Site, Latte Creek | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Erosion and Sediment Control Plan<br>Water Management Plan | A | L | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability – Mine Site, Halfway Creek | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures. | Erosion and Sediment Control Plan<br>Water Management Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability – Mine Site, YT-24 | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Erosion and Sediment Control Plan<br>Water Management Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Contaminant Toxicity | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures | Water Management Plan<br>Erosion and Sediment Control Plan<br>Water Quality Guidelines | A | L | S | L | F | L | P | L | NS | H | H |
| Stream Productivity | Operation of open pits, WRSFs, stockpiles, HLFs, sediment ponds and water management infrastructure. | Water Management Plan<br>Erosion and Sediment Control Plan<br>Water Quality Guidelines | A | M | L | L | F | L | P | L | NS | M | H |

| Potential Residual Effects | Contributing Project Activities | Proposed Mitigation Measures | Residual Effects Characterization (see Notes for details) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction | Magnitude | Geographic Extent | Timing | Frequency | Durations | Reversibility | Probability of Occurrence | Significance | Level of Confidence | Context |
| **Reclamation and Closure Phase** | | | | | | | | | | | | | |
| Habitat Suitability – Mine Site, Latte Creek | Reclamation and Closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Water Management Plan<br>Erosion and Sediment Control Plan | A | L | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability – Mine Site, Halfway Creek | Reclamation and Closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Erosion and Sediment Control Plan<br>Water Management Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability – Mine Site, YT-24 | Reclamation and Closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Erosion and Sediment Control Plan<br>Water Management Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Contaminant Toxicity | Reclamation and Closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Reclamation and Closure Plan<br>Water Management Plan<br>Erosion and Sediment Control Plan<br>Water Quality Guidelines | A | L | S | L | F | L | P | L | NS | H | H |
| Stream Productivity | Reclamation and Closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Reclamation and Closure Plan<br>Water Management Plan<br>Erosion and Sediment Control Plan<br>Water Quality Guidelines | A | M | L | L | F | L | P | L | NS | M | H |

| Potential Residual Effects | Contributing Project Activities | Proposed Mitigation Measures | Residual Effects Characterization (see Notes for details) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction | Magnitude | Geographic Extent | Timing | Frequency | Durations | Reversibility | Probability of Occurrence | Significance | Level of Confidence | Context |
| **Post-Closure Phase** | | | | | | | | | | | | | |
| Habitat Suitability – Mine Site, Latte Creek | Site closed - long-term monitoring | Reclamation and Closure Plan | A | L | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability – Mine Site, Halfway Creek | Site closed - long-term monitoring | Reclamation and Closure Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability – Mine Site, YT-24 | Site closed - long-term monitoring | Reclamation and Closure Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Contaminant Toxicity | Site closed - long-term monitoring | Water Quality Guidelines<br>Reclamation and Closure Plan | A | L | S | L | F | L | P | L | NS | H | H |
| Stream Productivity | Site closed - long-term monitoring | Water Quality Guidelines<br>Reclamation and Closure Plan | A | M | L | L | F | L | P | L | NS | M | H |

**Notes:**

| | |
|---|---|
| Direction | A = Adverse, P = Positive |
| Magnitude: | N = Negligible, L = Low, M = Moderate, H = High. P = Positive |
| Geographic Extent: | S = Site specific, L = local, R = regional |
| Timing: | L = Less-sensitive timing, S = Sensitive timing, |
| Frequency: | I = Infrequent, F = Frequent, C = Continuous |
| Duration: | S = Short-term, L = Long-term, P = Permanent |
| Reversibility: | F = Fully Reversible, P = Partially Reversible, I = Irreversible |
| Probability of Occurrence: | U = Unlikely, L = Likely |
| Significance: | NS = Not-Significant, S = Significant |
| Level of confidence | L = Low, M = Moderate, H = High |
| Context | L = Low, M = Moderate, H = High |

#### 4.5.2 CHINOOK SALMON

Chinook salmon are not as widespread in the stream in the LAA as Arctic Grayling and, as such, there are fewer residual effects that were assessed for this species (**Table 4.5-2**). The assessment of alteration to Chinook habitat suitability indicated that flow changes in Halfway Creek downstream of the mine site (related to all mine phases) and habitat alteration along the NAR will be affected (related to the Construction Phase). The context (resilience) is considered high due to limited amount of habitat that will be affected and the high availability of juvenile Chinook rearing habitat in the region.

Changes to surface water hydrology in the LAA downstream of the mine site (no changes at streams along the NAR) are not expected to be reduced below the level required to maintain channel flushing and forming processes. Therefore, residual effects to Chinook Salmon habitat suitability from flow level changes downstream of the mine site are limited to the lower 350 m Halfway Creek where they have been found occasionally. Flow changes in lower Halfway Creek were predicted to be low to moderate in magnitude, and positive in direction (increase in overall flows), making the habitat suitability effects a predominantly positive one. This stream provides occasional summer rearing habitat for Chinook rather than more sensitive spawning or overwintering habitats.

Based on these considerations, the residual effects of the mine site on habitat suitability are not expected to result in any permanent adverse effects on the ability of Chinook to carry out their life processes, and so are assessed as not significant.

Habitat alteration during the construction stage along NAR is limited to small portions of marginal habitat along the Yukon River and tributary streams where embedded culverts will be installed. The limited amount of area affected and the limited quality of habitat is not anticipated to limit Chinook Salmon in the LAA and was assessed as insignificant.

The assessment of contaminant toxicity indicated after the application of mitigation measures, residual effects to contaminant toxicity are predicted for juvenile Chinook Salmon in the Halfway Creek watershed. These potential residual effects are associated with increases in nitrate and uranium above baseline conditions and applicable guidelines (CCME AL and PSSWQO) during the Operations, Reclamation and Closure and Post-Closure phases. However, given the limited use of this watershed by juvenile Chinook Salmon, combined with the magnitude of change of the concentrations of these contaminants in water, this residual effect is deemed not significant.

The assessment of stream productivity indicated that the anticipated changes to nutrient enrichments in Halfway Creek may have a residual effect on stream productivity for Chinook Salmon. The residual environmental effects of nutrient enrichment on stream productivity, including effects to benthic algae and invertebrate communities, are predicted to be adverse, low to moderate in magnitude frequent (but expressed seasonally), and will occur through all Project phases (long-term) (**Section 4.4.6**). The effect has a moderate likelihood of occurring (given the conservative predictions) and would be partially reversible when discharge ceases.

Chinook Salmon have not been documented in the vicinity of the NAR crossings where fish passage will be restored; therefore, effects will be neutral to habitat accessibility. There are no predicted residual effects associated with contaminant toxicity to Chinook Salmon because they are not present in YT-24.

**Table 4.5-2 Summary of Potential Residual Effects for Chinook Salmon**

| Potential Residual Effects | Contributing Project Activities | Proposed Mitigation Measures | Residual Effects Characterization (see Notes for details) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction | Magnitude | Geographic Extent | Timing | Frequency | Durations | Reversibility | Probability of Occurrence | Significance | Level of Confidence | Context |
| **Construction Phase** | | | | | | | | | | | | | |
| Habitat Suitability – Mine Site, Halfway Creek | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures. | Erosion and Sediment Control Plan<br>Water Management Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Habitat Suitability - NAR | Upgrade of existing road sections, and constructions of new road sections along the NAR including barge landings | Project Design (incorporation of fish habitat features)<br>Erosion and Sediment Control Plan<br>Access Route Construction Plan<br>DFO Timing Windows | A | N | S | L | C | LT | P | L | NS | H | H |
| **Operations Phase** | | | | | | | | | | | | | |
| Habitat Suitability – Mine Site, Halfway Creek | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures. | Erosion and Sediment Control Plan<br>Water Management Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Contaminant Toxicity | Operation of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructures | Water Management Plan<br>Erosion and Sediment Control Plan<br>Water Quality Guidelines | A | L | S | L | F | L | P | L | NS | H | H |
| Stream Productivity | Operation of open pits, WRSFs, stockpiles, HLFs, sediment ponds and water management infrastructure. | Water Management Plan<br>Erosion and Sediment Control Plan<br>Water Quality Guidelines | A | M | L | L | F | L | P | L | NS | M | H |

| Potential Residual Effects | Contributing Project Activities | Proposed Mitigation Measures | Residual Effects Characterization (see Notes for details) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction | Magnitude | Geographic Extent | Timing | Frequency | Durations | Reversibility | Probability of Occurrence | Significance | Level of Confidence | Context |
| **Reclamation and Closure Phase** | | | | | | | | | | | | | |
| Contaminant Toxicity | Reclamation and Closure of open pits, WRSFs, stockpiles, HLF, sediment ponds and water management infrastructure. | Reclamation and Closure Plan<br>Water Management Plan<br>Erosion and Sediment Control Plan<br>Water Quality Guidelines | A | L | S | L | F | L | P | L | NS | H | H |
| **Post-closure Phase** | | | | | | | | | | | | | |
| Habitat Suitability – Mine Site, Halfway Creek | Site closed - long-term monitoring | Reclamation and Closure Plan | P | L - H | L | L | C | L - P | P | L | NS | M | H |
| Contaminant Toxicity | Site closed - long-term monitoring | Water Quality Guidelines<br>Reclamation and Closure Plan | A | L | S | L | F | L | P | L | NS | H | H |
| Stream Productivity | Site closed - long-term monitoring | Water Quality Guidelines<br>Reclamation and Closure Plan | A | M | L | L | F | L | P | L | NS | M | H |

**Notes:**

| | |
|---|---|
| Direction | A = Adverse, P = Positive |
| Magnitude: | N = Negligible, L = Low, M = Moderate, H = High. P = Positive |
| Geographic Extent: | S = Site specific, L = local, R = regional |
| Timing: | L = Less-sensitive timing, S = Sensitive timing, |
| Frequency: | I = Infrequent, F = Frequent, C = Continuous |
| Duration: | S = Short-term, L = Long-term, P = Permanent |
| Reversibility: | F = Fully Reversible, P = Partially Reversible, I = Irreversible |
| Probability of Occurrence: | U = Unlikely, L = Likely |
| Significance: | NS = Not-Significant, S = Significant |
| Level of confidence | L = Low, M = Moderate, H = High |
| Context | L = Low, M = Moderate, H = High |

#### 4.5.3 CHUM SALMON

Chum salmon are limited to the Yukon and Stewart rivers in the LAA and, as such, there are few residual effects that were assessed (**Table 4.5-3**). There are no anticipated residual effects to Chum Salmon habitat suitability from flow changes downstream of the mine site as they are not present in the Latte, Halfway or YT-24 creeks.

Habitat alteration during the construction stage along NAR is limited to small portions of marginal habitat along the Yukon and Stewart rivers where the project is encroaching on the river (barge landings and side channel encroachment). The limited amount of area affected and the limited quality of habitat is not anticipated to limit Chum Salmon in the LAA and was assessed as not significant.

Chum Salmon have not been documented in the vicinity of the NAR crossings where fish passage will be restored; therefore, effects will be neutral to their habitat accessibility.

There are no predicted residual effects associated with contaminant toxicity or stream productivity to Chum Salmon because they are not present in YT-24.

#### 4.5.4 SUMMARY

Based on the determination of 'not significant' for all adverse residual effects listed in **Table 4.5-1 to Table 4.5-3,** it is concluded that there is no potential for a significant adverse residual effect(s) on Fish and Fish Habitat. Though there will be Project-related alterations to Fish and Fish Habitat, none of these changes will result in measurable adverse effects to Arctic Grayling, Chinook Salmon or Chum Salmon. There will be a Residual adverse effects are carried forward into the cumulative effects assessment (**Section 5.0**). The assessment also determined that upgrading crossing structures along the NAR to the project design standards will have a positive effect on the accessibility of fish habitat in the LAA at three streams; this was considered a significant effect.

**Table 4.5-3 Summary of Potential Residual Effects for Chum Salmon**

| Potential Residual Effects | Contributing Project Activities | Proposed Mitigation Measures | Residual Effects Characterization (see Notes for details) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction | Magnitude | Geographic Extent | Timing | Frequency | Durations | Reversibility | Probability of Occurrence | Significance | Level of Confidence | Context |
| **Construction Phase** | | | | | | | | | | | | | |
| Habitat Suitability - NAR | Construction of barge landings and road along back channel of Stewart River. | Project Design (incorporation of fish habitat features)<br>Erosion and Sediment Control Plan<br>Access Route Construction Plan<br>DFO Timing Windows | A | N | S | L | C | LT | P | L | NS | H | H |
| **Operations Phase** | | | | | | | | | | | | | |
| None | | | | | | | | | | | | | |
| **Closure and Reclamation Phase** | | | | | | | | | | | | | |
| None | | | | | | | | | | | | | |
| **Post-closure Phase** | | | | | | | | | | | | | |
| None | | | | | | | | | | | | | |

**Notes:**

| | |
|---|---|
| Direction | A = Adverse, P = Positive |
| Magnitude: | N = Negligible, L = Low, M = Moderate, H = High. P = Positive |
| Geographic Extent: | S = Site specific, L = local, R = regional |
| Timing: | L = Less-sensitive timing, S = Sensitive timing, |
| Frequency: | I = Infrequent, F = Frequent, C = Continuous |
| Duration: | S = Short-term, L = Long-term, P = Permanent |
| Reversibility: | F = Fully Reversible, P = Partially Reversible, I = Irreversible |
| Probability of Occurrence: | U = Unlikely, L = Likely |
| Significance: | NS = Not-Significant, S = Significant |
| Level of confidence | L = Low, M = Moderate, H = High |
| Context | L = Low, M = Moderate, H = High |

# 5.0 ASSESSMENT OF CUMULATIVE EFFECTS

This section provides a preliminary assessment of potential cumulative effects to the Fish and Fish Habitat VC and the three fish species that comprise the sub-components. It assesses the residual project effects (**Section 4.4)** with the incremental effects of foreseeable activities. There are seven general categories of developments being considered in the Project's cumulative effects assessment:

- Quartz mining project
- Placer projects
- Transportation projects
- Forestry projects
- Agricultural projects
- Industrial projects
- Wildlife projects (e.g., trapping concessions).

## 5.1 PROJECT-RELATED RESIDUAL EFFECTS

The majority of potential Project interactions with Fish and Fish Habitat are related to changes in water quality, water quantity, changes to habitat and access to habitat. The interactions that could not be fully mitigated and are therefore expected to have a residual effect are summarized in **Table 5.1-1**. These effects included changes in water quality as a result of increased nutrient enrichment and trace metal enriched discharge, changes in surface water hydrology in streams of the LAA, and changes to habitat and access to habitat as a result of stream crossings.

**Table 5.1-1 Project-Related Residual Effects Considered in the Cumulative Effects Assessment for Fish and Fish Habitat**

| Project-related Residual Effect | Included in Cumulative Effects Assessment | Rationale |
|---|---|---|
| Changes in Habitat Suitability due to construction of barge landings, road construction along the edge of a Stewart River back channel and installation of embedded culverts at 3 fish bearing streams along the NAR. | Yes | Combined changes in habitat suitability could have an adverse cumulative effect on Fish and Fish Habitat |
| Improvement of Habitat Accessibility at three stream crossings along the NAR | No | Effects of this project are predicted to be positive |
| Changes in Contaminant Toxicity in Latte, Halfway and YT-24 creeks | Yes | Combined changes in contaminant toxicity could have an adverse cumulative effect on Fish and Fish Habitat |
| Changes in Stream Productivity in Halfway Creek | Yes | Combined changes in stream productivity could have an adverse cumulative effect on Fish and Fish Habitat |

## 5.2 Spatial and Temporal Scope of the Cumulative Effects Assessment

The spatial boundaries for the cumulative effects assessment (CEA) is the same as the RAA boundary (refer to **Section 1.3**). The temporal boundary used for the assessment of Fish and Fish Habitat include the full life-of-mine time span extending to the Post-Closure stage of the project, as this includes the all project activities which could affect Fish and Fish Habitat.

## 5.3 Other Projects and Activities

Other relevant projects and activities within the spatial and temporal scope of the CEA that may result in residual adverse effects to Fish and Fish Habitat that could interact with the Project-related residual effects are identified in **Table 5.3-1**. An overview description of each of these projects and activities is provided, along with relevant potential residual effects on Fish and Fish Habitat. Relevant projects and land use activities were selected from the Project and Activity Inclusion List in the Project Proposal (**Volume I, Section 5.4.2**). Based on this information, the other types of projects or activities that could have a cumulative effect on Fish and Fish Habitat include:

- Quartz mining projects
- Placer projects
- Transportation projects
- Forestry projects
- Agricultural projects
- Industrial projects, and
- Wildlife projects (e.g., trapping concessions).

The following definitions were used to classify the status of projects and activities that could interact with the Project:

- Past — projects and land use activities that occurred in the past and are no longer active
- Present — existing and active projects and land use activities; all projects or land use activities that applied for approval or permitting prior to 2015 are assumed to be present projects or land use activities
- Future — reasonably foreseeable future projects or land use activities for which proposals have been submitted to YESAA (subsection 50(1)), or have entered into a formal approval or permitting process; applications submitted in 2015 and 2016 are assumed to be future projects or land use activities

**Table 5.3-1 Potential Residual Adverse Effects of Other Project and Activities on Fish and Fish Habitat**

| Other Project / Activity | Status | Description | Potential Residual Effects |
|---|---|---|---|
| **Project Name** | | | |
| Casino Project | Future | Water quality in the Coffee Creek watershed. | Lease boundary extends into the Coffee Creek watershed; however, proposed project footprint does not. No effect on water quality to Coffee Creek based on current Casino project development plans. |
| Casino Project | Future | Effects of the Casino project on the lower portion of Britannia Creek could affect Arctic Grayling and juvenile Chinook Salmon habitat for Yukon River populations that use tributary streams. | Localized changes in habitat suitability |
| **Activity Name** | | | |
| Quartz Mining Projects | Present and Future | There are numerous existing quartz mining projects in the RAA, particularly in the vicinity of the NAR and mine site LAA. These locations are also under existing Yukon Quartz Claims. | Localized changes in habitat suitability and water quality (contaminant toxicity and stream productivity) |
| Placer Mining Projects | Past, Present and Future | Placer development along the Northern Access Route has had an effect on fish habitat and fish access to tributary streams. Numerous claims exist in in the RAA, and the NAR could improve access, and increase the likelihood of development of these claims.<br>Upgrade of the NAR will make access easier and could lead to an expansion of placer mining activity. Conversely, upgrading the NAR will provide an opportunity to rectify poorly designed crossings that are creating barriers to fish movements. | Localized changes in habitat suitability and water quality (contaminant toxicity and stream productivity) |
| Transportation Projects | Present | The majority of transportation projects are associated with the Klondike Highway corridor that is located along the northern boundary of the Fish and Fish Habitat RAA. These projects would not have an effect on the fish populations that could be directly affected by the Project. Therefore, there would be no negative residual cumulative effect on the Fish and Fish Habitat subcomponents. | No Effect |

| Other Project / Activity | Status | Description | Potential Residual Effects |
|---|---|---|---|
| Forestry Projects | Present | The majority of forestry projects are associated with the Klondike Highway corridor that is located along the northern boundary of the Fish and Fish Habitat RAA. These projects would not have an effect on the fish populations that could be directly affected by the Project. Therefore, there would be no negative residual cumulative effect on the Fish and Fish Habitat subcomponents. | No Effect |
| Agricultural Projects | Present | The majority of agricultural projects are associated with the Klondike Highway corridor that is located along the northern boundary of the Fish and Fish Habitat RAA. These projects would not have an effect on the fish populations that could be directly affected by the Project. Therefore, there would be no negative residual cumulative effect on the Fish and Fish Habitat subcomponents. | No Effect |
| Industrial Projects | Present | The majority of industrial projects are associated with the Klondike Highway corridor that is located along the northern boundary of the Fish and Fish Habitat RAA. These projects would not have an effect on the fish populations that could be directly affected by the Project. Therefore, there would be no negative residual cumulative effect on the Fish and Fish Habitat subcomponents. | No Effect |
| Wildlife Projects | Present and Future | Trappers do not conduct activities that result in notable effects to fish or fish habitat. | No Effect |

### 5.4 POTENTIAL CUMULATIVE INTERACTIONS

This section will discuss the potential project related residual effects combined with those of other projects (**Table 5.3-1**). The potential adverse cumulative effects resulting from these interactions are also described. For each identified interaction, the potential residual cumulative effects were assessed using the same process described for the assessment of Project-related residual effects (see **Section 4.4.1**), including consideration of potential mitigation measures and characterization of residual effects. The results of this assessment are summarized in **Table 5.4-1**. All potential cumulative effects on Fish and Fish Habitat were carried forward for assessment. If an interaction resulted in no cumulative effect or a negligible cumulative effect, it was not carried forward for assessment beyond **Table 5.4-1**.

**Table 5.4-1 Potential Cumulative Effects on Fish and Fish Habitat due to Interactions between the Project and Other Project and Activities**

| Other Project / Activity | Potential Residual Adverse Effect | Potential for Interaction Resulting in Cumulative Effect (see Note) and Rationale |
|---|---|---|
| **Project Name** | | |
| Casino Project | Localized changes in habitat suitability | No – Changes to fish habitat occur in other watersheds that are not associated with the Coffee Gold Project. Habitat compensation is also proposed. |
| **Activity Name** | | |
| Quartz Projects | Localized changes in habitat suitability from flow changes | No – Other quartz mining projects in the RAA will not affect the streams that will experience changes in flows as a result of the Project; therefore, there will be no cumulative effect on stream flows. |
| Quartz Projects | Changes in concentrations of potential contaminants including trace elements (metals) and nutrient parameters including phosphorus and nitrogen (contaminant toxicity and stream productivity) | No – The other quartz mining projects in the RAA will not affect the streams that will receive Project discharges; therefore, there will be no cumulative effect on water quality. |
| Quartz and Placer Projects | Localized changes in habitat suitability from habitat alteration associated with mining projects on streams associated with the NAR | Yes – Habitat alteration associated with other past, present and future projects could affect similar streams and fish populations that are affected by the NAR. |
| Placer Projects | Changes in concentrations of potential contaminants including trace elements (metals) and nutrient parameters including phosphorus and nitrogen | No – The other quartz mining and placer mining projects in the RAA will not affect the streams that will receive Project discharges; therefore, there will be no cumulative effect on water quality. |

**Note:** **No**: no interaction or not likely to interact cumulatively; **Yes**: potential for cumulative effect.

### 5.5 Mitigation Measures for Cumulative Effects

**Section 4.4.3** outlines general Project mitigations, many of these will help mitigate cumulative effects on Fish and Fish Habitat. There are no additional Project specific mitigation actions that the Proponent can implement to manage cumulative effects.

### 5.6 Residual Cumulative Effects and Significance of Residual Cumulative Effects

This section describes the nature of the residual cumulative effects identified with respect to the overall Fish and Fish Habitat VC, including an assessment of significance, at the regional level (i.e., RAA) arising from potential interactions identified in **Table 5.4-1**. For the purpose of the CEA, habitat for all subcomponents was evaluated together. The cumulative effects of the project on fish and habitat have been evaluated together, rather than by subcomponent, as this would provide a more holistic and conservative approach. After the application of the mitigation measures described above, residual cumulative effects to habitat suitability are expected to occur for Fish and Fish Habitat subcomponents.

### 5.6.1 HABITAT SUITABILITY ASSESSMENT

Improper road construction and mining practiced during placer or quartz mining operations (hereafter referred to collectively as “mining”) can have a detrimental effect on fish habitat. Improperly designed stream crossings can restrict access to habitat. Increased sediment loading (TSS) from roads and mining areas can have a number of effects on Fish and Fish Habitat, ranging from sub-lethal population effects (e.g. avoiding areas of high TSS) to direct mortalities (Newcombe and Jensen 1996). Some of these negative effects on Fish and Fish Habitat were documented (having occurred or occurring) during the NAR stream crossing assessments (PECG 2016).

The upgrade of the road will alter small amounts of habitat along the NAR (**Section 4.2.1.2**); however, the upgrade will also bring the road up to higher level of engineering standards. This will include the proper stream crossing selection, installation and erosion control around stream crossings and adjacent areas as outlined by the Access Route Construction Management Plan (**Appendix 31-A**). As such the road will actually reduce some of the effects from past projects on Fish and Fish Habitat. In addition, the road will also improve fish accessibility at three fish bearing streams (Sulphur, Eureka and a tributary to Barker Creek). Overall the upgrading of the NAR is expected to have a positive effect on addressing Fish and Fish Habitat effects.

An improved access route may encourage additional mining activity along the NAR. With additional mining, there is an increased potential of cumulative effects occurring on streams along the NAR. New quartz activities are subject to regulatory reviews and approvals (YESAA, Water Board and DFO). New placer operations are subject to YESAA review and approval as per the project thresholds outlined in the *Assessable Activities, Exceptions, and Executive Committee Projects Regulation* (SOR/2005-379). For projects that would affect anadromous fish and their habitat, project reviews and approval by Fisheries and Oceans Canada would also be required. To obtain a project approval, the project proponent will need to demonstrate that project related activities meet current guidelines (e.g., Government of Yukon 2011) and have implementation the hierarchy of controls to mitigate significant environmental effects (i.e., redesign, relocate, mitigate, and offset). Therefore, the likelihood of a cumulative negative effect occurring from future development of placer mining as a result of improvements to access is low. Furthermore, if the effects occur, they are at least partial reversible with appropriate rehabilitation and reclamation at the end of the projects (i.e., seeding areas to prevent erosion, deactivating stream crossings).

As noted previously, the improvements associated with upgrading the existing sections of the Northern Access Route to the project design standards, represent the opportunity to rectify some of the poor practices from previous mining activity in the RAA and bring many of the existing stream crossings up to current crossing requirements. This will improve fish access to tributary streams and reduce sediment run-off into streams and create a positive effect on regional Fish and Fish Habitat. Furthermore, a large portion of the NAR is temporary and approximately 37 km will be deactivated during the Reclamation and Closure phase of the Project and the stream crossings removed.

The potential cumulative effects on Fish and Fish Habitat are low in magnitude and partially reversible (**Table 5.6-1**). In addition, the upgrades to the existing portions of the NAR corridor have the potential to reverse effects of poorly designed and installed watercourse crossing structures. Therefore, the cumulative effect to Fish and Fish Habitat subcomponents due to changes in habitat suitability is assessed as not significant.

**Table 5.6-1 Cumulative Effect Characteristics Ratings for Habitat Suitability**

| Residual Effects Characteristic | Rating | Rationale for Rating |
|---|---|---|
| Magnitude | Low | Streams directly affected by the Project at the mine are not likely to experience other mining activity during the operational stages of the mine. The streams crossed by the NAR could be affected, but have or would require regulatory approval. |
| Geographic Extent | Regional | Placer and quartz mining in other watersheds could affect other populations of VC sub-components within the RAA. |
| Timing | Seasonal | Most placer/quartz/road building activity only occurs under unfrozen conditions. |
| Frequency | Infrequent to Frequent | Many variables factor into the development of a mining project. New projects will likely be developed in response to exploration results, market prices, etc. |
| Duration | Long-term | Direct loss of habitat would be long-term. |
| Reversibility | Partially reversible | Habitat loss could be partially reversed with appropriate restoration/rehabilitation at end of mine life. |
| Probability of Occurrence | Likely | Future mining projects are currently being planned. |
| Context | Moderate | Ability of fish to adapt to habitat loss will vary as some species are more resilient to disturbance than others. |

## 5.7 SUMMARY OF RESIDUAL CUMULATIVE EFFECTS AND SIGNIFICANCE OF CUMULATIVE EFFECTS ON FISH AND FISH HABITAT

There are few Project components that will likely have a cumulative effect on Fish and Fish Habitat with other activities currently under way in the Fish and Fish Habitat RAA or likely to occur before the Project reaches the Post-Closure stage. The upgrades to the NAR have the greatest likelihood to resulting in a cumulative effect on fish habitat. Most road-related effects to fish habitat can be readily mitigated with known technology and BMPs. The adoption of existing Yukon guidelines for working around water and the standards proposed by the Project to other resources road and trail development would mitigate cumulative effects of increasing road construction in the RAA and along the road corridor. Therefore, there residual cumulative effects associated with Fish and Fish Habitat in the RAA are reversible (**Table** 5.7-1).

**Table 5.7-1 Summary of Potential Residual Effects for Fish and Fish Habitat**

| Potential Residual Effects | Other Projects / Activities | Proposed Mitigation Measures | Residual Effects Characterization (see Notes for details) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direction | Magnitude | Geographic Extent | Timing | Frequency | Durations | Reversibility | Probability of Occurrence | Significance | Level of Confidence | Context |
| Localized changes in habitat accessibility and water quality/quantity | Placer and Quartz Mining | Existing regulatory project review process.<br>Use appropriate stream crossings on fish streams and BMPs when working around water. | N | M | R | S | F | L | F | U | NS | M | H |

**Notes:**

| | |
|---|---|
| Direction | A = Adverse, P = Positive |
| Magnitude: | N = Negligible, L = Low, M = Moderate, H = High. P = Positive |
| Geographic Extent: | S = Site specific, L = local, R = regional |
| Timing: | L = Less-sensitive timing, S = Sensitive timing, |
| Frequency: | I = Infrequent, F = Frequent, C = Continuous |
| Duration: | S = Short-term, L = Long-term, P = Permanent |
| Reversibility: | F = Fully Reversible, P = Partially Reversible, I = Irreversible |
| Probability of Occurrence: | U = Unlikely, L = Likely |
| Significance: | NS = Not-Significant, S = Significant |
| Level of confidence | L = Low, M = Moderate, H = High |
| Context | L = Low, M = Moderate, H = High |

# 6.0 SUMMARY OF EFFECTS ASSESSMENT ON FISH AND FISH HABITAT

Fish and Fish Habitat were selected as a Valued Component (VC) for social, biological, and environmental assessment best practice procedures. Fish and Fish Habitat is of significant importance to the local First Nations and other local Yukon residents. Fish are important because of their value to local people as a subsistence, traditional, and recreational resource, and, in the case of the Chinook and Chum Salmon, are important for their commercial value.

Arctic Grayling, Chinook Salmon and Chum Salmon occur in the LAA and are of traditional and cultural importance. Arctic Grayling are found in Latte, Coffee, and Halfway creeks downstream of the Mine Site footprint and in a number of the watercourses that are intersected by the NAR, including the Yukon, Stewart and Indian rivers as well as Sulphur, Maisy May, Barker, and Ballarat creeks. Juvenile Chinook Salmon are found in Coffee and lower Halfway creeks downstream of the Mine footprint and a few water courses that are interested by the NAR including the Yukon and Stewart rivers and Maisy May and Ballarat creeks. Adult Chinook and Chum Salmon use the Yukon and Stewart rivers for migration and Chum also spawn in the Yukon River (ground water fed side channels) in the LAA. All these species rely on the health and integrity of their environment for their life requisites. The environmental components important to the health of fish species include sufficient physical habitat, surface water flow (hydrology), surface water and sediment quality, and the presence of abundant benthic invertebrate and phytoplankton populations that provide food sources for the fish species.

There are a number of Project activities during all Project phases that will interact with Fish and Fish Habitat. These include construction, operation and maintenance of the NAR, as well as construction and operation of the open pits, WRSFs, HLF, and other mine infrastructure. Project activities can affect Fish and Fish Habitat in a number of ways including changes to habitat suitability (via changes in surface water hydrology or habitat encroachment), changes to accessibility of fish habitat, changes in water quality leading to changes to contaminant toxicity, fluctuations in stream productivity including the abundance and diversity of plankton and benthic invertebrates, and fish mortality.

A number of mitigation measures to alleviate Project interactions with Fish and Fish Habitat were selected based on a review of mitigation measures and follow-up programs undertaken for similar past projects and through input by regulators. The resulting mitigations included Project design measures (e.g. Infrastructure location, road and barge landing design), water management, when working around water, as described in the various management plans for the project (including the Access Route Construction Management Plan, the Access Route Operational Plan, the Erosion and Sediment Control Plan, the Water Management Plan and the Conceptual Reclamation and Closure Plan). Any Project interactions that could not be fully mitigated were further assessed for residual effects to Fish and Fish Habitat.

The assessment of changes to fish habitat suitability indicated that while the Project will affect the surface water hydrology in the Mine LAA, the frequency of high flows events is not expected to be reduced below the level required to maintain channel flushing and forming processes. Downstream of the Mine Site, the residual adverse effects on habitat suitability that are predicted are low magnitude reductions in fish habitat at low flows on Latte Creek, and low to high increases in fish habitat in Halfway and YT-24 creeks (resulting in a predominantly positive effect). The measureable residual effects will be focused in small, headwater streams that provide seasonal rearing habitat for Arctic Grayling and juvenile Chinook Salmon (Halfway Creek only) and no sensitive spawning or overwintering habitats. Therefore, the residual effects of the mine site on habitat suitability are not expected to result in any permanent adverse effects on the suitability of habitat for fish to carry out their life processes, and so are deemed not significant.

Habitat alteration during the construction stage along NAR is limited to small portions of marginal habitat along the Stewart and Yukon rivers (barge landings and road alignment) and tributary streams where embedded culverts will be installed. The limited amount of area affected and the limited quality of habitat is not anticipated to limit Fish and Fish Habitat in the LAA and was assessed as not significant.

The assessment of the accessibility of fish habitat indicated that replacement and upgrading the crossing structures to Project design standards will result in a positive effect on the accessibility of fish habitat in the LAA. The upgrades will improve fish habitat accessibility at three of the stream crossings along the NAR where existing undersized culverts are being replaced with culverts or bridge structures that will permit fish passage. Application of the design standards to the other fish stream crossings will significantly reduce the risk that fish barriers will develop during the operational life of the NAR.

The assessment of contaminant toxicity to Fish and Fish Habitat revealed that anticipated changes to surface water quality associated with Project activities will result in some increases in concentrations of a number of CoPCs. However, concentrations are generally projected to remain below GWQGs, below concentrations known to provoke a toxic response, or anticipated changes to water quality will occur in areas with no overwintering habitat during the under ice season, limiting exposure. Residual effects to Fish and Fish Habitat associated with contaminant toxicity are limited to Latte, Halfway and YT-24 creeks where water quality will change the most from baseline conditions. However, given the limited, seasonal fish use these watersheds, this residual effect is deemed not significant.

Projected changes to stream productivity associated with nutrient enrichment are considered minor, and there are no predicted significant effects to Fish and Fish Habitat with respect to changes in stream productivity. However, continued monitoring of water quality, with a particular emphasis on water temperature, dissolved oxygen and nutrient parameters including total phosphorus, ammonia, nitrate and nitrite, as well as the abundance and diversity of periphyton, benthic invertebrate and fish communities in the LAA will detect any unanticipated adverse effects with respect to changes in stream productivity.

There are no predicted residual effects to fish mortality following the application of all appropriate mitigation measures.

Few Project components are anticipated to combine with other existing or planned activities in the RAA such that there are negative effects to Fish and Fish Habitat. Upgrades to the NAR and associated future development have the greatest likelihood of resulting in cumulative effects to Fish and Fish Habitat; however, all such developments will require regulatory screening and approval.

All of the above predictions regarding Project related effects to Fish and Fish Habitat will be continually tested and validated throughout all Project phases as part of the effects monitoring and adaptive management.

# 7.0 EFFECTS MONITORING AND ADAPTIVE MANAGEMENT

## 7.1 EFFECTS MONITORING PRINCIPLES

Effects of the Project will be minimized by mitigation measures described in **Section 4.3.** However, monitoring programs provide a means to gain certainty in predicted Project-related effects and determine the effectiveness of mitigation measures where uncertainty exists in Project-related effects due to limited data or where the effectiveness of proposed mitigation measures is uncertain. Specifically, the goal of the monitoring programs is to:

- Monitor and verify potential Project-related effects
- Ensure monitoring efforts are able to detect natural and Project-related changes to the environment
- Monitor and evaluate the effectiveness of mitigation measures
- Identify unanticipated effects
- Provide an early warning of undesirable change in the environment, and
- Inform adaptive management measures.

The monitoring and adaptive management approach will be fully described in the Fish and Aquatic Habitat Management Plan (currently under development for project licensing). The monitoring program will outline how fish and aquatic biota will be monitored during all phases of the Project and how this information will be used to confirm the predictions of the environmental assessment or detect unanticipated effects. Where relevant, the monitoring program will also meet the requirements of Environment Canada's Metal Mining Effluent Regulations (MMER; Environment Canada 2012b), and associated Environmental Effects Monitoring.

## 7.2 EFFECTS MONITORING AND ADAPTIVE MANAGEMENT

The objective of the monitoring components outlined in the in the Fish and Aquatic Habitat Management Plan will be to assess the effects of Project on Fish and Fish Habitat in exposure areas within the Mine LAA. Fish distribution, habitat usage and abundance data will be collected from streams downstream of the Mine site and compared to baseline data and reference sites to determine if there are any effects on Fish and Fish Habitat as a result of the Project. Additional fish habitat data (benthic invertebrate, sediment, aquatic primary productivity, physical habitat and water quality data) will be used to support the data on fish; and as such, could be used explain/understand any why changes to fish are occurring.

There will be a number of predetermined thresholds and responses outlined in the Fish and Aquatic Habitat Management Plan; adaptive management will be implemented should any of these thresholds be met. If any unanticipated effects are detected additional adaptive responses will be developed in coloration/consultation with relevant agencies and First Nations.

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### 8.1 PERSONAL COMMUNICATIONS

Rivest, G. 2016. Biological Technician, EDI Environmental Dynamics Inc. Email sent, June 17, 2016.

Interview 14, February 10, 2016. Anonymous Contributor. Trapline Concession Holder, Socio-ec Interview.