Figure 6.5-2
Phase 2 Infrastructure Footprint and Waterbodies with Potential Fish Habitat Loss or Alteration, South Belt

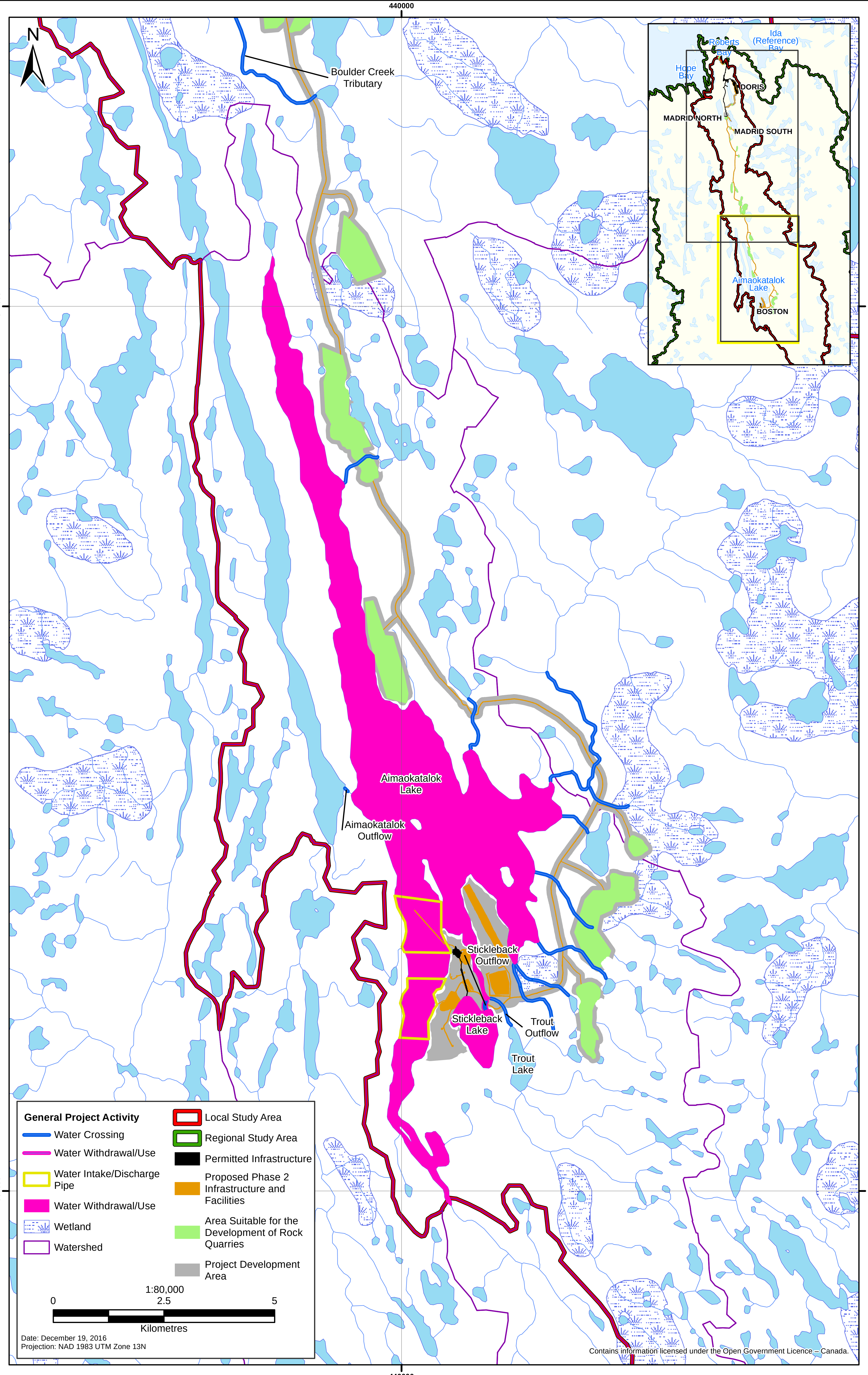


Table 6.5-4. Locations and Fish-Bearing Status for Potential Water Crossings by Phase 2 All-Weather Roads

Access Road	Crossing ID	UTM Easting	UTM Northing	Watershed	Waterbody Name	Fish-bearing Status*	Confirmed or Predicted Stream Fish Species**
Roberts Bay Cargo Dock Access Road	C-CDR-01	432108	7562941	2 - Roberts Bay	Roberts Bay Inflow	Assumed fish-bearing	Unknown
Roberts Bay Cargo Dock Access Road	C-CDR-02	431627	7563806	Windy	Glenn Outflow	Fish-bearing	LKTR, ARCH, SLSC, NSSB, STFL
Madrid North to Doris TIA AWR	N/A	433622	7552784	Doris	Patch Inflow	Assumed fish-bearing	NSSB
Madrid North to Doris TIA AWR	N/A	434781	7553327	Doris	Doris Inflow	Fish-bearing	NSSB
Madrid North to Doris TIA AWR	N/A	435039	7553604	Doris	Doris Inflow	Likely non-fish-bearing	-
Madrid North to Doris TIA AWR	N/A	435094	7555505	Doris	Ogama Outflow	Fish-bearing	LKTR, LKWH, CISC, NSSB
Madrid South AWR	N/A	434760	7547111	Doris	Wolverine Outflow	Assumed fish-bearing	NSSB
Boston-Madrid AWR	C-MBR-7	434964	7531135	Koignuk/Aimaokatalok	Boulder Creek	Fish-bearing	ARGR
Boston-Madrid AWR	C-MBR-8	437979	7524706	Koignuk/Aimaokatalok	Boulder Creek Tributary	Fish-bearing	ARGR
Boston-Madrid AWR	C-MBR-9	439158	7516576	Aimaokatalok	Aimaokatalok Inflow	Assumed fish-bearing	Unknown
Boston-Madrid AWR	C-MBR-10	439433	7515859	Aimaokatalok	Aimaokatalok Inflow	Likely non-fish-bearing	-
Boston-Madrid AWR	C-MBR-11	441626	7510781	Aimaokatalok	Aimaokatalok Inflow	Fish-bearing	NSSB, ARGR
Boston-Madrid AWR	C-MBR-12	444365	7509635	Aimaokatalok	Aimaokatalok Inflow	Fish-bearing	NSSB, ARGR
Boston-Madrid AWR	C-MBR-13	444444	7508833	Aimaokatalok	Aimaokatalok Inflow	Assumed fish-bearing	NSSB, ARGR
Boston-Madrid AWR	C-MBR-14	444109	7508180	Aimaokatalok	Aimaokatalok Inflow	Assumed fish-bearing	NSSB, ARGR
Boston-Madrid AWR	C-MBR-15	443420	7507037	Aimaokatalok	Aimaokatalok Inflow	Fish-bearing	NSSB, ARGR
Boston-Madrid AWR	C-MBR-16	443649	7505485	Aimaokatalok	Aimaokatalok Inflow	Fish-bearing	NSSB, ARGR
Boston-Madrid AWR	C-MBR-17	443490	7504607	Aimaokatalok	Aimaokatalok Inflow	Assumed fish-bearing	NSSB, ARGR
Boston-Madrid AWR	C-MBR-18	442718	7504389	Aimaokatalok	Aimaokatalok Inflow	Assumed fish-bearing	Unknown
Boston-Madrid AWR	C-MBR-19	442298	7504222	Aimaokatalok	Trout Outflow	Fish-bearing	LKTR, ARGR, BURB,

Access Road	Crossing ID	UTM Easting	UTM Northing	Watershed	Waterbody Name	Fish-bearing Status*	Confirmed or Predicted Stream Fish Species**
Boston-Madrid AWR	C-MBR-20	441941	7504209	Aimaokatalok	Stickleback Outflow	Fish-bearing	SLSC, NSSB NSSB, SLSC, ARGR

**Status to be confirmed prior to construction*
***Predicted species bolded; based on habitat characterization and/or confirmed species presence in upstream or downstream waterbodies, additional species may be present*
N/A = Crossing ID not assigned

The installation of the Aimaokatalok Lake water intake and discharge pipes during the Construction Phase will result in a loss of fish habitat (PAD) in the areas under the intake and discharge pipe, and in any part of the in-water construction zone where lake substrates are altered due to the placement of structures (i.e., screens, pipes, ballasts) and materials (i.e., rip rap or other armouring). Final siting and design of the intake and the discharge pipe in Aimaokatalok Lake will define pipe diameters, pipe lengths, type of armouring and ballasting required, and daylighting locations and depths. Fish habitat characteristics will be considered in final design plans and areas where natural substrates provide critical habitat for fish (e.g., spawning shoals or substrates for Lake Trout, Lake Whitefish, Cisco, and/or Least Cisco) will be avoided to the extent possible. Floating water intake pipes will be removed during the Reclamation and Closure Phase with any anchors left in place. Discharge pipelines and any armour rock will be left in place to minimize additional disturbance to lake substrates and fish habitat.

Potential direct effects on fish mortality and population abundance resulting from the design and operation of water intakes and discharge pipes (i.e., screening to avoid entrainment/impingement) are considered under the effects assessment for fish community VECs (section 6.5.5.1)

Winter Road Construction and Use

Use of the established Madrid-Boston winter road route or other short localized winter routes may be required during the Construction Phase to enable efficient construction of the Boston accommodations and the Madrid-Boston AWR. The proposed Phase 2 winter road route is presented on Figure 6.5-3. The proposed route crosses two large lakes (Windy Lake and Aimaokatalok Lake) in addition to several streams and ponds, most of which are tributaries or connected to tributaries of the Koignuk River. The seasonal use of the winter road has the potential to restrict the temporal availability of fish habitat in streams and degrade habitat quality in streams and along the shorelines of lakes and ponds.

The construction and presence of winter roads over streams in the Phase 2 Project footprint is most likely to affect Arctic Grayling, which rely on stream habitat for migration and spawning in the spring, and for juvenile rearing and migration throughout the summer (Stewart et al. 2007) and forage fish species that rely on streams as migratory habitat (Ninespine Stickleback and Slimy Sculpin). For example, improper decommissioning of winter road crossings may result in temporary barriers to fish passage where ice and snow may block access to spawning areas during the spring spawning season, and erosion of stream banks may increase sedimentation, smothering spawning gravels, and increasing suspended sediment loads in the water column (DFO 2007c). Winter roads also have the potential to affect Lake Trout, Lake Whitefish, Cisco, and Least Cisco which rely on rocky habitats and shoals along the shorelines of lakes for spawning. If improperly constructed, winter roads may lead to shoreline erosion, increased suspended sediment, and increased sediment deposition (DFO 2007c). Sediment eroded from shorelines and stream crossings may settle along the rocky shorelines of lakes and ponds, possibly affecting the quality of Lake Trout, Lake Whitefish, Cisco, and Least Cisco spawning habitat (Marcus, Hubert, and Anderson 1984), or the spawning habitats of forage fish species (e.g. Slimy Sculpin).

Increased erosion and suspended sediments may also reduce water quality in streams and ponds, and could potentially result in an *indirect* effect on fish habitat through water quality and/or sediment quality effects on primary and secondary producers (biological resources; (DFO 2007c). The assessment of Project effects on Freshwater Water Quality and Freshwater Sediment Quality are completed individually in Volume 5, Sections 4 and 5, and left out of this assessment as outlined in Section 6.3.2 of this chapter.

<u>Mitigation and Management Measures for Specific Potential Effects</u>

The majority of Project infrastructure has been sited to avoid fish-bearing water and, wherever possible, to avoid encroaching on freshwater fish habitat by adhering to a minimum 31 m setback from all water. A 51-m setback has been applied, where possible. The TIA/TMA, waste rock piles, ore stockpiles, and overburden piles have all been sited to avoid fish habitat and have been confined to local watersheds close to the main infrastructure at the Doris and Boston Project areas. The following additional mitigation will be implemented to avoid adverse effects on fish habitat resulting from the design, construction, and use of Phase 2 Project infrastructure including water crossings, water intakes and discharge pipes, and winter roads. Where Project activities overlap with fish-bearing waters and fish habitat loss or alteration is anticipated, mitigation will be applied through fisheries offsetting.

Water Crossings

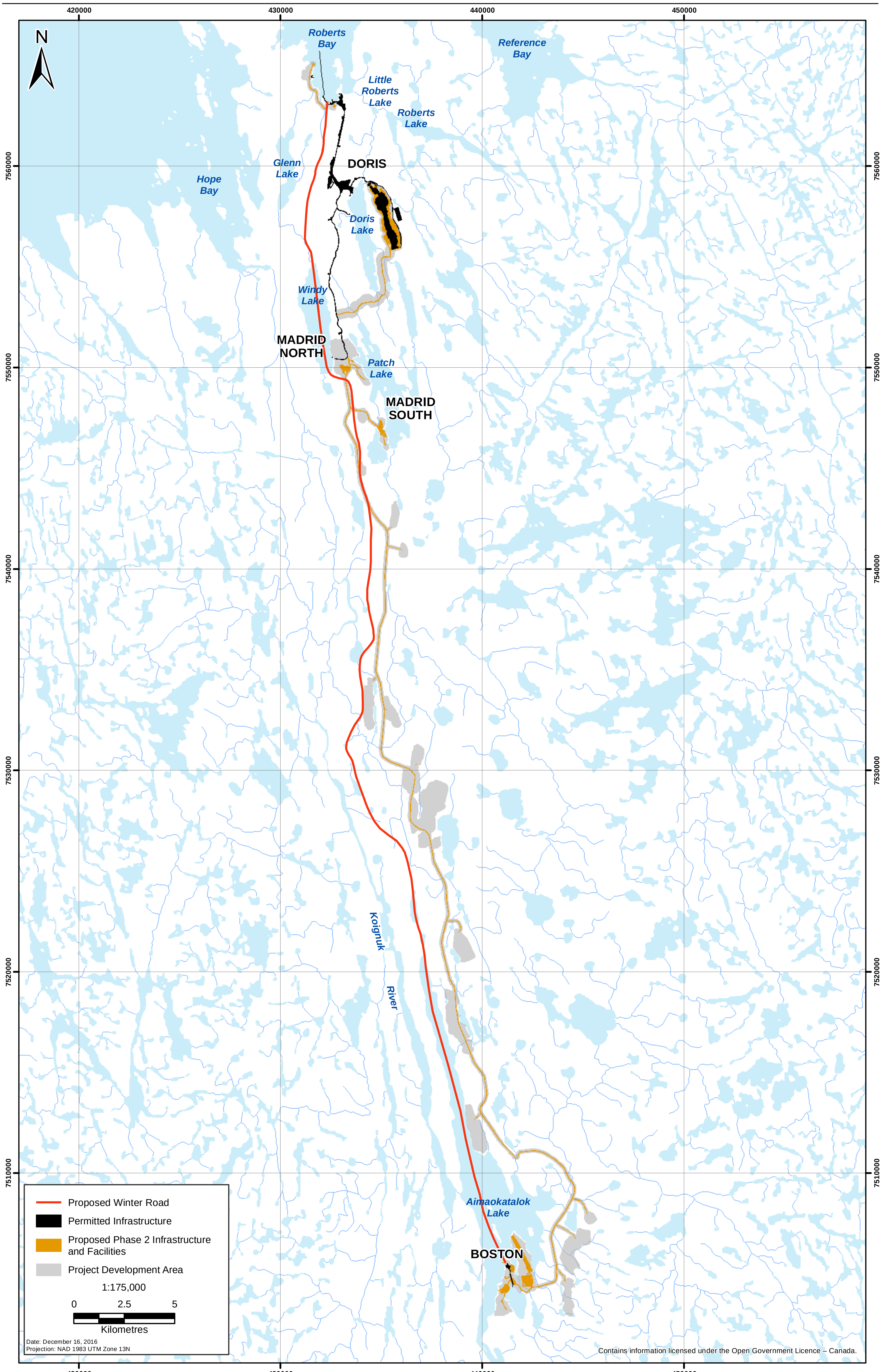
The construction of stream crossings, roads, and berms will follow DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2). Timing of in-water construction activities will conform, when possible, to Nunavut Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat (DFO 2013h). For stream activities, the window is in place from May 1 to July 15 during which in-water activities should be minimized to avoid the spring spawning period for Arctic Grayling. In streams used as migration corridors between marine and freshwater habitats by spawning anadromous Arctic Char, Lake Trout, cisco, and/or whitefish (e.g. Roberts Bay Cargo Dock Access Road crossing at Glenn Outflow), stream activities will also avoid the fall migration window (beginning on August 15 and lasting until freeze-up). Winter construction activities will not be initiated until streams are considered isolated from flows (i.e., frozen to the substrate).

Fish-bearing crossings along the Roberts Bay Cargo Dock Access Road, the Madrid North-TIA AWR, the Madrid South AWR, and the Madrid-Boston AWR will continue to serve as migration corridors between upstream and downstream waterbodies. Bridges will be used or fish-bearing culvert crossings will be designed to maintain fish passage by keeping water velocities and depths within acceptable limits such that they do not present a velocity or depth barrier to migration of species known to be present. In addition, culverts will be embedded in the natural channel and filled material added to promote fish passage and habitat suitability. Bridges crossings will be preferentially constructed to minimize the footprint below the HWM to avoid alteration or destruction of fish-bearing habitats.

Mitigation measures for the maintenance of bridges and culverts at crossing locations will incorporate DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013; section 6.5.3.2) and additional best management practices demonstrated to effectively mitigate the effects of bridge/culvert maintenance (DFO 2007a, 2007b) which include:

- Existing trails or roads will be used for access wherever possible to avoid disturbance to riparian vegetation.
- Removal of vegetation will be kept to a minimum.
- Unless accumulated material (i.e., vegetation, ice build-up, etc.) is preventing the passage of water and/or fish through the structure, material and debris removal will be completed according to the Nunavut Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat (DFO 2013h).
- The removal of accumulated material will be limited to the area within the culvert/bridge, immediately upstream of the culvert/bridge, and to that which is necessary to maintain culvert/bridge function and fish passage.
- Accumulated material and debris will be removed gradually such that flooding downstream, extreme flows downstream, release of suspended sediment, and fish stranding can be avoided.

Figure 6.5-3
Proposed Phase 2 Winter Road



- o If replacement rock reinforcement/armouring is required to stabilize eroding inlets and outlets of culverts or bases of bridge supports, the following measures will be incorporated:
    - Appropriately-sized rocks will be placed into the eroding area.
    - Only clean, non-acid generating rocks will be used.
    - Rocks will not be obtained from below the ordinary high water mark of any waterbody.
    - Rock will be installed at a similar slope to maintain a uniform stream bank and natural stream alignment.
    - Rocks installed will be done so as to not interfere with fish passage or constrict the channel width.

Water Intakes and Discharge Pipes

Mitigation to avoid adverse effects on fish is required to avoid habitat degradation during construction of water intake and discharge pipelines and to offset habitat losses in lakes in the locations of intake and discharge pipelines. Timing of in-water construction activities will conform, when possible, to Nunavut Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat (DFO 2013h). For lake activities, the applicable window is in place from August 15 to June 30 during which in-water activities should be minimized to avoid disturbance of fall spawning fish, (e.g., Lake Trout, Arctic Char, cisco and whitefish) and to avoid the disturbance of their eggs incubating in the substrates over the winter. Mitigation measures that will be applied during the construction of intake and discharge pipelines follow DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2). The design and operation of water intakes and discharge pipes (i.e., screening to avoid entrainment/impingement) are considered under the effects assessment for fish community VECs (section 6.5.5.1).

Winter Road Construction and Use

Mitigation measures for the construction the winter road and of ice bridges and snow fills along the winter road route will incorporate DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2) and additional best management practices demonstrated to effectively mitigate the effects of ice bridges and snow fills on fish habitats (DFO 2007c) which include:

- o Existing trails or winter ice roads will be used wherever possible as access routes to limit unnecessary clearing of additional vegetation and prevent soil compaction.
- o Approaches and crossings will be constructed perpendicular to watercourses wherever possible.
- o Ice bridges and snow fill approaches will be constructed using clean, compacted snow and ice to a sufficient depth to protect the banks of the lake, river or stream.
- o Crossings will not impede water flow at any time of the year.
- o When the crossing season is over and where it is safe to do so, a v-notch will be created in the center of ice bridges to allow them to melt from the center and to prevent blockage of fish passage, channel erosion and flooding. Compacted snow will be removed from snow fills prior to spring freshet.
- o The site will be stabilized using effective sediment and erosion control measures. In areas with permafrost, care will be exercised to ensure these measures do not cause thawing or frost heave.
- o Speed limits during road use will be established to prevent ice scour along shorelines.

Fisheries Offsetting

The purpose of a Fisheries Offsetting Plan (Appendix V5-6V), as per the guiding policies of DFO, is to maintain or improve the productivity of CRA fisheries. The Offsetting Plan will address fish habitat losses related to the encroachment of Phase 2 Project infrastructure, as deemed necessary and approved by DFO. Localized areas of fish-bearing stream habitat loss or permanent alteration will occur in up to 21 streams as a result of the placement of culverts or bridge support structures at road crossings. Habitat losses or permanent alterations will also occur in Aimaokatalok Lake due to the construction or upgrading of water intakes and discharge pipes and associated armouring of these structures.

Unavoidable habitat loss or alteration due to Phase 2 infrastructure will be restricted to the five watersheds within the LSA (Doris Watershed, Windy Watershed, Koignuk/Aimaokatalok sub-Watershed, Aimaokatalok Watershed, and East Watershed). Where possible, final infrastructure designs will consider how to include forms of "self-offsetting", through the consideration of how the placement of material or structures in fish habitat can help to make up (i.e., offset) for the losses or alterations resulting from construction. For example, the final design of the water intake and discharge pipe in Aimaokatalok Lake will consider how the amount, angle, and wetted surface area of armouring rock can replace or enhance existing habitat. Where deemed necessary by the DFO *Fisheries Authorization* process, offsetting for remaining fish habitat losses resulting through the placement of infrastructure will be incorporated into the Fisheries Offsetting Plan.

The objective of the Fisheries Offsetting Plan will be to compensate for the alteration or destruction of fish-bearing habitat, for example by creating or modifying fish habitat elsewhere on the landscape (see section 6.5.3.4). Habitat losses related to the Phase 2 Project infrastructure footprint will be offset with the objective of maintaining the productivity of CRA species. The conceptual approach to fisheries offsetting proposed to balance all losses of fish habitat from Phase 2 Project infrastructure can be found in Appendix V5-6V. The Fisheries Offsetting Plan, including the detailed description of the fisheries offsetting options and proposed monitoring plan, will be developed prior to an Application for a *Fisheries Act* Authorization and prior to effects occurring (Volume 8, Management Plans; Section 2.19).

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans there are no residual effects anticipated on the VEC freshwater fish habitat due to interaction with the Phase 2 Project infrastructure footprint.

<u>Characterization of Hope Bay Project Potential Effects</u>

Fish habitat loss and alteration resulting from the Project Infrastructure footprint of Approved Projects generally has been or will be limited to one time construction events. Seasonal winter road construction and use is an exception, however with appropriate mitigation and management, winter road construction in not anticipated to result in residual effects on fish habitat. Habitat loss and alteration resulting from the Project Infrastructure footprint of Approved Projects has been or will be mitigated or has been or will be offset through compliance with the *Fisheries Act*. This has been achieved through the implementation of biophysical management plans including an AEMP (Volume 8, Management Plans; Table 1.1-1), through the implementation of fisheries offsetting plans (e.g., for the loss of fish and fish habitat in Tail Lake when it was reclassified as a tailings impoundment area under Schedule 2 of the MMER and was fished out; Golder 2007b; Rescan 2012b), and through commitments to develop and implement fisheries offsetting plans, where required. Therefore, there are no residual effects resulting from fish habitat loss or alteration from Approved Projects which could combine with Phase 2 effects.

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans for both the Phase 2 Project and Approved Projects, there are no residual effects anticipated on the VEC freshwater fish habitat due to the Hope Bay Project infrastructure footprint.

6.5.4.2 Loss or Alteration of Fish Habitat: Water Withdrawal and Use

Characterization of Phase 2 Potential Effects

Water withdrawal and use for the Phase 2 Project has the potential for effects on the freshwater fish habitat VEC through changes in surface hydrology which may result in the loss or alteration of fish habitat. The assessment of Phase 2 Project effects on Surface Hydrology was completed separately and independently in Volume 5, Section 1. This section assessed Phase 2 Project-related changes in stream flows using indicators that have quantitative relationships or thresholds associated with supporting and evaluating the significance of residual effects using ratings that considered fish habitat requirements (i.e., streamflow requirements). The following assessment of water withdrawal and use on the freshwater fish habitat VEC considers the effects on streamflow identified in Volume 5, Section 1, particularly with respect to mitigation and offsetting measures. In addition to effects on stream flows, the following assessment also characterizes the effects of water withdrawal and use on lake volume and lake surface elevation.

Water for domestic and industrial use for the Phase 2 Project will be drawn from Doris, Windy, and Aimaokatalok lakes (Table 6.5-5). Other Phase 2 Project-related effects that may result in a decrease in water elevation, volume, or discharge in fish-bearing freshwater waterbodies include drawdown of water through talik to underground workings and the modification of natural drainages (i.e., contact water diversion and discharge and modification of runoff at disturbed sites; Table 6.5-5). All these activities contribute to the water withdrawal and use effects pathways associated with freshwater fish VECs. These are anticipated to occur during all Phases of the Phase 2 Project, though at various intensities, with the possible exception of the Post-Closure Phase (Table 6.5-3). Figures 6.5-1 and 6.5-2 indicate the waterbodies in the LSA and RSA where there is the potential for freshwater fish habitat loss or alteration as a result of interactions with the Phase 2 Project. These include the lakes that may be directly affected through water withdrawal and use (Table 6.5-5), as well as downstream outflow streams that may be indirectly affected by those same upstream lakes (e.g., reductions in lake volumes and surface elevations leading to reduced discharge in outflows; Table 6.5-5).

The potential effects from water withdrawal and use pathways listed in Tables 6.5-5 on fish habitat were characterized using results of the *Hope Bay Project Water and Load Balance* (i.e., the water balance model; Appendix V3-2D). Results of the water balance model include stream flow predictions at 13 assessment nodes during different phases of the Project (Appendix V5-1P), as well as lake volume and surface elevation predictions at five lakes during different phases of the Project (Appendices V5-1Q and V5-1R). For the purpose of the effects assessment of water withdrawal and use on the fish habitat VEC, the potential effect of Phase 2 in isolation of Approved Projects is not assessed. Instead, the assessment is based on Phase 2 in combination with Approved Projects (i.e., the overall Hope Bay Project) relative to baseline flow projections as carried out in the effects assessment for surface hydrology (Volume 5, Section 1.5.4). Rationale for this method is summarized as follows.

Table 6.5-5. Lakes and Lake Outflows in the LSA and RSA with Potential Effects from Water Withdrawal and Use

	Waterbody		Water Withdrawal and Use			
Watershed	Lake	Stream	Domestic and/or Industrial Use	Underground Mines - Drawdown through Talik	Modification of Natural Drainage	Upstream Withdrawal and Use
Doris	Imniagut Lake		-	X	-	-
Doris		Imniagut Outflow	-	-	-	X
Doris	Wolverine Lake		-	X	X	-
Doris		Wolverine Outflow	-	-	-	X
Doris	Patch Lake		-	X	X	-
Doris		Patch Outflow	-	-	-	X
Doris	P.O. Lake		-	-	-	X
Doris		P.O. Outflow	-	-	-	X
Doris	Ogama Lake		-	-	-	X
Doris		Ogama Outflow	-	-	-	X
Doris	Doris Lake		X	X	-	-
Doris		Doris Outflow	-	-	-	X
Doris	Little Roberts Lake		-	-	-	X
Doris		Little Roberts Outflow	-	-	-	X
Windy	Windy Lake		X	X	X	-
Windy		Windy Outflow	-	-	-	X
Windy	Glenn Lake		-	-	-	X
Windy		Glenn Outflow	-	-	-	X
Aimaokatalok	Trout Lake*		-	-	-	-
Aimaokatalok		Trout Outflow*	-	-	-	-
Aimaokatalok	Stickleback Lake		-	-	X	-
Aimaokatalok		Stickleback Outflow	-	-	-	X
Aimaokatalok	Aimaokatalok Lake		X	-	-	-
Aimaokatalok		Aimaokatalok Outflow	-	-	-	X
Koignuk		Koignuk River 1	-	-	-	X
Koignuk		Koignuk River 2	-	-	-	X

Bolded waterbodies are those modelled for lake volume and lake surface elevation
Waterbodies are ordered from upstream to downstream within a watershed
Dashes indicate no potential effect from water withdrawal and use
**no potential effects from water withdrawal and use; not carried forward for further assessment*

Assessment of Phase 2 potential effects in isolation of Approved Projects would include comparison of project-affected lake volume, lake surface elevation, and stream flows during the Construction, Operation, Closure, and Post-closure phases of the Phase 2 Project, with conditions before Construction of Phase 2 (hereafter referred to as Year 0). Lake volumes, lake surface elevations, and stream flows in Year 0 are not pre-development natural conditions since they include the predicted effects of the Doris Project. In contrast, assessment of Phase 2 in combination with Approved Projects compares project-affected lake volume, lake surface elevation, and stream flows during the Construction, Operation, Closure, and Post-closure phases of the Phase 2 Project (Appendix V5-1P), with baseline projections without any development (Appendix V5-1M).

Assessment of Phase 2 in combination with Approved Projects results in greater lake volume, lake surface elevation, and stream flow effects than those of Phase 2 in isolation of Approved Projects (Volume 5, Section 1; Table 1.5-2). In this way the effect assessment provides conservative predictions of the effects of Phase 2 in isolation of Approved Projects. Therefore, for the purpose of assessing effects on the fish habitat VEC and the application of mitigation and management measures, characterization of potential effects is only performed for the overall Hope Bay Project in the following sections, based on Phase 2 in combination with Approved Projects relative to baseline lake volume, lake surface elevation, and stream flow projections. This is consistent with the natural flow regime paradigm (Poff 2010) and best practices for hydrologic effects assessments, and was thus applied to the fish habitat assessment, allowing for consistent interpretation of potential effects on freshwater fish VECs relative to the surface hydrology VEC.

Water withdrawal for the Phase 2 Project may also occur during winter road construction at select lakes and ponds along the proposed winter road corridor. Waterbodies will be selected as required for seasonal construction. Finally, exploration activities related to the Phase 2 project will continue throughout the Project life and will include diamond drilling which requires a drilling fluid that uses water (heated or salinated; Volume 3, Project Description and Alternatives; Section 4.8 Exploration Activities). For Madrid drill locations, Patch, Windy and Wolverine Lakes may serve as the sources of water. For Boston drill locations, Aimokatalok Lake, and possibly Trout and Stickleback lakes may provide drill water. The potential effects of water withdrawal from under ice for winter road construction and drilling on the freshwater fish habitat VEC are not assessed using results from the water balance report because lakes and ponds from which water will be withdrawn will be identified as required, however activities will comply with DFO's *Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the Northwest Territories and Nunavut* (DFO 2010a).

Water withdrawal from lakes has the potential to affect fish habitat through multiple pathways, including a reduction in available fish habitat, changes to primary and secondary producers, and a reduction in discharge volume at lake outflows. Water withdrawal from lakes may cause a decrease in the amount and suitability of overwintering or spawning habitat available for fish or potentially expose overwintering eggs of Lake Trout, Arctic Char, cisco or whitefish species to air (Cott 2007). Reduction in discharge at lake outflow streams can result in a reduction of available or suitable fish habitat for migration, rearing, and spawning (Arctic Grayling). Lower stream flows can influence the ability for fish passage through changes in water depth and velocity (i.e., passage barriers and stranding), changes in the timing of flows, decrease in the number of days stream habitat is accessible, and increase the duration of sensitive periods (flow less than 30% Mean Annual Discharge; DFO 2013f). Smaller, shallow lakes and ponds are more susceptible to habitat changes due to water withdrawals than large lakes.

Water withdrawal also has the potential to modify water quality and/or sediment quality. The suspension and deposition of sediments during lake water withdrawal could result in an *indirect* loss of fish habitat through water quality and/or sediment quality effects on primary and secondary producers. Sedimentation could also affect the physical availability and quality of spawning habitats for fish that rely on gravel and rock substrates for spawning (e.g., gravel for Arctic Grayling in streams and rock shoals for Lake Trout, Arctic Char, cisco and whitefish in lakes).The assessment of Project effects on Freshwater Water Quality and Freshwater Sediment Quality are completed individually in Volume 5, Sections 4 and 5, and thus not included in this assessment as outlined for the reasons provided in Section 6.3.2 of this chapter.

<u>Mitigation and Management Measures for Specific Potential Effects (Phase 2)</u>

Mitigation and management measures for specific potential effects on fish habitat from water withdrawal for domestic and industrial use, drawdown through talik, and modification of natural drainage are presented for the overall Hope Bay Project in the following sections.

To mitigate the effects of water withdrawal for the construction of winter roads and drilling, these activities will adhere to DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2) and the *Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the Northwest Territories and Nunavut* (DFO 2010a):

- In one ice-covered season, total water withdrawal from a single waterbody is not to exceed 10% of the available water volume.
- In cases where there are multiple users withdrawing water from a single waterbody, the total combined withdrawal volume is not to exceed 10% of the available water volume.
- Only waterbodies with maximum depths that are ≥1.5 m than their corresponding maximum expected ice thickness will be considered for water withdrawal.

Further, water to supply drill sites will be provided by a lake nearby to the drill that has a surface area of at least 15,000 m^2.

<u>Characterization of Hope Bay Project Potential Effect</u>

Lake Volume and Lake Surface Elevation

Simulated effects of the Hope Bay Project on lake volume and lake surface elevation in lakes in the Doris Watershed (Doris, Patch, Wolverine, and Imniagut lakes), the Windy Watershed (Windy Lake), and the Aimaokatalok Watershed (Stickleback Lake) are presented in Table 6.5-6. Although water withdrawal effects may also occur in other lakes as listed in Table 6.5-5, the effects on lake volume and surface elevation in these lakes could not be simulated due to the absence of a rating curve for the relevant lake outflow. In all cases except for Aimaokatalok Lake, the potential for effects in lakes with no volume and surface elevation data result from upstream water withdrawal and use, rather than a direct interaction with Project activities. For these lakes, the effects of upstream water withdrawal and use on fish habitat have been characterized exclusively through effects on stream flows at lake outflows.

Because fish life histories are represented by annual cycles that rely on different habitats for different life processes, even temporary loss or alteration in fish habitat that occurs during specific periods when fish rely on those habitats have the potential to influence the survival and population abundance of fish. Fish present in the lakes listed in Table 6.5-6 rely on lakes as critical overwintering habitats based on the premise that they all have sufficient depths (i.e., more than 3 m max depth) to provide habitat under thick winter ice cover. Water withdrawal during the ice-covered period may cause a decrease in the amount and suitability of overwintering habitat by decreasing the under ice habitat area and potentially affecting water quality (i.e., oxygen depletion). Additionally, Lake Trout, Arctic Char, cisco and whitefish spawn in the fall over rock substrates and shoals in lakes and their eggs overwinter in the substrates. Water withdrawal from lakes could decrease the water surface elevation under the ice and potentially expose overwintering eggs to air, resulting in mortality (Cott 2007).

Table 6.5-6. Baseline and Hope Bay Project-affected Reductions in Average Annual Lake Volume and Monthly Under-Ice Lake Surface Elevation during the Life of the Phase 2 Project (Years 1 to 22)

Watershed	Waterbody	Fish Species Present	Maximum Depth (m)	Maximum Reduction in Annual Lake Volume[a]		No. of Years with Reduction in Annual Lake Volume >10%[b]	Variation in Baseline Lake Surface Elevation[c]		Maximum Reduction in Under-Ice Lake Surface Elevation[d]		No. of Years with Monthly Reduction in Lake Surface Elevation > Avg. Baseline Variation[e]
				(%)	Year (s)		Average Variation (m)	Baseline Years	Change from baseline (m)	Year(s)	
Doris	Imniagut Lake	NSSB	4.9	-51.8	2032	18	0.09**	N/A	1.31	2032	19
Doris	Wolverine Lake	NSSB, LSCS	4.0	-1.6	2032	0	0.19	2006, 2008 - 2011	0.07	2032	0
Doris	Patch Lake	LKTR, LKWH, CISC, LSCS, NSSB	14.3	-1.4	2031	0	0.24	2006 - 2011	0.09	2031	0
Doris	Doris Lake	LKTR, LKWH, CISC, LSCS, NSSB	19.4	-2.4	2030 - 2031	0	0.53	2004 - 2015	0.50	2030, 2031	0
Windy	Windy Lake	LKTR, LKWH, CISC, SLSC, NSSB	21.2	-0.1	2018-2034	0	0.17	2007 - 2015	0.01	2018 - 2034	0
Aimaokatalok	Stickleback Lake	NSSB, ARGR	6.1	-0.1	2021-2035	0	0.07**	N/A	0.004	2023 - 2028	0

Waterbodies are ordered from upstream to downstream within a watershed

a = maximum annual reduction of simulated Hope Bay Project-affected lake volume from simulated baseline lake volume during the life of the Phase 2 Project (i.e., Years 1 to 22) under average conditions including climate change effects

b = number of Hope Bay Project-affected years where reduction of simulated Hope Bay Project-affected lake volume from simulated baseline lake volume exceeded 10%

c = average of field collected baseline variation in lake surface elevation during the open water season (June to September), values obtained from Volume 5, Section 1; Table 1.2-6

d = maximum monthly reduction of simulated Hope Bay Project-affected lake surface elevation from simulated baseline lake surface elevation in ice-covered months during the life of the Phase 2 Project (i.e., Years 1 to 22) under average conditions including climate change effects

e = number of Hope Bay Project-affected years where reduction of simulated Hope Bay Project-affected lake surface elevation from simulated baseline lake surface elevation was greater than "c" (i.e., variation in baseline lake surface elevation)

*** field collected baseline data not available, calculated as the average difference between simulated baseline lake surface elevation in September and June (Years 1 to 22) under average conditions including climate change effects*

N/A = field collected baseline data not available.

NSSB = Ninespine Stickleback, LSCS = Least Cisco, LKTR = Lake Trout, LKWH = Lake Whitefish, CISC = Cisco, ARGR = Arctic Grayling

To prevent negative impacts on over-wintering habitat, DFO has developed a guideline for water withdrawal from ice-covered lakes in the Northwest Territories and Nunavut (DFO 2010a) that limits the total water withdrawal from a single waterbody in one ice-covered season to less than 10% of the available water volume. This guideline has been applied as a first basic step for assessing the potential for effects of the Hope Bay project on water volume in affected lakes. The limitation of solely applying this guideline is that it does not allow to address how water withdrawal may impact available fish habitat located in shallower areas (e.g., littoral zone, shoals) where a small drop in elevation (due to reduction in lake volume) may result in the loss of critical habitats (e.g., spawning along shallow shoals).

Baseline and Hope Bay Project-affected average annual lake volumes from the water balance model were compared for average hydrologic conditions over the life of the Phase 2 Project (Years 1 to 22) to assess whether simulated reductions in volume exceed 10% of baseline values for available water volume. To proceed with this comparison, the maximum change in lake volume in all Phase 2 Project years was first determined. Then, to provide an assessment of duration of effect, the number of years where the Project-affected lake volume was reduced by more than 10% of annual baseline volume was also determined. Where the simulated change in average annual lake volume was less than 10% of average annual baseline volume, the Hope Bay Project-affected lake volume was considered to be within the range of natural variation and thus effects of the Hope Bay Project on the fish habitat VEC due to a change in lake volume of the life of the Phase 2 Project were considered negligible.

To assess the potential changes in lake surface elevation, the baseline average annual variation in lake surface elevation during the open water season (typically June to September; Volume 5, Section 1; Table 1.2-6) was compared to the maximum decrease in lake surface elevation simulated during each ice-covered month (October to May) of each Phase 2 Project Year (Table 6.5-6) from the water balance model. Where the simulated change in lake surface elevation during ice-covered months was less than the baseline annual variation in lake sure elevation from field collected data, the Hope Bay Project-affected lake surface elevation was considered to be within the range of natural variation, and thus effects of the Hope Bay Project on the fish habitat VEC due to a change in lake surface elevation over the life of the Phase 2 Project were considered negligible.

The maximum simulated reduction in average annual lake volume and ice-covered lake surface elevation in lakes in the Doris Watershed (i.e., Doris, Patch, and Wolverine) generally occurred near the end of the Operations Phase (Table 6.5-6). The maximum simulated reduction in average annual lake volume over the life of the Phase 2 Project in Doris, Patch, Wolverine, Windy, and Stickleback lakes was less than 10% (Table 6.5-6). The maximum reduction lake surface elevation in any single ice-covered month in Patch, Wolverine, Windy, and Stickleback lakes was less than the variation in lake surface elevation observed in those lakes during the open water season in baseline years. Therefore, effects on fish habitat due to a reduction in water volume from withdrawal and use from these aforementioned lakes (i.e., excluding Imniagut Lake, discussed below) are considered negligible based on the application of a 10% threshold. Effects on fish habitat due to a reduction in lake surface elevation in these lakes due to water withdrawal and use is thus also considered to be negligible, based on comparison to baseline variation.

The maximum simulated reduction in average annual lake volume in Imniagut Lake was 51.8% and the maximum reduction in lake surface elevation during the ice-covered period was 1.31 m, occurring during the last year of the Operations Phase (i.e., Year 14 or 2032). The simulated reduction in average annual lake volume was greater than 10% of baseline values in 18 years over the life of the project, beginning in Phase 2 Project Year 5 (2023, Year 1 of Operations phase) and continuing until Phase 2 Project Year 22 (2040; last year of Post-Closure phase). The simulated reduction in lake volume during at least one ice-covered month was greater than the baseline variation in lake surface elevation during the open water season in 19 years over the life of the Phase 2 Project, beginning in Phase 2 Project Year 4 (2022; the final year of Construction phase) and continuing until Project Year 22 (2040; the final year of Post-Closure phase). Reduction in average annual lake volume in the final Project Year was simulated at 34.6% (Appendix V5-1R) and the simulated average annual reduction in lake surface elevation in the final Project Year was 0.82 m less than the simulated baseline (Appendix V5-1Q). Although surface hydrology has the potential to recover and effects are expected to be fully reversible, the magnitude of effects on lake volume and lake surface elevation that persist in Imniagut Lake until the final year of the Phase 2 Project suggest that recovery of fish habitat in Imniagut Lake may extend beyond the Post-Closure Phase.

Imniagut Lake is deemed fish-bearing, with confirmed occurrence of Ninespine Stickleback, a forage fish known to support CRA fisheries. It is located upstream of Patch Lake to which it is connected by an ephemeral outflow stream. Due to this connectivity, Ninespine Stickleback in Imniagut Lake may partially support CRA fish in Patch Lake as food supply, although to a small extent given that the two lakes are only ephemerally connected. Imniagut Lake is a relatively shallow lake (maximum depth = 4.9 m), likely providing only poor and limited overwintering conditions for most species other than low oxygen tolerant fish such as Ninespine Stickleback. Due to its already shallow depth, a reduction in surface elevation of 1.31 m could exacerbate effects on the availability of overwintering habitat and under-ice water quality, though no overwintering spawning habitat (i.e., egg incubation) would be affected given absence of fall-spawning species (e.g., Lake Trout). Therefore, given that only Ninespine Stickleback have been documented in this lake, it is likely that overall habitat quality is already of low value even under natural conditions. However, activities associated with the Phase 2 Project would still likely result in the permanent loss of fish habitat for most of Imniagut lake, although its value as a contributor of forage fish production towards CRA fisheries within Patch Lake is likely also of low value. Notwithstanding, the effects of reduction in water volume on Imniagut Lake may require offsetting. Offsetting would be commensurate with the productivity contribution Imniagut Lake likely provides to Patch Lake fish populations. As previously described, this characterization of potential effects is based on the Hope Bay Project (Phase 2 in combination with Approved Projects), but is conservatively also used for Phase 2 in isolation of Approved Projects.

Streamflow

In the effects assessment for the surface hydrology VEC (Volume 5, Section 1.5.2), the following potential effects on streamflow were assessed:

- Alteration of streamflow in Doris Watershed (i.e., Wolverine Outflow, Patch Outflow, P.O. Outflow, Ogama Outflow, Doris Outflow, and Little Roberts Outflow);
- Alteration of streamflow in Windy Watershed (i.e., Windy Outflow and Glenn Outflow); and
- Alteration of streamflow in Aimaokatalok Watershed (i.e., Trout Outflow, Stickleback Outflow, Aimaokatalok Outflow, Koignuk River 1, and Koignuk River 2).

Predictions of the water balance model (Volume 5, Section 1; Table 1.5-3) showed that these potential effects on the surface hydrology VEC would not be fully eliminated after implementation of the mitigation measures applied in Section 1.5.3. Therefore, they were carried forward as residual effects for characterization of significance on the surface hydrology VEC. They were concluded to be not significant, based on magnitude, duration, frequency, geographic extent, and reversibility of effects. While residual effects on the surface hydrology VEC as a key component of the biophysical environment are not significant, alterations in stream flows also have the potential to affect fish habitat and thus require further assessment as part of the fish habitat VEC.

Water withdrawal and use from lakes can reduce discharge in lake outflow streams. Lower stream flows can influence fish habitat use in streams through numerous pathways associated with changes in water depth and velocity, changes in the timing of flows, decreases in the number of days stream habitat is accessible, and increases in the duration of already sensitive low flow periods (flow less than 30% Mean Annual Discharge; DFO 2013f). Because fish life histories are represented by annual cycles that rely on different habitats for different life processes, even temporary loss or alteration in fish habitat that occurs during specific periods when fish rely on access to those critical habitats (e.g., spawning, overwintering, migration) has the potential to influence the survival and population abundance of fish. This is particularly relevant for arctic-dwelling species where access to stream habitat and movement across the landscape is limited only to the open-water season (Hershey et al. 2006). Arctic Char (and other anadromous species including Lake Trout, ciscoes, and whitefish) rely on stream habitats as migratory corridors during their seasonal migrations between freshwater overwintering/spawning and seasonal marine feeding habitats (Johnson 1980). Unimpeded access to critical summer feeding in marine habitats during freshet high flows and return migration during low flows (August to October) to critical spawning/overwintering is key to maintaining fisheries productivity of anadromous species such as juvenile and adult Arctic Char. Juvenile fish of multiple species (e.g., Arctic Char, Lake Trout, Arctic Grayling, cisco, and whitefish) and forage fish rely on stream habitats as migratory corridors to move between waterbodies during the open water season (Evans, Reist, and Minns 2002; Hershey et al. 2006). Juvenile fish also rely on stream habitats for rearing/feeding opportunities and predator avoidance (Evans, Reist, and Minns 2002). Finally, Arctic Grayling rely on stream habitats for critical spawning/egg incubation habitat in the spring, as well as for providing critical rearing/feeding habitat for newly-emerged fry and juveniles (Stewart et al. 2007). Since most arctic streams freeze to the bottom during winter, unimpeded access to overwintering habitat is also critical for survival.

Because fish depend on natural flow regimes in streams to support these various life processes, DFO has developed guidance for assessing the probability of alterations in flow in resulting in degradation to systems that sustain fish (DFO 2013f). Based on this guidance, cumulative flow alterations of less than 10% of the magnitude of actual flow in the river relative to a natural flow regime are considered to have a low probability of detectable negative impacts to systems that support CRA fisheries (DFO 2013f). However, instantaneous flows less than 30% of the Mean Annual Discharge (MAD) have a heightened risk of impacts to systems that support CRA fisheries. These two guidelines form the basis of the assessment of effects of changes in streamflow on the fish habitat VEC to provide context on the aspects of hydrological changes most relevant to fish habitat access and use, particularly with regards to critical habitats. A variation of 10% from baseline conditions was initially used to identify waterbodies that may be affected by reduced streamflows, allowing “least risk” waterbodies to be scoped out. The “higher risk” waterbodies were then further assessed using a minimum flow threshold of 30% of the MAD to determine periods of highest risk for fish and potential effects on habitat use. The application of these guidelines in this assessment is in agreement with other recent EIS studies in the region of the Phase 2 Project (e.g., Back River and Mary River).

Simulated baseline and Hope Bay Project-affected stream flows from the water balance model based on preliminary mine design aspects were compared for average hydrologic conditions over the life of the Phase 2 Project (Years 1 to 22) to assess whether simulated reductions in streamflow exceeded 10% of baseline values during high and low flow periods (Table 6.5-7). To proceed with this comparison, the maximum reduction in monthly streamflow at high flow (June) and low flow (July, August, September, or October) in all Phase 2 Project Years was first determined. Then, to provide an assessment of duration of effect, the number of years where the Hope Bay Project-affected streamflow was reduced by more than 10% of baseline flow in one month at high and/or low flow was also determined. Where the simulated change in monthly streamflow at high or low flow was less than 10% of baseline monthly streamflow, the Hope Bay Project-affected streamflow was considered to have a low probability of detectable negative impacts to fish habitat and thus effects of the Hope Bay Project on the fish habitat VEC due to a change in streamflow over the life of the Phase 2 Project were considered negligible.

For waterbodies where the simulated change in monthly streamflow at high or low flow was greater than 10%, the MAD of the stream was calculated from simulated baseline flows during the open-water period for average hydrologic conditions over the life of the Phase 2 Project (Years 1 to 22) from the water balance model (Appendix V5-1P). The flow in the month with the maximum Hope Bay Project-affected reduction in flow during high and low flow periods in all Phase 2 Project Years was used to calculate the percentage of MAD for the assessment (Table 6.5-7). The timing and duration of a “highest risk” period was determined based on the timing and number of years in which there was a period of streamflow less than 30% of MAD (DFO 2013f) as well as the habitat functions of the affected streams.

The maximum simulated reductions in monthly streamflow over the life of the Phase 2 Project in streams in the Windy, Aimaokatalok, and Koignuk Watersheds were less than 10% in both the open-water high flow and low flow periods (Table 6.5-7). Therefore, effects on fish habitat due to a reduction in stream flow are considered negligible based on the application of a 10% variation from baseline threshold. However, effects due to changes in the timing of flows (e.g., later onset of freshet if lake volume is reduced and does not begin flowing in streams) and decrease in the number of days stream habitat is accessible (i.e., later freshet and/or earlier freeze up) are not assessed. The resolution of the simulated monthly data from the water balance report does not allow for detailed assessment for these variables and effects on fish habitat due to a change in the timing of flows may require additional assessment to ensure that effects on access to habitat do not occur. These analyses will be refined prior to submission of the final EIS.

The maximum simulated reductions in monthly streamflow over the life of the Phase 2 Project in streams in the Doris Watershed were greater than 10% in the open-water high and/or low flow periods (Table 6.5-7). Therefore, effects on fish habitat due to reduction in streamflow are possible based on the application of a 10% variation from baseline threshold. The effects of reduced streamflow were further assessed for each Doris Watershed stream based on a threshold of monthly Hope Bay Project-affected stream flow of 30% of MAD (Table 6.5-8).

The primary potential effect of decreased streamflow in Doris, Patch, P.O. and Ogama Outflows is related to their function for providing suitable rearing/feeding habitat for juvenile stages of Arctic Char (limited to section of Doris Outflow downstream of impassable barrier only), Lake Trout, cisco, and/or whitefish. Patch, P.O., and Ogama Outflows also serve as migratory corridors between lakes, allowing for seasonal species distribution across the landscape (Hershey et al. 2006). The entire lower section of Doris Outflow (i.e., downstream of the impassable barrier) is also accessible for rearing to fish originating from Little Roberts Lake and Roberts Lake during the open water season. The assessment based on the 30% of MAD threshold indicated that, during high flows when the primary habitat use of stream habitats is for migratory purposes, fish habitat function will likely not be affected in Patch, P.O., Ogama, and Doris outflows. Simulated monthly stream flows were between 143% and 249% of MAD suggesting that reductions during the high flow period will not result in barriers to migration. The assessment based on the 30% of MAD threshold indicated that, during low flows when the primary use of stream habitats is for rearing as well as migratory purposes, fish habitat function may only be affected in Ogama and Doris outflows. Simulated monthly streamflow was 12.6% and 12.7% of MAD in Ogama and Doris outflows, respectively. The period where flows were reduced in Ogama Outflow occurred in July in all Phase 2 Project Years which may thus affect the availability of rearing and migratory habitat for fish. The period where flows were most reduced in Doris Outflow occurred in October, and in all Phase 2 Project Years. Juvenile fish in Doris Outflow in October may still be migrating to overwintering habitat in lakes although to a lesser extent depending on the timing of freeze-up, and thus reduced streamflow in October may partially affect migratory potential. However, it is unlikely to have a high magnitude of effect on rearing habitat use. Reduced high flows (all streams) and reduced low flows (Doris and Ogama ouflows) also have the potential to alter the timing of flow by delaying the onset of freshet or inducing the onset of freeze-up, further limiting the length of fish use over the open water season. Furthermore, although not discussed at length due to limitations on the available habitat information for each of the potentially affected streams, predicted changes in stream flows may also result in reductions in usable habitat (i.e., permanent loss) available to fish over the life of the Phase 2 Project, resulting in decreased fisheries productivity that may require offsetting.

The primary effect of decreased streamflow in Little Roberts Outflow is most relevant regarding its function of serving as a migratory corridor for Arctic Char (and other anadromous species such as Lake Trout, ciscoes, and whitefish) between marine/estuarine habitats found in Roberts Bay and freshwater spawning and/or overwintering habitats in Roberts Lake. Little Roberts Outflow is also used as migratory and rearing habitat for various species of juvenile fish originating from Roberts Lake and Little Roberts Lake populations. Decreased streamflow in Little Roberts Outflow, particularly during the late summer/early fall migration period (start in July, peak in August and early September and continue into October) could compromise the ability of adult Arctic Char to reach spawning and/or overwintering habitat in Roberts Lake. Little Roberts Outflow also functions to provide suitable rearing/feeding habitat for juvenile stages of Arctic Char, Lake Trout, cisco, and/or whitefish. Based on the 30% of MAD threshold, the period where flows were most reduced in Little Roberts Outflow occurred in October in all Phase 2 Project Years. This may reduce the ability of Arctic Char to migrate through Little Roberts Outflow due to decreased water depth, and may also result in earlier freeze-up, and therefore reduce the migration window. Habitat available to juvenile fish resulting from reductions in stream flows may also decrease, and in the process lower fisheries productivity of the stream.

Wolverine and Imniagut outflows are ephemeral streams that act as seasonal migratory habitat, primarily for Ninespine Stickleback between Patch and Wolverine lakes, and between Patch and Imniagut lakes, respectively. Ninespine Stickleback and Least Cisco are present in Wolverine Lake and Ninespine Stickleback are present in Imniagut Lake. Ninespine Stickleback in these lakes may partially support CRA fish in Patch Lake as food supply. Based on the 30% of MAD threshold, migration potential will be maintained in Wolverine Outflow during high flows. Under Hope Bay Project-affected conditions, flows will recede to only 2.6% of MAD in July, and the stream will likely stop flowing by August, based on simulated flows. However, simulated baseline conditions suggest that Wolverine Outflow is ephemeral under baseline conditions and, that because connectivity will be maintained at high flow, effects on stream habitat use as migratory corridor are likely to be low. Based on the 30% of MAD threshold, migration potential in Imniagut Outflow will cease beginning in Project Year 1 and persist for the life of the Phase 2 Project (up to Year 22). Simulated baseline conditions and field surveys indicate that an ephemeral stream between Imniagut and Patch lakes allows for migration of Ninespine Stickleback. Therefore, Hope Bay Project-affected streamflow will remove connectivity between Imniagut and Patch lakes for the life of the Phase 2 Project. Given that only Ninespine Stickleback have been documented in Imniagut Lake and its outflow, it is likely that overall habitat quality is already of low value even under natural conditions. However, activities associated with the Phase 2 Project would still likely result in the permanent loss of fish habitat in Imniagut Outflow, although its value as a contributor of forage fish production towards CRA fisheries within Patch Lake is likely also of low value. Notwithstanding, the effects of reduction in water volume on Imniagut Lake may require offsetting. Offsetting would be commensurate with the forage fish productivity contribution Imniagut Lake provides to Patch Lake CRA fish populations.

Table 6.5-7. Baseline and Hope Bay Project-affected Reductions in Monthly Flow during Critical Life Stages of Freshwater Fish over the Life of the Phase 2 Project (Years 1 to 22)

		Open-water High Flow Period (June)				Open-water Low Flow Period (July, Aug, Sept, Oct)			
		Max. Reduction in Monthly Hope Bay Project-affected Stream Flow*				Max. Reduction in Monthly Hope Bay Project-affected Stream Flow*			
Watershed	Stream	Stream Flow (m^3/s)	% of Baseline Flow	Year(s)	No. of Years with Reduction in Flow > 10%	Stream Flow (m^3/s)	% of Baseline Flow	Years(s)	No. of Years with Reduction in Flow > 10%
Doris	Imniagut Outflow	0.000	-100	2020 - 2040	21	N/A	N/A	N/A	N/A
Doris	Wolverine Outflow	0.049	-36.7	2032	4	0.001	-6.5	2032	0
Doris	Patch Outflow	0.257	-24.3	2031	10	0.069	-23.9	2031	10
Doris	P.O. Outflow	0.343	-19.4	2031	10	0.098	-26.5	2031	10
Doris	Ogama Outflow	1.048	-7.3	2031	0	0.053	-39.9	2031	11
Doris	Doris Outflow	0.757	-52.4	2031	16	0.051	-55.7	2031	16
Doris	Little Roberts Outflow	3.688	-31.1	2031	14	0.126	-50.3	2031	16
Windy	Windy Outflow	0.162 - 0.167	-7.5	2024 - 2027	0	0.017	-9.8	2024 - 2025	0
Windy	Glenn Outflow	0.618 - 0.627	-2.1	2025 - 2032	0	0.091 - 0.093	-5	2023 - 2028	0
Aimaokatalok	Stickleback Outflow	0.056 - 0.057	-5.8	2023 - 2027	0	0.001	-4.2	2022 - 2027	0
Aimaokatalok	Aimaokatalok Outflow	27.801 - 27.809	-0.2	2023 - 2030	0	0.300 - 0.309	-1.3	2019 - 2034	0
Koignuk	Koignuk River 2	46.373 - 46.412	-0.1	2022 - 2040	0	0.505 - 0.520	-0.8	2020 - 2034	0
Koignuk	Koignuk River 1	31.563 - 31.632	-0.1	2020 - 2040	0	0.343	-1.2	2021 - 2022	0

Waterbodies are ordered from upstream to downstream within a watershed
Bolded values indicate those with modelled change in streamflow >10%
**maximum reduction of simulated monthly Hope Bay Project-affected streamflow from simulated monthly baseline streamflow during the life of the Phase 2 Project (i.e., Years 1 to 22) under average conditions including climate change effects*

Table 6.5-8. Hope Bay Project-affected Monthly Flow as a Percentage of Mean Annual Discharge during Critical Life Stages of Freshwater Fish

Watershed	Stream	MAD[a] (m^3/s)	30% of MAD (m^3/s)	Habitat Function: High Flow	Habitat Function: Low Flow	High Flow (June): Flow in Month with Max. Hope Bay Project-affected Flow Reduction[b] (m^3/s)	High Flow (June): Year	High Flow (June): % of MAD	High Flow (June): No. Project Years with Minimum Flow < 30% MAD	Low Flow (July, Aug, Sept, Oct): Flow in Month with Max. Hope Bay Project-affected Flow Reduction[b] (m^3/s)	Low Flow (July, Aug, Sept, Oct): Year	Low Flow (July, Aug, Sept, Oct): % of MAD	Low Flow (July, Aug, Sept, Oct): No. Project Years with Minimum Flow < 30% MAD
Doris	Imniagut Outflow	0.002	0.001	Migration	N/A (ephemeral)	0.000	2040	0.0	0	N/A	2040	N/A	21
Doris	Wolverine Outflow	0.039	0.012	Migration	N/A (ephemeral)	0.049	2032	125.6	0	0.001	2032	2.6	22 (July, Aug = no flow)
Doris	Patch Outflow	0.180	0.054	Migration	Migration, Rearing	0.257	2031	142.8	0	0.069	2031	38.3	0
Doris	P.O. Outflow	0.216	0.065	Migration	Migration, Rearing	0.343	2031	158.8	0	0.098	2031	45.4	0
Doris	Ogama Outflow	0.421	0.126	Migration	Migration, Rearing	1.048	2031	248.9	0	0.053	2031	12.6	22 (July only)
Doris	Doris Outflow	0.402	0.121	Migration	Migration, Rearing	0.757	2031	188.3	0	0.051	2031	12.7	22 (October only)
Doris	Little Roberts Outflow	1.307	0.392	Migration	Migration, Rearing	3.688	2031	282.2	0	0.126	2031	9.6	22 (October only)

MAD = Mean annual discharge

a = calculated as the mean of annual average open-water simulated baseline streamflow during the life of the Phase 2 Project (i.e., Years 1 to 22) under average conditions including climate change effects

b = minimum simulated monthly Hope Bay Project-affected streamflow during the life of the Phase 2 Project (i.e., Years 1 to 22) under average conditions including climate change effects

N/A = not applicable; simulated baseline streamflow during the life of the Phase 2 Project (i.e., Years 1 to 22) is zero.

As previously described, this characterization of potential effects is based on the Hope Bay Project (Phase 2 in combination with Approved Projects), but is conservatively also used for Phase 2 in isolation of Approved Projects.

<u>Mitigation and Management Measures for Specific Potential Effects (Hope Bay Project)</u>

The primary mitigation measure for effects of water withdrawal and use on freshwater fish habitat is to protect habitat necessary for life stages of freshwater fish by limiting the amount of water withdrawn from each waterbody. This is accomplished by recycling water where possible to reduce the demand from water withdrawals, limiting groundwater inflows to underground workings were practical, and returning compliant effluent to waterbodies from which they were withdrawn where not prohibited by salinity (i.e., Aimaokatalok Lake; Volume 3, Project Description and Alternatives; Section 4.4.5 Water Management). Other measures for the mitigation and management of water withdrawal and use are applied to the surface hydrology VEC and are included in Volume 5, Section 1.5.3). The following mitigation and management measures are specifically related to effects on the fish habitat VEC resulting from water withdrawal and use.

To mitigate the potential effects of altered stream flows downstream of Doris Lake (i.e., in Doris Outflow and Little Roberts Outflow) and to maintain fish migration potential (i.e., fish passage) between Roberts Bay and Roberts Lake, fish migration channels will be modified through sections of Little Roberts Outflow that may become compromised by flow reductions associated with Hope Bay Project-related activities. Existing fish migration channels may be modified by improving fish passage potential in existing stream channels through the removal of boulders and alteration of flow paths. Channels will be designed and modified based on guidance from a team of professionals including habitat biologists, hydrologists, and engineers. Prior to the water withdrawal effects, an evaluation of the entire length of Little Roberts Outflow will be completed to identify sections of stream where passage barriers and elevated levels of stranding could occur. Construction will focus on these sections of the stream and durable channels will be constructed to improve low-discharge passage. These channels will be created by hand, if possible, or by light machinery where necessary.

Similar migration channels, created through the modification of a boulder garden in Roberts Outflow, have proven extremely effective in facilitating fish passage through a boulder garden. Average survival of adult Arctic Char undertaking spawning migrations or migrations to overwintering habitat in Roberts Lake from Roberts Bay in three years of monitoring following the construction of the migration channels was 94%; while the average survival in five years of pre-enhancement monitoring was 62% (ERM 2016c). Moreover, post-enhancement survival through the boulder garden is no longer correlated with discharge levels in Roberts Outflow; survival has remained between 93 and 96% in post-enhancement years over a range of discharge levels. In pre-enhancement years, survival was strongly correlated with discharge, with more fish perishing due to stranding at lower flows (Rescan 2013b).

Fisheries Offsetting

The purpose of a Fisheries Offsetting Plan (Appendix V5-6V), as per the guiding policies of DFO, is to maintain or improve the productivity of CRA fisheries. The Offsetting Plan will address permanent fish habitat losses/alterations related to water withdrawal and use from the Phase 2 Project, as deemed necessary and approved by DFO. The potential loss or alteration of fish habitat was preliminarily assessed using simulated results from the water balance report (Appendix V3-2D) and the application of four thresholds for assessing the effects of water withdrawal and use in lakes and streams.

Based on this preliminary assessment, habitat losses or permanent alteration to fish habitats that may occur as a result of water withdrawal and use from the Hope Bay Project (including Phase 2 and

Approved Projects; conservatively used to describe habitat losses or permanent alteration from Phase 2 in isolation of Approved Projects) include:

- Partial loss of overwintering habitat for Ninespine Stickleback in Imniagut Lake (as a contributor of forage fish production towards CRA fisheries within Patch Lake);
- Total loss of migratory habitat for Ninespine Stickleback in Imniagut Outflow (as a contributor of forage fish production towards CRA fisheries within Patch Lake);
- Partial loss of migratory habitat for Ninespine Stickleback in Wolverine Outflow (as a contributor of forage fish production towards CRA fisheries within Patch Lake);
- Partial loss of migratory and rearing habitat for CRA and forage fish species in Ogama Outflow;
- Partial loss of migratory and rearing habitat for CRA and forage fish species in in Doris Outflow; and
- Partial loss of migratory and rearing habitat for CRA and forage fish species in Little Roberts Outflow.

Unavoidable habitat loss or alteration due to water withdrawal and use for the Hope Bay Project is predicted to occur in the Doris, Windy, and Aimaokatalok watersheds within the LSA, and in the 3 – Roberts Bay Watershed within the RSA (Figure 6.2-1). Where possible, changes in access to habitats resulting from altered stream flows that may create fish passage barriers downstream of Doris Lake will be mitigated through creation of migration channels. Where deemed necessary by the DFO *Fisheries Authorization* process, offsetting for remaining fish habitat losses in lakes and streams resulting from water withdrawal and use will be incorporated into a Fisheries Offsetting Plan. Habitat losses may be calculated based on a combination of hydrological modelling, baseline fish habitat data, and baseline fish community data (Appendix V5-6V). Fish habitat loss and alteration resulting from water use by Approved Projects generally has been or will be mitigated or offset and/or commitments to develop and implement offsetting plans have been made. Because waterbodies in which effects of water withdrawal and use for Approved Projects are the same as those that will be further affected by Phase 2 activities, future offsetting deemed necessary by DFO for both Phase 2 and Approved Projects may be considered as a whole such that all fish habitat losses from the Hope Bay Project are offset.

The objective of the Fisheries Offsetting Plan will be to compensate for the alteration or destruction of fish-bearing habitat, for example by creating or modifying fish habitat elsewhere on the landscape (see section 6.5.3.4). Habitat losses related to the Phase 2 Project infrastructure footprint will be offset with the objective of maintaining the productivity of CRA species. The conceptual approach to fisheries offsetting proposed to balance all losses of fish habitat from Phase 2 Project infrastructure can be found in Appendix V5-6V. The Fisheries Offsetting Plan, including the detailed description of the fisheries offsetting options and proposed monitoring plan, will be developed prior to an Application for a *Fisheries Act Authorization* and prior to effects occurring (Volume 8, Management Plans; Section 2.19).

As previously described, the characterization of potential effects of water withdrawal and use on the fish habitat VEC is based on the Hope Bay Project (Phase 2 in combination with Approved Projects), but is conservatively also used for Phase 2 in isolation of Approved Projects.

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans there are no residual effects anticipated on the VEC freshwater fish habitat due to Phase 2 Project water withdrawal and use.

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans for both the Phase 2 Project and Approved Projects, there are no residual effects anticipated on the VEC freshwater fish habitat due to Hope Bay Project water withdrawal and use.

6.5.4.3 Changes in Water and Sediment Quality: Management of Contact Water, Effluent, and Dust

Characterization of Phase 2 Potential Effect

Potential effects of Phase 2 Project activities on the VEC freshwater fish habitat may occur through the deposition of deleterious substances in contact water (surface discharge), effluent (water discharge to the receiving environment), and/or dust. The deposition of deleterious substances could affect fish habitat through effects water quality, sediment quality, and/or on biological resources (primary and secondary producers, forage fish). As described in Section 6.3.2, Project activities that affect primary and secondary producers through the deposition of deleterious substances result from *indirect* trophic level interactions which are predominantly due to changes in water quality and/or sediment quality. The assessment of Phase 2 Project effects on Freshwater Water Quality and Freshwater Sediment Quality were completed separately and independently in Volume 5, Sections 4 and 5, respectively. These chapters assessed Phase 2 Project-related changes in freshwater water quality and sediment quality using indicators that have quantitative relationships or thresholds associated with supporting aquatic organisms and biogeochemical processes, including established guidelines for the protection of aquatic life.

Project activities that result in the deposition of deleterious substances could also affect fish habitat through effects on forage fish species including mortality and/or reduction in fish health. The assessment of Project effects on the mortality and population abundance of fish community VECs is found in Section 6.5.5.4 of this chapter. Fish community VEC species of Lake Trout, Arctic Grayling, Arctic Char, and Cisco/Whitefish are assessed and these assessments are considered representative of the potential effects on freshwater forage fish species in the LSA and RSA.

The assessment of residual effects on the VECs Freshwater Water Quality and Freshwater Sediment Quality can be found in Volume 5, Sections 4 and 5, respectively. No significant residual effects were identified. Therefore, the potential for effects of changes in water quality and/or sediment quality on physical fish habitat and biological resources are not carried forward into subsequent sections of the assessment of the VEC freshwater fish habitat.

Mitigation and Management Measures for Specific Potential Effects

Mitigation and management measures to avoid potential Phase 2 Project effects from changes in water quality and sediment quality can be found in section 4.5.3 of Volume 5, Section 4 (Freshwater Water Quality) and section 5.5.3 of Volume 5, Section 5 (Freshwater Sediment). Mitigation measures will also incorporate DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2), which specifically consider effects on water quality and sediment quality during in-water work that may affect fish and fish habitat (e.g., site selection, contaminant and spill management, erosion and sediment control). Finally, the AEMP (Volume 8, Management Plans; Section 2.17 and Annex 21) will monitor freshwater water quality and sediment quality, and results will indicate the need for adaptive management to avoid effects on fish and fish habitat.

As a result of mitigation and monitoring plans there are no residual effects anticipated on the VEC freshwater fish habitat due to changes in water quality and/or sediment quality resulting from Phase 2 Project activities.

Characterization of Hope Bay Project Potential Effect

Effects on fish habitat resulting from changes in freshwater water quality and/or sediment quality resulting from Approved Project activities have been or will be mitigated through the implementation of biophysical management plans including an AEMP (Volume 8, Management Plans; Table 1.1-1). Therefore, there are no residual effects resulting from fish habitat loss or alteration from Approved Projects which could combine with Phase 2 effects.

As a result of mitigation and monitoring plans for both the Phase 2 Project and Approved Projects, there are no residual effects anticipated on the VEC freshwater fish habitat due to changes in water quality and/or sediment quality resulting from Hope Bay Project activities.

6.5.5 Characterization of Potential Effects - Fish Community VECs

Project residual effects are the effects that are remaining after mitigation and management measures are taken into consideration. If the implementation of mitigation measures eliminates a potential effect and no residual effect is identified on that VEC, the effect is not carried forward for further analyses. If the proposed implementation controls and mitigation measures are not sufficient to eliminate an effect, a residual effect is identified and carried forward for additional characterization and a significance determination. Residual effects of the Project can occur directly or indirectly. Direct effects result from specific Project/environment interactions between Project activities and components, and VECs. Indirect effects are the result of direct effects on the environment that lead to secondary or collateral effects on VECs.

The following characterization of specific potential Project effects on the fish community VECs describes the potential effects of interactions of fish with the Phase 2 Project and the Hope Bay Project (including Phase 2 activities), identifies mitigation measures (including fisheries offsetting), and assesses whether residual effects remain after mitigation and management measures are taken into consideration. Residual effects from project-related interactions associated with the fish community VECs may be avoided and/or considered mitigable even when serious harm (as per the *Fisheries Act*) may be concluded by DFO, as long as it is considered feasible to offset the serious harm.

6.5.5.1 Direct Mortality and Population Abundance: Project Infrastructure Footprint

Characterization of Phase 2 Potential Effect

Phase 2 Project infrastructure has the potential to interact with the freshwater fish community VECs wherever the locations of infrastructure overlap with fish-bearing freshwater. Potential effects freshwater fish community VECs are anticipated during all phases of the Phase 2 Project, beginning in Construction when the building of most infrastructure will take place, and occurring through Post-Closure (Table 6.5-3). Figures 6.5-1 and 6.5-2 indicate the waterbodies in the LSA and RSA where there is the potential for freshwater fish habitat loss or alteration as a result of interaction with the Phase 2 Project. These waterbodies also represent the locations were fish community VECs may interact with Phase 2 construction activities and include waterbodies crossed by all-weather roads and Aimaokatalok Lake, where a water intake and discharge pipe will be constructed. Waterbodies with the potential for effects on fish community VECs due to water withdrawal/use are discussed further in section 6.5.5.2.

Water Crossings

The potential for direct mortality or reduction in population abundance of Lake Trout, Arctic Grayling, Cisco, and Arctic Char during the construction of water crossings along the proposed AWRs (Roberts Bay Cargo Dock Access Road, Madrid North-TIA AWR, Madrid-Boston AWR) exists only if in-water work is completed outside of restricted activity timing windows and if appropriate mitigation is not followed

(DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2). In the absence of proposed mitigation, in-water work in fish habitat has the potential to cause direct mortality of fish and their eggs. This could occur, for example, through interactions with industrial equipment, the resuspension of sediments, or through oil, grease or fuel leaks from equipment. In addition, improperly placed or sized culverts may result in the restriction of migration and access to spawning, rearing, feeding habitat (Arctic Grayling) or juvenile rearing habitat (Lake Trout, Arctic Char, Lake Whitefish, and Cisco). Restriction of access to overwintering habitats or spawning habitats (for anadromous species) may also occur where these species rely on stream crossing locations as part of migratory corridors.

Water Intakes and Discharge Pipes

Phase 2 Project infrastructure that interacts with freshwater fish VECs is restricted to water intakes and discharge pipelines associated with domestic and industrial water use and water discharge to the receiving environment. Water intakes will be used to withdraw water from lakes in the LSA for domestic water use and industrial uses. Water discharge pipes will be used to discharge compliant effluent to the receiving environment. The Phase 2 Project will continue to use existing water intake points in Doris and Windy Lakes in addition to the TIA discharge line, which discharges TIA and groundwater effluent to Roberts Bay. Water intake and discharge lines will also be established in Aimaokatalok Lake.

The potential for direct mortality or reduction in fish populations during the installation of the Aimaokatalok Lake water intake and discharge pipes during the Construction Phase exists if in-water work is completed outside of restricted activity timing windows and if appropriate mitigation is not followed (DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g); section 6.5.3.2). In the absence of proposed mitigation, in-water work in fish habitat has the potential to cause direct mortality of fish and their eggs for example through interactions with industrial equipment, the resuspension of sediments, or through oil, grease or fuel leaks from equipment.

Direct mortality to freshwater fish community VECs may also be caused by improper design and installation of pumps and intake and discharge pipe systems located in fish habitats and used for water withdrawal. Entrainment may occur where fish are drawn into water intakes and cannot escape. Impingement may occur where fish are held in contact with water intake screens and are unable to free themselves (DFO 1995). In order to prevent entrainment or impingement, end-of-pipe fish screens will be designed and installed according to DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2).

Winter Road Construction and Use

Use of the established Madrid-Boston winter road route or other short localized winter routes may be required during the Construction Phase to enable efficient construction of the Boston accommodations and the Madrid-Boston AWR. The proposed Phase 2 winter road route is presented on Figure 6.5-3.

Lake Trout and Cisco/Whitefish

If improperly constructed, the winter road may lead to shoreline erosion, increased suspended sediment, and increased sediment deposition along the shorelines of lakes and ponds. Sediment eroded from shorelines and stream crossings may settle along the rocky shorelines of lakes and ponds, possibly affecting the quality of Lake Trout, cisco, and whitefish spawning habitat (Marcus, Hubert, and Anderson 1984) and may result in the smothering of incubating eggs or failure of these species to spawn or emerge.

Arctic Grayling

The potential effects of winter roads are likely to be more evident in streams than in lakes due to the necessity of constructing and decommissioning ice bridges and snow fills. Arctic Grayling may be adversely affected by winter road development. Arctic Grayling spawn in streams and rivers early in the spring when the ice melts and spawning success appears to be affected by stream blockages (Stewart et al. 2007). Improper decommissioning of ice bridges and snow fills could cause stream channels to become blocked to fish migration during the spring migration, which could in turn lead to Arctic Grayling failing to spawn.

Arctic Char

The winter road route does not cross any waterbodies that are known to contain Arctic Char during any season. Therefore, Arctic Char will not be affected by these activities.

Other potential impacts on fish communities arising from the construction and use of winter roads arise from accidents and malfunctions, including spills and vehicle accidents. These potential impacts are covered under Accidents and Malfunctions (Volume 7, Section 1).

Mitigation and Management Measures for Specific Potential Effects

Water Crossings

The construction of stream crossings, roads, and berms will follow DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2). Timing of in-water construction activities will conform, when possible, to Nunavut Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat (DFO 2013h). For stream activities, the restricted activity window is in place from May 1 to July 15 to avoid the spring spawning period for Arctic Grayling. In streams used as migration corridors between marine and freshwater habitats by spawning anadromous Arctic Char, Lake Trout, cisco, and/or whitefish, stream activities will also avoid the fall migration window (beginning on August 15 and lasting until freeze-up). Winter construction activities will not be initiated until streams are considered isolated from flows (i.e., frozen to the substrates).

Fish-bearing crossings along the Roberts Bay Cargo Dock Road, the Madrid North-TIA AWR and the Madrid-Boston AWR will continue to serve as migration corridors between upstream and downstream waterbodies. Bridges will be used or fish-bearing culvert crossings will be designed to maintain fish passage by keeping water velocities and depths within acceptable limits such that they do not present a velocity or depth barrier to migration of species known to be present. In addition, culverts will be embedded in the natural channel and filled with material added to promote fish passage and habitat suitability. Bridge crossings will be preferentially constructed outside of the HWM to avoid alteration or destruction of fish-bearing habitats.

Mitigation measures for the maintenance of bridges and culverts at crossing locations will incorporate DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2) and additional best management practices (DFO 2007a, 2007b) which include:

- Unless accumulated material (i.e., vegetation, ice build-up, etc.) is preventing the passage of water and/or fish through the structure, material and debris removal will be completed according to the Nunavut Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat (DFO 2013h).

- Accumulated material and debris will be removed gradually such that flooding downstream, extreme flows downstream, release of suspended sediment, and fish stranding can be avoided.
- If replacement rock reinforcement/armouring is required to stabilize eroding inlets and outlets of culverts, the following measures will be incorporated:
  - Only clean, non-acid generating rocks will be used;
  - Rocks installed will be done so as to not interfere with fish passage or constrict the channel width.

Water Intakes and Discharge Pipes

Mitigation to avoid adverse effects on fish is required during construction of water intake and discharge pipelines. Timing of in-water construction activities will avoid, when possible, the Nunavut Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat (DFO 2013h). For lake activities, the applicable window is in place from August 15 to June 30 to avoid disturbance of fall spawning fish, e.g., Lake Trout, Arctic Char, cisco and whitefish and to avoid the disturbance of their eggs incubating in the substrates over the winter. Mitigation measures that will be applied during construction of intake and discharge pipelines follow DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g) as well as best management practices demonstrated to effectively mitigate the direct effects of in-water construction on fish include the following:

- The in-water construction zone may be isolated from the main water body using a turbidity curtain or silt booms if construction activities are anticipated to result in turbidity issues that could affect fish survival; and
- Fish salvage activities will be undertaken to relocate fish that may be stranded in isolated areas during the water intake construction to a location nearby in the waterbody.

Mitigation measures that will be applied during the design, and operation of any intakes or pumps (i.e., water supply for drilling or winter road construction) as well as intake and discharge pipelines in Aimaokatalok Lake follow DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g) and best management practices demonstrated to effectively mitigate the direct effects of water intakes on fish (DFO 1995) include the following:

- Water intakes or outlet pipes will be screened to prevent entrainment or impingement of fish.
- Screens will be located away from natural or artificial structures that may attract fish that are in migrating, spawning, or rearing habitat.
- In flowing water, the screen face will be oriented in the same direction as the flow.
- Openings in the guides and seals will be less than the opening criteria to make them "fish tight".
- Uptake points will be located a minimum of 300 mm (12 in.) above the bottom of the watercourse to prevent entrainment of sediment and aquatic organisms associated with the bottom area.
- Structural support will be provided to the screen panels to prevent sagging and collapse of the screen.
- Large cylindrical and box-type screens will be constructed to ensure even water velocity distribution across the screen surface. The ends of the structure will be made out of solid materials and the end of the manifold capped.

- o Heavier cages or trash racks may be fabricated out of bar or grating to protect the finer fish screen, especially where there is organic debris loading. A 150 mm (6 in.) spacing between bars is typical.
- o Provisions will be made for the inspection, removal, and cleaning of screens.
- o Screen mesh size will be a maximum of 2.54 cm.
- o Maintenance and repair of cleaning apparatus, seals, and screens will be carried out when needed to prevent debris-fouling and impingement of fish.
- o Pumps will be shut down when fish screens are removed for inspection and cleaning.

Winter Road Construction and Use

Mitigation measures for the construction of ice bridges and snow fills along the winter road route will incorporate DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2) and additional best management practices demonstrated to effectively mitigate the direct effects of ice bridges and snow fills on fish (DFO 2007c) which include:

- o Where water is pumped, intakes will be sized and adequately screened to prevent debris blockage and fish mortality. Fish screen mesh size will not be larger than 2.54 mm.
- o Crossings will not impede water flow at any time of the year.
- o When the crossing season is over and where it is safe to do so and indicated, a v-notch will be created in the centre of ice bridges to allow them to melt from the centre and to prevent blockage of fish passage, channel erosion and flooding. Compacted snow will be removed from snow fills prior to spring freshet.

Fisheries Offsetting

The purpose of a Fisheries Offsetting Plan (Appendix V5-6V), as per the guiding policies of DFO, is to maintain or improve the productivity of CRA fisheries. Where deemed necessary by DFO through the *Fisheries Authorization* process, serious harm to fish resulting from Phase 2 activities could be mitigated through the application of offsetting measures. However, mitigation and management measures other than offsetting that will be applied to the construction and operation of water crossings along Phase 2 AWRs, water intakes and discharge pipes, and the winter road, have high anticipated effectiveness in preventing the death of fish or any effects on fish population abundance. Thus, fisheries offsetting is not anticipated to be required to mitigate residual effects on the survival and population abundance of fish community VECs due to Phase 2 activities.

As a result of mitigation, and monitoring plans there are no residual effects anticipated on freshwater fish community VECs due to interaction with the Phase 2 Project infrastructure footprint.

<u>Characterization of Hope Bay Project Potential Effect</u>

The potential for direct mortality and reduction in population abundance of fish community VECs due to interaction with the Project Infrastructure footprint of Approved Projects has been or will be mitigated or has been or will be offset. This has been achieved through the implementation of biophysical management plans including an AEMP (Volume 8, Management Plans; Table 1.1-1), through the implementation of fisheries offsetting plans ((e.g., for the loss of fish and fish habitat in Tail Lake when it was reclassified as a tailings impoundment area under Schedule 2 of the MMER and was fished out; Golder 2007b; Rescan 2012b), and through commitments to develop and implement fisheries offsetting plans, where required. Therefore, there are no residual effects resulting from the potential for direct mortality and reduction in population abundance of fish community VECs from Approved Projects which could combine with Phase 2 effects.

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans for both the Phase 2 Project and Approved Projects, there are no residual effects anticipated on freshwater fish community VECs due to interactions with the Hope Bay Project infrastructure footprint.

6.5.5.2 Direct Mortality and Population Abundance: Water Withdrawal and Use

Characterization of Phase 2 Potential Effect

Water for domestic and industrial use for the Phase 2 Project will be drawn from Doris, Windy, and Aimaokatalok lakes (Table 6.5-5). Other Phase 2 Project-related effects that may result in a decrease in water elevation, volume, or discharge in fish-bearing freshwater waterbodies include drawdown of water through talik to underground workings and the modification of natural drainages (i.e., contact water diversion and discharge and modification of runoff at disturbed sites; Table 6.5-5). All these activities contribute to the water withdrawal and use effects pathways associated with freshwater fish VECs. These are anticipated to occur during all Phases of the Phase 2 Project, though at various intensities, with the possible exception of the Post-Closure Phase (Table 6.5-3). Figures 6.5-1 and 6.5-2 indicate the waterbodies in the LSA and RSA where there is the potential for freshwater fish habitat loss or alteration as a result of interactions with the Phase 2 Project. These include the lakes that may be directly affected through water withdrawal and use (Table 6.5-5), as well as downstream outflow streams that may be indirectly affected by those same upstream lakes (e.g., reductions in lake volumes and surface elevations leading to reduced discharge in outflows; Table 6.5-5).

Water withdrawal for the Phase 2 Project may also occur for winter road construction at select lakes and ponds along the proposed winter road corridor. Waterbodies will be selected as required for seasonal construction. Finally, exploration activities related to the Phase 2 project will continue throughout the Project life and will include diamond drilling which requires a drilling fluid that uses water (heated or salinated; Volume 3, Project Description and Alternatives; Section 4.8 Exploration Activities). For Madrid drill locations, Patch, Windy and Wolverine Lakes may serve as the sources of water. For Boston drill locations, Aimokatalok Lake, and possibly Trout and Stickleback lakes may provide drill water. Water withdrawn from under ice for winter road construction and will comply with DFO's *Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the Northwest Territories and Nunavut* (DFO 2010a).

Lake Trout, Arctic Char, Cisco/Whitefish

Lake Trout, Arctic Char, cisco and whitefish rely on the lakes listed in Table 6.6-5 as critical overwintering habitats based on the premise that they all have sufficient depths (i.e., >3 m max depth) to provide habitat under thick winter ice cover. Water withdrawal during the ice-covered period may cause a decrease in the availability and suitability of overwintering habitat by potentially affecting water quality (i.e., oxygen depletion). Extreme decreases in dissolved oxygen can result in the death of fish. Additionally, Lake Trout, Arctic Char, cisco and whitefish spawn in the fall over rock substrates and shoals in lakes and their eggs overwinter in the substrates. In Arctic environments, spawning must occur below the depth to which ice forms — typically 1.5 to 2 m in the LSA lakes (Volume 5, Section 3; Bathymetry and Limnology). Water withdrawal from lakes could decrease the water surface elevation under the ice, decreasing the availability of spawning habitat and potentially exposing overwintering eggs to air, resulting in mortality (Cott 2007).

Water withdrawal and use from lakes can also reduce discharge in lake outflow streams. Lower stream flows can influence fish habitat use in streams through numerous pathways associated with changes in water depth and velocity, changes in the timing of flows, decreases in the number of days stream habitat is accessible, and increases in the duration of already sensitive low flow periods (flow less than 30% Mean Annual Discharge; DFO 2013f). Arctic Char and other anadromous species including Lake Trout, ciscoes, and whitefish rely on stream habitats as migratory corridors during their seasonal migrations between freshwater overwintering/spawning and seasonal marine feeding habitats (Johnson 1980; Swanson et al. 2010a). Unimpeded access to critical summer feeding in marine habitats during freshet high flows (outmigration) and return migration during low flows (August to October) to critical spawning/overwintering is key to maintaining fisheries productivity of anadromous species such as juvenile and adult Arctic Char. Lower stream flows can influence water depth and velocity and the timing and duration of flow. In certain areas, reductions in streamflow can result in stream conditions that are impassable by fish and fish may become stranded and die (Rescan 2013b). Juvenile fish of the VEC species Arctic Char, Lake Trout, cisco, and whitefish as well as forage fish also rely on stream habitats as migratory corridors to move between freshwater waterbodies during the open water season (Evans, Reist, and Minns 2002; Hershey et al. 2006) and for rearing/feeding opportunities and predator avoidance (Evans, Reist, and Minns 2002). Since most arctic streams freeze to the bottom during winter, unimpeded access to overwintering habitat is also critical for survival.

Arctic Grayling

Arctic Grayling rely on stream habitats for critical spawning/egg incubation habitat in the spring, as well as for providing critical rearing/feeding habitat for newly-emerged fry and juveniles throughout the remainder of the open-water season (Stewart et al. 2007). Arctic Grayling spawn in streams in the early spring soon after ice-off (Stewart et al. 2007). Eggs incubate for two to three weeks, and alevins remain the gravel for up to five days after hatching. Fry typically stay in small streams throughout the summer, migrating towards lakes in the late summer before freeze-up (Scott and Crossman 1973; Stewart et al. 2007). Water withdrawal and use may potentially result in a reduction in the population abundance of Arctic Grayling if it causes spawning habitat to become exposed while eggs or alevins are incubating resulting in mortality, or if it inhibits spawning or migration. Arctic Grayling are also susceptible to stranding during the summer in isolated habitats if water levels drop.

As described above, the potential for direct mortality and reduction in population abundance of the fish community VECs due to water withdrawal and use is primarily due to losses or alterations of fish habitat (i.e., reductions in water volume and surface elevation in lakes and flow in streams) that result in the death of fish (i.e., stranding, exposure of eggs to air, under-ice oxygen depletion) or prevent fish from carrying out their life processes (i.e., changes in availability and access to spawning, rearing, migration, and overwintering habitats). As such, the assessment of effects of water withdrawal and use on the fish habitat VEC through the pathway of habitat loss or alteration (Section 6.5.4.2) is considered to adequately and comprehensively assess the effects of water withdrawal and use on the fish community VECs via the pathways of direct mortality and population abundance. Therefore, the effects of water withdrawal and use on fish community VECs are not discussed in this section.

The potential effects of water withdrawal and use on the fish habitat VEC are assessed in detail in Section 6.5.4.2. For the purpose of the assessment of water withdrawal and use on the fish habitat VEC, the potential effect of Phase 2 in isolation of Approved Projects is not assessed. Instead, the assessment is based on Phase 2 in combination with Approved Projects (i.e., the overall Hope Bay Project) relative to baseline flow projections as carried out in the effects assessment for surface hydrology (Volume 5, Section 1.5.4). Rationale for this method is summarized in Section 6.5.4.2; Characterization of Phase 2 Potential Effects. Briefly, the assessment of the fish habitat VEC was based on the Hope Bay Project (Phase 2 in combination with Approved Projects), but is conservatively also used for Phase 2 in isolation of Approved Projects.

Mitigation and Management Measures for Specific Potential Effects

Mitigation and management measures for specific potential effects on fish community VECs due to withdrawal for domestic and industrial use, drawdown through talik, and modification of natural drainage are reflected in the measures used to mitigate these same effects on fish habitat and are presented for the overall Hope Bay Project in Section 6.5.4.2 (Mitigation and Management Measures for Specific Potential Effects (Hope Bay Project)). These mitigation and management measures address effects to fish habitat that could result in the direct mortality or reduction in population abundance of the fish community VEC species including mitigation by design and fisheries offsetting. Mitigation by design includes the design and modification of migration channels downstream of Doris Lake (i.e., in Doris Outflow and/or Little Roberts Outflow) to maintain fish passage in areas that may become compromised by flow reductions associated with Hope Bay Project-related activities, and that may create barriers to migration, potentially lead to fish mortality from stranding.

Fisheries Offsetting

The purpose of a Fisheries Offsetting Plan (Appendix V5-6V), as per the guiding policies of DFO, is to maintain or improve the productivity of CRA fisheries. As described in Section 6.5.4.2, the Fisheries Offsetting Plan will address fish habitat losses related to water withdrawal and use from the Phase 2 Project, as deemed necessary and approved by DFO. Because the potential for direct mortality and reduction in population abundance of the fish community VECs due to water withdrawal and use results from losses or alterations of fish habitat, offsetting proposed to mitigate the effects on the fish habitat VEC will also mitigate effects on fish community VECs.

Finally, to prevent declines in water quantity and quality that could affect the survival of fish, water withdrawal for the construction of winter ice roads will adhere to DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2) and the *Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the Northwest Territories and Nunavut* (DFO 2010b):

- In one ice-covered season, total water withdrawal from a single waterbody is not to exceed 10% of the available water volume;
- In cases where there are multiple users withdrawing water from a single waterbody, the total combined withdrawal volume is not to exceed 10% of the available water volume; and
- Only waterbodies with maximum depths that are ≥1.5 m than their corresponding maximum expected ice thickness should be considered for water withdrawal.

While the fish habitat assessment and the applied mitigation were based on the Hope Bay Project (Phase 2 in combination with Approved Projects), they are also conservatively also used for Phase 2 in isolation of Approved Projects.

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans there are no residual effects anticipated on the freshwater fish community VECs due to Phase 2 Project water withdrawal and use.

Characterization of Hope Bay Project Potential Effect

As previously described, potential effects on the fish community VECs due to water withdrawal and use from the Hope Bay Project were adequately and comprehensively assessed in the assessment of the fish habitat VEC. The fish habitat assessment was based on the Hope Bay Project (Phase 2 in combination with Approved Projects), but is conservatively also used for Phase 2 in isolation of Approved Projects. Therefore potential effects of the Approved Projects that may interact with Phase 2 have been considered.

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans for both the Phase 2 Project and Approved Projects, there are no residual effects anticipated on the freshwater fish community VECs due to Hope Bay Project water withdrawal and use.

6.5.5.3 Direct Mortality and Population Abundance: Blasting

Characterization of Phase 2 Potential Effect

Detonation of explosives in or adjacent to fish habitat has been demonstrated to cause mortality, injury, and/or behavioural changes in fish and/or fish eggs and larvae (Wright and Hopky 1998; Faulkner et al. 2006). The detonation of explosives in or near water produces post-detonation compressive shock waves that result in a pressure deficit that can cause adverse impacts on fish such as swimbladder damage, hemorrhaging in various organs (e.g., kidney, liver, spleen and sinus venous), as well as death of fish eggs and larvae (Wright 1982; Faulkner et al. 2006; Kolden and Aimone-Martin 2013 and references therein). Vibrations from the detonation of explosives may also cause damage to incubating eggs (Wright 1982). Finally, noise produced by explosives can cause sublethal effects, such as changes in behaviour of fish. These effects may be intensified near ice and hard substrates.

Because the detonation of explosives in or adjacent to fish habitat may cause harm to fish or fish habitat (DFO 2013g), works involving the use of explosives near waterbodies must follow the recommendations developed by DFO provided in the "Guidelines for the use of explosives in or near Canadian fisheries waters" (Wright and Hopky 1998). These guidelines provide minimum setback distances for safe detonation based on type of fish habitat (e.g., active spawning [includes egg incubation] versus non-spawning-specific habitat). It is stipulated that no explosive can be detonated in or near fish habitat that produces, or is likely to produce, a peak particle velocity that is greater than 13 mm/s at spawning habitat during the period of egg incubation. Furthermore, no explosive can be detonated such that an instantaneous pressure change (IPC; i.e., overpressure) greater than 100 kPa in the swimbladder of a fish is produced. Proper adherence to these guidelines is not limited to, but may include knowing which waterbodies are in the vicinity of proposed blasting activities, the distance separating each waterbody and the point of detonation, species composition and associated life history information of each waterbody (i.e., critical timing windows, including spawning and egg incubation; DFO 2013h), and substrate type where the explosive will be detonated (Wright and Hopky 1998).

Effects on fish community VECs from blasting may occur where areas suitable for Phase 2 quarry development (i.e., Phase 2 quarries) are located adjacent to waterbodies that contain Lake Trout, Arctic Grayling, Arctic Char and/or Cisco/Whitefish or forage fish that support these species (e.g., Ninespine Stickleback and Slimy Sculpin). Prior to quarry development, the fish-bearing status of nearby waterbodies will be confirmed (based on fish community sampling and habitat conditions). Tables 6.2-22 and 6.2-23 describe the life history characteristics, spawning timing, and fry emergence timing for fish species present in the freshwater LSA and RSA. Blasting activities will consider seasonal variations in habitat use by the species present over the year. Potential effects of blasting on fish present in waterbodies located near quarries will be mitigated by adjusting the timing of blasting to avoid sensitive life stages of fish (e.g., incubating eggs) and by limiting the weight of explosive charges detonated simultaneously to avoid producing overpressure or ground vibrations that exceed DFO guidelines (Wright and Hopky 1998).

Waterbodies located in proximity to Phase 2 quarries where blasting has the potential to affect fish are identified, and the fish species captured in those waterbodies during baseline studies are presented, in Table A5-6U-1 of Appendix A5-6U. These waterbodies were identified based the waterbody being located with a setback distance contour calculated based on DFO guidelines of 100 kPa for overpressure and 13 mm/s for ground vibration (Wright and Hopky 1998) and representative worst-case blasting charges (two charge values were assessed based on historic blasting data at Doris; 90 kg and 162 kg). The same representative blasting charges were used to assess noise and vibration effects on human and wildlife receptors (Volume 4, Section 3; Noise and Vibration). Setback distances were calculated for rock substrates because areas suitable for quarry development are located in hard rock benches. Visual representations of setback distance contours around quarries are presented in Figures A5-6U-1 to A5-6U-8 in Appendix V5-6U.

Mitigation and Management Measures for Specific Potential Effects

When explosives are required to be used in or adjacent to fish bearing water, the potential for impacts to fish and fish habitat will be minimized by implementing the following measures based on DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g):

- In-water work requiring the use of explosives will adhere to appropriate fisheries timing windows prevent disruption of vulnerable fish life stages, including eggs and larvae.
- When necessary, the work site will be isolated to exclude fish from within the blast area by using bubble/air curtains (i.e., a column of bubbled water extending from the substrate to the water surface as generated by forcing large volumes of air through a perforated pipe/hose), cofferdams or aquadams.
- Any fish trapped within the isolated area will be removed and released unharmed beyond the blast area prior to initiating blasting.
- Blast charge weights will be minimized, possibly by subdividing each charge into a series of smaller charges in blast holes with a minimum 25 millisecond (1/1000 seconds) delay between charge detonations.
- Blast holes will be back-filled with sand or gravel to grade or to streambed/water interface to confine the blast.
- Blasting mats will be placed over top of holes to minimize scattering of blast debris around the area.
- Ammonium nitrate based explosives will not be used in water due to the production of toxic by-products.
- All blasting debris and other associated equipment/products will be removed from the blast area once compete.

Explosives use will employ the following additional guidelines for the use of explosives in or near waters taken from Wright and Hopky (1998):

- No explosive is to be detonated in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change (i.e., overpressure) greater than 100 kPa (14.5 psi) in the swimbladder of a fish.
  - For confined explosives, setback distances from the land-water interface (e.g., the shoreline), or burial depths from fish habitat (e.g., from under the riverbed) that will

ensure that explosive charges meet the 100 kPa overpressure guideline are shown in Table 1 of Wright and Hopky (1998).

- o No explosive is to be detonated that produces, or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during the period of egg incubation.
  - For confined explosives, setback distances or burial depths from spawning beds that will ensure that explosive charges meet the 13 mm/s guideline criteria are shown in Table 2 of Wright and Hopky (1998).
  - For unconfined explosives, the appropriate DFO Regional/Area authorities may be contacted for further guidance.

Explosives products will be stored on site in accordance with Territorial and Federal regulations. The main storage of ammonium nitrate is located at Doris, with secondary storage areas at Boston.

As a result of mitigation there are no residual effects anticipated on freshwater fish community VECs due to blasting associated with Phase 2 Project activities.

<u>Characterization of Hope Bay Project Potential Effect</u>

The potential for direct mortality and reduction in population abundance of fish community VECs due to blasting has been and will continue to be mitigated through the implementation of mitigation strategies (Volume 8, Management Plans; Annexes 17, 18, and 21).

As a result of mitigation and monitoring plans for both the Phase 2 Project and Approved Projects, there are no residual effects anticipated on freshwater fish community VECs due to blasting associated with Hope Bay Project activities.

6.5.5.4 Changes in Water Quality and/or Sediment Quality: Management of Contact Water, Effluent, and Dust

<u>Characterization of Phase 2 Potential Effect</u>

Potential effects of Project activities on the freshwater fish community VECs may occur through the deposition of deleterious substances in contact water (surface discharge), effluent (water discharge to the receiving environment), and/or dust. The deposition of deleterious substances and resulting potential changes in water quality and/or sediment quality could affect fish community VECs through the pathway of decreased health and indirect mortality. The assessment of Project effects on Freshwater Water Quality and Freshwater Sediment Quality were completed separately and independently in Volume 5, Sections 4 and 5 using indicators that have quantitative relationships or thresholds associated with supporting aquatic organisms and biogeochemical processes, including established guidelines for the protection of aquatic life. The assessment of residual effects on the VECs Freshwater Water Quality and Freshwater Sediment Quality can be found in Volume 5, Sections 4 and 5, respectively. No significant residual effects were identified. Therefore, the potential for effects of changes in water quality and/or sediment quality on freshwater fish community VECs through decreased health and indirect mortality, are not carried forward into subsequent sections of the assessment of the freshwater fish community VECs.

The potential for bioaccumulation of contaminants in Lake Trout, Arctic Grayling, Arctic Char, and Cisco/Whitefish is quantitatively assessed in the Human Health and Environmental Risk Assessment (Volume 6, Section 5) using receptor fish species representative of different freshwater trophic levels and habitat preferences (i.e., Ninespine Stickleback, Lake Whitefish, and Lake Trout). The primary exposure pathway for fish is direct contact with water and/or sediment. They could also be indirectly exposed through trophic effects if a bioaccumulative contaminant of potential concern (COPC; e.g., mercury and selenium). Estimation of risk to aquatic life ecological receptors including fish from COPCs were evaluated through the calculation of hazard quotients for existing conditions (see Volume 6, Section 5.5.4.2 for further information); no adverse effects to freshwater aquatic life were anticipated via this pathway under existing conditions. Similarly, because freshwater water quality is anticipated to meet all CCME marine water quality guidelines, no significant residual effects were concluded, thus no COPCs were identified and carried forward; Phase 2 Project-related changes to the health of ecological receptors including fish are therefore not expected and are not carried as a potential effect (Volume 6, Section 5.6.1.3).

<u>Mitigation and Management Measures for Specific Potential Effects</u>

Mitigation and management measures to avoid potential Phase 2 Project effects from changes in water quality and sediment quality can be found in section 4.5.3 of Volume 5, Section 4 (Freshwater Water Quality) and section 5.5.3 of Volume 5, Section 5 (Freshwater Sediment). Mitigation measures will also incorporate DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g; section 6.5.3.2), which specifically consider effects on water quality and sediment quality during in-water work that may affect fish and fish habitat (e.g., site selection, contaminant and spill management, erosion and sediment control). Finally, the AEMP (Volume 8, Management Plans; Section 2.17 and Annex 21) will monitor freshwater water quality and sediment quality, and results will indicate the need for adaptive management to avoid effects on fish and fish habitat.

As a result of mitigation and monitoring plans there are no residual effects anticipated on freshwater fish community VECs due to changes in water quality and/or sediment quality resulting from Phase 2 Project activities.

<u>Characterization of Hope Bay Project Potential Effect</u>

Effects on fish habitat resulting from changes in freshwater water quality and/or sediment quality resulting from Approved Project activities have been or will be mitigated through the implementation of biophysical management plans including an AEMP (Volume 8, Management Plans; Table 1.1-1). Therefore, there are no residual effects resulting from fish habitat loss or alteration from Approved Projects which could combine with Phase 2 effects.

As a result of mitigation and monitoring plans for both the Phase 2 Project and Approved Projects, there are no residual effects anticipated on freshwater fish community VECs due to changes in water quality and/or sediment quality resulting from Hope Bay Project activities.

6.5.6 Characterization of Project-related Residual Effects

6.5.6.1 Fish Habitat VEC

After considering mitigation, fisheries offsetting, and monitoring, no residual effects on the VEC fish habitat are anticipated as a result of Project-related activities. Consequently, no potential residual effects were evaluated for significance or carried forward to a cumulative effects assessment. Potential effects of the Phase 2 Project and other aspects of the Hope Bay Project on fish habitat are expected to be Not Significant.

6.5.6.2 Fish Community VECs

After considering mitigation, fisheries offsetting, and monitoring, no residual effects on the VECs Lake Trout, Arctic Grayling, Arctic Char, or Cisco/Whitefish are anticipated as a result of Project-related activities. Consequently, no potential residual effects were evaluated for significance or carried forward to a cumulative effects assessment. Potential effects of the Phase 2 Project and other aspects of the Hope Bay Project on fish habitat are expected to be Not Significant.

6.6 CUMULATIVE EFFECTS ASSESSMENT

6.6.1 Methodology Overview

The potential for cumulative effects arises when the potential residual effects of the Project affect (i.e., overlap and interact with) the same VEC that is affected by the residual effects of other past, existing or reasonably foreseeable projects or activities. When residual effects are present, the cumulative effects assessment (CEA) follows the general methodology described in Volume 2, Section 4 (Effects Assessment Methodology).

6.6.2 Potential Interactions of Residual Effects with Other Projects

6.6.2.1 Fish Habitat VEC

After considering mitigation, fisheries offsetting, and monitoring, no residual effects of Phase 2 Project activities or Hope Bay Project activities on the VEC fish habitat are predicted. Thus, there exists no potential for interactions with Projects – past, existing, or in the foreseeable future – for the VEC freshwater fish habitat and a CEA was not conducted (see CEA Methodology; Volume 2, Section 4).

6.6.2.2 Fish Community VECs

After considering mitigation, fisheries offsetting, and monitoring, no residual effects of Phase 2 Project activities or Hope Bay Project activities on the VECs Lake Trout, Arctic Grayling, Arctic Char, and Cisco/Whitefish are predicted. Thus, there exists no potential for interactions with Projects – past, existing, or in the foreseeable future – for the freshwater fish community VECs and a CEA was not conducted (see CEA Methodology; Volume 2, Section 4).

6.7 TRANSBOUNDARY EFFECTS

6.7.1 Methodology Overview

The Project EIS guidelines define transboundary effects as those effects linked directly to the activities of the Project inside the NSA, which occur across provincial, territorial, international boundaries or may occur outside of the NSA (NIRB 2012a) Transboundary effects of the Project have the potential to act cumulatively with other projects and activities outside the NSA.

6.7.2 Potential Transboundary Effects

6.7.2.1 Fish Habitat VEC

After considering mitigation, fisheries offsetting, and monitoring, no residual effects of Phase 2 Project activities or Hope Bay Project activities on the VEC fish habitat are predicted. Thus, no transboundary effects on the VEC freshwater fish habitat are expected to occur.

6.7.2.2 Fish Community VECs

After considering mitigation, fisheries offsetting, and monitoring, no residual effects of Phase 2 Project activities or Hope Bay Project activities on the VECs Lake Trout, Arctic Grayling, Arctic Char, and Cisco/Whitefish are predicted. Thus, no transboundary effects on the freshwater fish community VECs are expected to occur.

6.8 IMPACT STATEMENT

The VEC freshwater fish habitat comprises both the physical habitat and the biological resources that are necessary for the productivity of fisheries species. Freshwater fish habitat may interact with and be affected by Phase 2 activities along two general pathways: through a direct loss or alteration of fish habitat by permanent alteration or destruction (PAD), or through changes to water quality and/or sediment quality arising from the deposition of deleterious substances.

A PAD is a *direct* loss or alteration of fish habitat area potentially incurred through planned construction (e.g., encroachment of infrastructure on existing fish habitat) or water withdrawal. Waterbodies with the potential for effects from encroachment of the Phase 2 infrastructure footprint include waterbodies crossed by all-weather roads, Aimaokatalok Lake where a water intake and discharge pipe will be constructed, and lakes, streams, and ponds along the seasonal winter road route. The primary mitigation measure is siting Project infrastructure to avoid fish-bearing water. Additional mitigation includes best management practices to minimize alteration of fish habitat during in-water work including include DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g). Localized areas of fish-bearing stream habitat loss or permanent alteration will occur in up to 21 streams as a result of the placement of culverts or bridge support structures at road crossings. Habitat losses or permanent alterations will also occur in Aimaokatalok Lake due to the construction or upgrading of water intakes and discharge pipes and associated armouring of these structures (which may be considered a form of self-offsetting). Unavoidable habitat loss or alteration due to Phase 2 infrastructure will be mitigated through fisheries offsetting to balance all fish habitat losses, as deemed necessary by DFO. A Fisheries Offsetting Plan, including the detailed description of habitat losses, fisheries offsetting options and proposed monitoring plan, will be developed prior to an Application for a *Fisheries Act Authorization* and prior to effects occurring.

Water for domestic and industrial use for the Phase 2 Project will be drawn from Doris, Windy, and Aimaokatalok lakes. Other Phase 2 Project-related effects that may result in a decrease in water elevation, volume, or discharge in fish-bearing freshwater waterbodies include drawdown of water through talik to underground workings and the modification of natural drainages (i.e., contact water diversion and discharge and modification of runoff at disturbed sites). Water withdrawal from lakes has the potential to affect fish habitat through multiple pathways, including a reduction in available fish habitat, changes to primary and secondary producers, and a reduction in discharge volume at lake outflows. Water withdrawal from lakes may cause a decrease in the amount and suitability of overwintering or spawning habitat available for fish or potentially expose overwintering eggs of Lake Trout, Arctic Char, cisco or whitefish species to air (Cott 2007). Reduction in discharge at lake outflow streams can result in a reduction of available or suitable fish habitat for migration, rearing, and spawning (Arctic Grayling). Lower stream flows can influence the ability for fish passage and result in fish stranding through changes in water depth and velocity, changes in the timing of flows, decrease in the number of days stream habitat is accessible, and increase the duration of sensitive periods (flow less than 30% Mean Annual Discharge; DFO 2013f).

The primary mitigation measure for effects of water withdrawal and use is by limiting the amount of water withdrawn from each waterbody by recycling water, limiting groundwater inflows to underground workings, and returning compliant effluent to waterbodies from which they were withdrawn. To mitigate the potential effects of altered stream flows downstream of Doris Lake (i.e., in Doris Outflow and Little Roberts Outflow) and to maintain fish migration potential (i.e., fish passage) between Roberts Bay and Roberts Lake, fish migration channels will be modified through sections of Little Roberts Outflow that may become compromised by flow reductions. Habitat loss or alteration is predicted to occur in at other locations in the Doris Watershed (Imniagut Lake and Outflow, Wolverine

Outflow, Ogama Outflow) due to reductions in lake volume, lake surface elevation, and/or discharge in lake outflow streams and will be mitigated through fisheries offsetting to balance all fish habitat losses, as deemed necessary by DFO. A Fisheries Offsetting Plan, if deemed necessary by DFO, including the detailed description of habitat losses, fisheries offsetting options, and proposed monitoring plan, will be developed prior to an Application for a *Fisheries Act Authorization* and prior to effects occurring.

The introduction of deleterious substances could alter fish habitat *directly* by changes in water quality and/or sediment quality to the extent that fish health decreases and mortality occurs, or *indirectly*, through trophic interactions with biological resources used by fish. Potential effects of Phase 2 Project activities on the VEC freshwater fish habitat may occur through the deposition of deleterious substances in contact water (surface discharge), effluent (water discharge to the receiving environment), and/or dust. The deposition of deleterious substances could affect fish habitat through effects water quality, sediment quality, and/or on biological resources (primary and secondary producers, forage fish). Project activities that affect primary and secondary producers through the deposition of deleterious substances result from *indirect* trophic level interactions which are predominantly due to changes in water quality and/or sediment quality. No significant residual effects were concluded for either the Freshwater Water Quality and/or Freshwater Sediment Quality VECs (Volume 5, Sections 4 and 5, respectively).

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans there are no residual effects anticipated on the VEC freshwater fish habitat due to the Phase 2 Project or the Hope Bay Project.

As no Project residual effects are anticipated, there are no potential residual effects that could act cumulatively with other project potential effects. Therefore no cumulative effects or transboundary effects are expected on the VEC freshwater fish habitat.

The freshwater fish community comprises the survival and abundance of individual fish VECs including Lake Trout, Arctic Grayling, and the freshwater life histories of Arctic Char and Cisco/Whitefish (including Lake Whitefish, Broad Whitefish, Cisco, and Least Cisco). The freshwater fish community may interact and be affected by Phase 2 activities along two general pathways: through *direct* mortality and changes to population abundance, or through decreased health and *indirect* mortality resulting from changes in water quality and/or sediment quality.

Direct mortality and changes to population abundance may potentially occur during the construction of in-water infrastructure and any Phase 2 activities that physically harm fish through blasting, water withdrawal, impact injury (e.g., interactions with industrial equipment), and spills, accidents and malfunctions. The potential for direct mortality or reduction in population abundance of fish community VECs during the construction of water crossings along the all-weather roads and the construction of the water intake and discharge pipe in Aimaokatalok Lake exists only if in-water work is completed outside of restricted activity timing windows and if appropriate mitigation is not followed (i.e., DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat; DFO 2013g). Direct mortality to freshwater fish community VECs may also be caused by entrainment or impingement through improper design and installation of pumps and intake and discharge pipe systems located in fish habitats and used for water withdrawal. To mitigate this effect, intakes will be screened according to DFO’s Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g). Finally, fish population abundance could be affected through alterations in lake and stream spawning habitats, and alterations in access to stream habitats by fish community VECs resulting from seasonal construction of the winter road route. Best management practices demonstrated to effectively mitigate the direct effects of ice bridges and snow fills on fish will be applied.

The potential for direct mortality and reduction in population abundance of the fish community VECs due to water withdrawal and use is primarily due to losses or alterations of fish habitat (i.e., reductions in water volume and surface elevation in lakes and flow in streams) that result in the death of fish (i.e., stranding, exposure of eggs to air, under-ice oxygen depletion) or prevent fish from carrying out their life processes (i.e., changes in availability and access to spawning, rearing, migration, and overwintering habitats). As such, the assessment of effects of water withdrawal and use on the fish habitat VEC through the pathway of habitat loss and/or alteration also is considered to be adequately and comprehensively inclusive of the potential effects of water withdrawal and use on the fish community VECs via the pathways of direct mortality and population abundance. Mitigation measures, including fisheries offsetting, applied to the effects on fish habitat due to water withdrawal and use are also effective in mitigating and offsetting the effects to fish community VECs.

Effects on fish community VECs from blasting may occur where areas suitable for Phase 2 quarry development (i.e., Phase 2 quarries) are located adjacent to waterbodies that contain Lake Trout, Arctic Grayling, Arctic Char and/or Cisco/Whitefish or forage fish that support these species (e.g., Ninespine Stickleback and Slimy Sculpin). Detonation of explosives in or adjacent to fish habitat has been demonstrated to cause mortality, injury, and/or behavioural changes in fish and/or fish eggs and larvae (Wright and Hopky 1998; Faulkner et al. 2006). When explosives are required to be used in or adjacent to fish bearing water, the potential for impacts to fish and fish habitat will be minimized by implementing the following measures based on DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013g). Explosive use will employ the additional guidelines for the use of explosives in or near waters where no explosive is to be detonated in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change (i.e., overpressure) greater than 100 kPa (14.5 psi) in the swimbladder of a fish or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during the period of egg incubation.

For the pathway of effects on fish community VECs of decreased health and *indirect* mortality, potential changes in water quality and/or sediment quality resulting from contact water, fugitive dust, and planned discharge of water/effluent to the receiving environment could have chronic effects on fish community VECs. The deposition of deleterious substances and resulting potential changes in water quality and/or sediment quality could affect fish community VECs through the pathway of decreased health and indirect mortality. The assessment of Project effects on Freshwater Water Quality and Freshwater Sediment Quality were completed separately and independently in Volume 5, Sections 4 and 5 using indicators that have quantitative relationships or thresholds associated with supporting aquatic organisms and biogeochemical processes, including established guidelines for the protection of aquatic life. The potential for bioaccumulation of contaminants in Lake Trout, Arctic Grayling, Arctic Char, and Cisco/Whitefish is quantitatively assessed in the Human Health and Environmental Risk Assessment (Volume 6, Section 5) using receptor fish species representative of different freshwater trophic levels and habitat preferences (i.e., Ninespine Stickleback, Lake Whitefish, and Lake Trout). The primary exposure pathway for fish is direct contact with water and/or sediment. They could also be indirectly exposed through trophic effects if a bioaccumulative contaminant of potential concern (COPC; e.g., mercury and selenium). Estimation of risk to aquatic life ecological receptors including fish from COPCs were evaluated through the calculation of hazard quotients for existing conditions (see Volume 6, Section 5.5.4.2 for further information); no adverse effects to freshwater aquatic life were anticipated via this pathway under existing conditions. Similarly, because freshwater water quality is anticipated to meet all CCME marine water quality guidelines, no significant residual effects were concluded, thus no COPCs were identified and carried forward; Phase 2 Project-related changes to the health of ecological receptors including fish are therefore not expected and are not carried as a potential effect (Volume 6, Section 5.6.1.3).

As a result of mitigation, balancing fisheries losses with fisheries offsetting, and monitoring plans there are no residual effects anticipated on the freshwater fish community VECs due to the Phase 2 Project or the Hope Bay Project.

As no Project residual effects are anticipated, there are no potential residual effects that could act cumulatively with other project potential effects. Therefore no cumulative effects or transboundary effects are expected on the freshwater fish community VECs.

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