APPENDIX 15-R
HADD FISH HABITAT COMPENSATION PLAN

Seabridge Gold Inc.

KSM PROJECT
HADD Fish Habitat Compensation Plan

SEABRIDGE GOLD







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KSM PROJECT
HADD FISH HABITAT COMPENSATION PLAN

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SEABRIDGE GOLD

Seabridge Gold Inc.

Prepared by:

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Executive Summary

This report presents a fish habitat compensation plan for the proposed KSM Project (the Project). This plan has been developed with Fisheries and Oceans Canada (DFO), the British Columbia Ministry of Environment, and Aboriginal groups (Section 11 Order) as part of the KSM Project Technical Working Group. The purpose of this compensation plan is to ensure that the Project follows DFO's habitat compensation measures required to offset loss of the productive capacity of fish habitat.

This report is concerned exclusively with fish habitat compensation required due to the unavoidable loss of fish habitat caused by construction and operation of the Project. These habitat losses will be caused by dams, road crossing structures, transmission line crossings, and water quantity reductions in South Teigen and North Treaty creeks downstream of the dams. Compensation for the loss of this fish habitat is governed by Section 35(2) of the *Fisheries Act* (1985).

A companion report presents a fish habitat compensation plan for habitat that will be lost due to construction of tailing management facilities (TMF) in areas occupied by natural waterbodies. That plan is called the MMER plan because the loss of fish habitat is governed by Section 36(1) of the *Metal Mining Effluent Regulations* (SOR/2002-222).

The objectives of the compensation plan are to follow DFO's regulatory requirements for Fisheries Authorizations, including to:

- describe the physical and biological characteristics of the habitat that will be lost;
- propose technically feasible compensations projects, as per regulatory requirements, that will provide compensatory habitat at a minimum 2:1 ratio;
- describe the methods that were used to prepare a habitat budget;
- describe the methods that will be used to mitigate the effects of habitat construction; and
- describe the post-monitoring evaluation program.

Field assessments implemented in 2008 and 2009 provided the information necessary to describe the physical habitat (bankfull width, bankfull depth, gradient, stream length, etc.) and biological attributes (riparian cover, instream cover, fish community) of each stream and reach where a loss of fish habitat will occur within the TMF. This information was used to assign fish habitat suitability indices to each stream and wetland.

The total area of habitat that will be lost was calculated from the proposed design of Project infrastructure and the results of water quantity modelling. By multiplying each area by the appropriate Habitat Suitability Index (HSI), habitat units (HUs) were calculated that incorporate both quantity and quality of habitat.

Pre-field planning and field assessments implemented in 2009, 2010, and 2011 provided the information necessary to identify technically feasible compensation projects. Two compensation projects in the Teigen and Glacier creek watersheds were identified as compensation sites to offset fish habitat loss. Existing site conditions, project objectives and techniques, and designs are discussed for each project within the report. The number of HUs that will be created are presented for each project.

The Habitat Evaluation Procedure was used to prepare a habitat budget. Peer-reviewed HSIs were used for HU calculation. A peer-reviewed habitat suitability model does not exist for Dolly Varden, hence HSI values were obtained from a search of the scientific literature on Dolly Varden habitat preferences.

A total area of 53,734 m^2 (5.37 ha) of fish habitat will be lost from TMF and seepage pond dams, access road crossings, transmission line crossings, and water quantity reductions in North Treaty and South Teigen creeks downstream of the dams. This represents a total of 91,115 HUs.

A total area of 165,694 m^2 (16.57 ha) of fish habitat will be created as a result of the Teigen and Glacier creeks technically feasible compensation projects. This represents a total of 300,917 HUs.

The ratio of compensatory habitat area to lost habitat area is 3.1:1. The ratio of compensatory HUs to lost HUs is 3.3:1, which is greater than the minimum 2:1 ratio typically requested by DFO. Therefore, the requirements to compensate for Project-related fish habitat loss have been achieved. However, when fish habitat compensation construction proceeds, projects will be built according to a 2:1 ratio of compensatory HUs to lost HUs.

Acknowledgements

This report was prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd. The project was managed, and this report written, by Christopher Burns (B.Sc., R.P.Bio.). Other contributors to the report were Steve Jennings (B.Sc., R.P.Bio.) and Kyla Warren (M.Sc.). Bob Askin (P.Eng.), Doug Griffin (RPF), and David Luzi (M.Sc.) provided technical field experience related to fish habitat compensation planning and design. François Landry (M.Sc., R.P.Bio.) provided senior technical review and support. Report production was coordinated by Robert Tarbuck (Word Processing), Francine Alford (Graphics) and Pieter van Leuzen (GIS).

KSM PROJECT
HADD FISH HABITAT COMPENSATION PLAN

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Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BACI	Before After Control Impact
BC	British Columbia
BC MOE	British Columbia Ministry of Environment
BC MOF	British Columbia Ministry of Forests
BC MWLAP	British Columbia Ministry of Water, Land and Air Protection
BMP	best management practice
DFO	Fisheries and Oceans Canada
FHAP	fish habitat assessment procedure
FINS	FINS Consulting Ltd.
HADD	harmful alteration, disruption, or destruction
HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability Index
HU	Habitat Unit
HWM	high water mark
LWD	large woody debris
MAD	mean annual discharge
MAF	mean annual flow
masl	metres above sea level
MMER	Metal Mining Effluent Regulations (SOR/2002-222)
Plan, the	the HADD Fish Habitat Compensation Plan
Project, the	the KSM Project
Q100	one-in-one hundred year flood
RISC	Resources Information Standards Committee
REE	routine effectiveness evaluation
Rescan	Rescan Environmental Services Ltd.
SE	standard error
Seabridge	Seabridge Gold Inc.
SHIM	Sensitive Habitat Inventory Mapping
SI	suitability index
TMF	tailing management facility
UTM	Universal Transverse Mercator
WUA	weighted usable area

1. Introduction

1.1 PROJECT PROPONENT

Seabridge Gold Inc. (Seabridge) is the proponent for the proposed KSM Project (the Project), a gold, copper, silver, molybdenum mine.

1.2 PROJECT LOCATION

The Project is located in the coastal mountains of northwestern British Columbia. It is approximately 950 km northwest of Vancouver and 65 km northwest of Stewart, within 30 km of the British Columbia–Alaska border (Figure 1.2-1).

1.3 PROJECT OVERVIEW

The Project is located in two geographical areas: the Mine Site and Processing and Tailing Management Area (PTMA), connected by twin 23-km tunnels, the Mitchell-Treaty Twinned Tunnels (Figure 1.3-1). The Mine Site is located south of the closed Eskay Creek Mine, within the Mitchell, McTagg, and Sulphurets Creek valleys. Sulphurets Creek is a main tributary of the Unuk River, which flows to the Pacific Ocean. The PTMA is located in the upper tributaries of Teigen and Treaty creeks. Both creeks are tributaries of the Bell-Irving River, which flows to the Nass River and into the Pacific Ocean. The PTMA is located about 19 km southwest of Bell II on Highway 37.

The Unuk and Bell-Irving rivers are large river systems with significant fisheries and cultural value. They provide important spawning routes for Pacific salmon (all species) and anadromous steelhead trout, as well as habitat for resident trout (cutthroat and rainbow), resident char (Dolly Varden and bull trout), and mountain whitefish.

The Mine Site will be accessed by a new road, the Coulter Creek Access Road, which will be built from km 70 on the Eskay Creek Mine Road. This road will follow Coulter and Sulphurets creeks to the Mine Site. The PTMA will also be accessed by a new road, the Treaty Creek Access Road, the first 3-km segment of which is a forest service road off of Highway 37. The Treaty Creek Access Road will parallel Treaty Creek.

Four deposits will be mined at the KSM Project—Kerr, Sulphurets, Mitchell, and Iron Cap—using a combination of open pit and underground mining methods. Waste rock will be stored in engineered rock storage facilities located in the Mitchell and McTagg valleys at the Mine Site. Ore will be crushed and transported through one of the Mitchell-Treaty Twinned Tunnels to the PTMA. This tunnel will also be used to route the electrical power transmission lines. The second tunnel will be used to transport personnel and bulk materials. The Process Plant will process an average of 130,000 tpd of ore to produce a daily average of 1,200 t of concentrate. Tailing will be pumped to the Tailing Management Facility from the Process Plant. Copper concentrate will be trucked from the PTMA along highways 37 and 37A to the Port of Stewart, which is approximately 170 km away via road.

The mine operating life is estimated at 51.5 years. Approximately 1,800 people will be employed annually during the Operation Phase. Project Construction will take about five years, and the capital cost of the Project is approximately US$5.3 billion.



Figure 1.2-1

SEABRIDGE GOLD
KSM PROJECT

KSM Project Location

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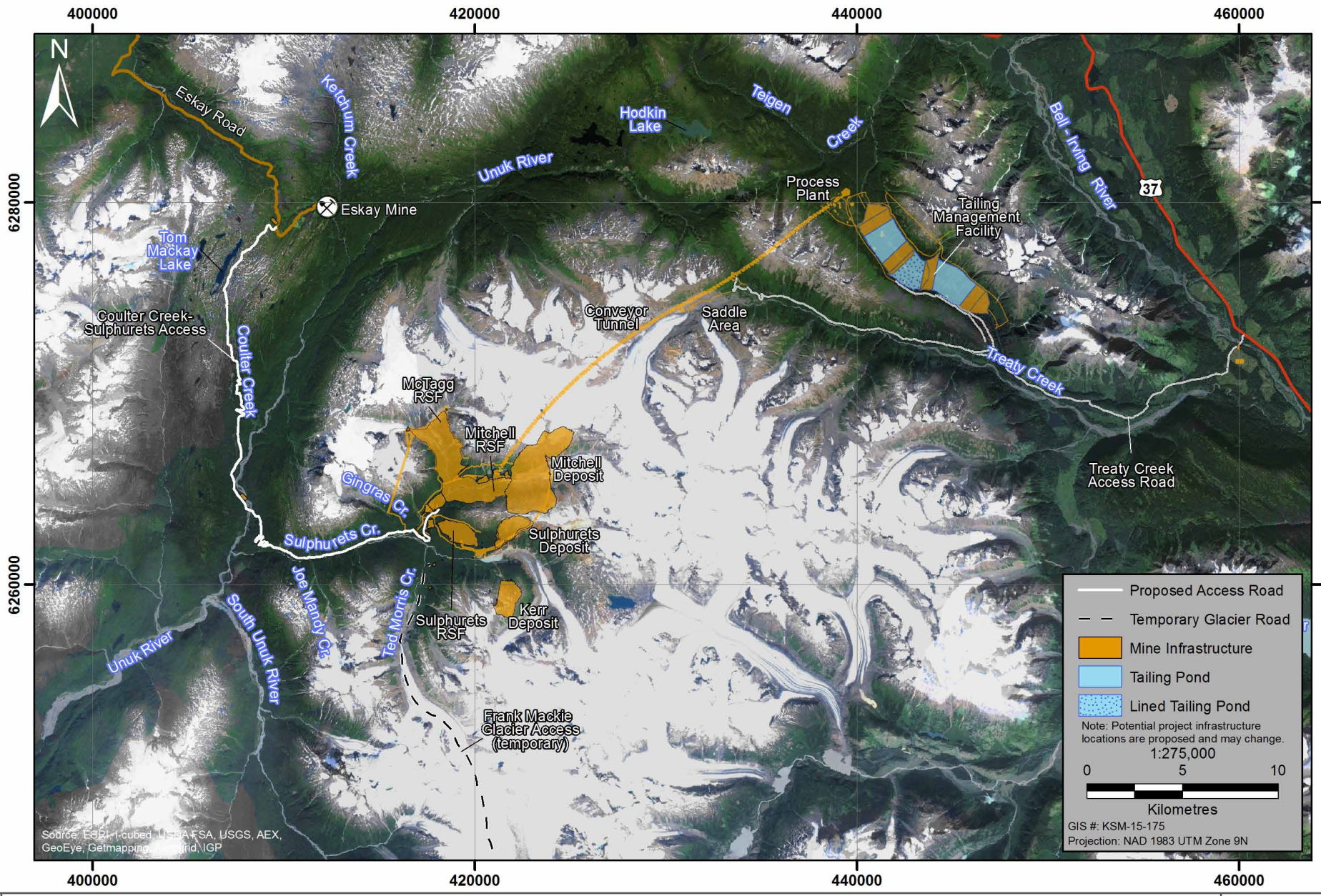


Figure 1.3-1

SEABRIDGE GOLD
KSM PROJECT

KSM Project Layout

Figure 1.3-1

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Some of the Project infrastructure (i.e., dams, road crossing structures, and transmission line crossings) will require an authorization pursuant to the *Fisheries Act* (1985) to permit the destruction or disruption of fish habitat. This report is concerned exclusively with fish habitat compensation for habitat impacts produced by the construction and operation of Project infrastructure such as dams, road crossing structures, transmission line crossings, and water quantity reductions in South Teigen and North Treaty creeks downstream of the dams. Habitat impacts will be caused by the installation of bridge pilings and rip-rap, redirection of stream channels and construction of the road bed over habitat. Habitat will also be temporarily lost at interim crossings where construction is planned.

A companion document entitled *KSM Project: MMER Fish Habitat Compensation Plan* (Rescan 2012c) presents a compensation plan for fish habitat that will be lost due to the creation of TMF from natural waterbodies. That plan is called the MMER plan because the loss of fish habitat is governed by Section 36(1) of the *Metal Mining Effluent Regulations* (SOR/2002-222).

The HADD Fish Habitat Compensation Plan (the Plan) has been developed with input from Fisheries and Oceans Canada (DFO), the British Columbia Ministry of Environment (BC MOE), and Aboriginal groups based on working group meetings and consultation. The Plan has been developed according to guidelines developed by DFO's Environmental Assessment Analyst for the KSM Project on July 27, 2010 (Appendix 1.1-1). The purpose is to ensure that the Project follows DFO's *No Net Loss* principle for the management of fish habitat (DFO 1986) and to follow legislated requirements under the *Fisheries Act* (1985).

1.4 REGULATORY FRAMEWORK

1.4.1 Legislation

In June 2012, the federal government proposed amendments to the *Fisheries Act* (1985). Proposed changes to the *Fisheries Act* would result in a shift for DFO from a focus on managing impacts to all fish habitat, to managing threats to fisheries. These amendments would support the long-term productivity and sustainability of Canada's commercial, recreational, and Aboriginal fisheries. The current *Fisheries Act* provisions used for the review of project impacts are indiscriminate and require consideration of all projects, on all waters, regardless of the importance of fish species present or their contribution to fisheries.

Currently, DFO is in a transition phase with respect to implementing *Fisheries Act* (1985) legislative changes. During the transition phase, the existing provision of the *Fisheries Act* will continue to apply. The transition phase is expected to last until January 2013, when the legislative changes are expected to come into force. Following the legislative changes, DFO's *Policy for Management of Fish Habitat* (1986) and guiding principle of *No Net Loss* will be changed. However, details on the timing of policy changes are unknown at the time of the Plan's production. Therefore, the current *Fisheries Act* (19845) legislation and policies are discussed below because they set the stage for how the Plan was developed.

Fish and fish habitat are protected under a variety of federal and provincial regulatory acts and principles. The *Fisheries Act* (1985) prohibits the harmful alteration, disruption, or destruction (HADD) of fish habitat through physical, chemical, or biological means. The *Policy for the Management of Fish Habitat* (DFO 1986) puts forth the principle of no net loss of productive capacity of fish habitat (*No Net Loss*).

Under Section 35(2) of the *Fisheries Act* (1985), any project or activity that causes a HADD requires an authorization from DFO. The *Fisheries Act* defines fish habitat as "spawning grounds, nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their

life processes." Included in this definition are both fish-bearing and non-fish bearing waterbodies, including the surrounding riparian area and fisheries sensitive zones.

Seabridge Gold Inc. (Seabridge) proposes to develop the Project; therefore, a fish habitat compensation plan must be developed to ensure no net loss of fish habitat results from the Project.

The fish habitat definition is articulated by DFO in a decision framework that evaluates the type and magnitude of potential changes to aquatic habitat by posing five questions. By answering these questions, DFO gathers information necessary to support a decision on whether a HADD is created and if so, whether the HADD can be authorized. The HADD decision framework (DFO 1998) asks these questions:

1. Is fish habitat present at the project site or in an area potentially impacted by the project?
2. Could the proposed project cause a HADD of fish habitat?
3. Can the impacts to fish habitat be fully mitigated?
4. Should the HADD be authorized?
5. Can the HADD be compensated?

1.4.2 The *No Net Loss* Principle

The objective of the DFO *No Net Loss* principle is to balance unavoidable habitat losses with habitat replacement. This principle prevents further reductions to fish populations and fish habitat. *No Net Loss* is achieved through a hierarchy of preferences (DFO 1998):

- avoidance of a HADD through the redesign of the project;
- compensation by replacing lost habitat with similar habitat in the same ecological unit (i.e., like-for-like compensation);
- compensation by increasing the productive capacity of existing habitat with unlike habitat in the same ecological unit;
- compensation by replacing lost habitat with natural habitat in another ecological unit; and
- compensation by using artificial production (i.e., building hatcheries or fertilizing lakes).

In developing a compensation plan, a key guiding principle is to ensure the amount of compensation is equal to at least a 2:1 gain to loss ratio to ensure certainty of success to maintain the overall net productive capacity.

1.5 OBJECTIVES AND APPROACH

The primary objective of Seabridge is to work in a collaborative, open manner to compensate for Project-related fish habitat lost by enhancing existing habitat or creating habitat using a variety of techniques and projects to benefit fish and aquatic habitat.

In developing the Plan for the Project, the general approach follows that of DFO's (1986) *Policy for Management of Fish Habitat* guiding principle of *No Net Loss*. Through the hierarchy described above and procedures outlined in the policy, the *No Net Loss* principle is designed to be flexible in finding a solution to managing fish habitat.

The Plan has been developed so that regulatory agencies and Aboriginal groups can review the approach, and Seabridge has proposed technically feasible compensation projects. To be transparent,

each procedural approach in the development of the Plan and compensation projects has been further subdivided and presented below:

- **Fish and aquatic habitat data compilation** – Relevant fish and fish habitat information within and outside of the fisheries study area was obtained from a variety of sources. These sources include, but are not limited to, environmental assessments, provincial and federal databases and reports, Aboriginal group databases and reports, and consultant and industry reports.
- **Determination of predicted Project effects** – Using the data collated in Rescan baseline reports (Rescan 2009, 2010, 2011a, 2012a, 2012b) and the Project description, the predicted Project effects to fish and fish habitat were assessed (Rescan 2012b).
- **Habitat evaluation and habitat loss calculation** – Review and calculation of fish habitat loss (i.e., HADDs). Calculation of habitat loss was based upon the Habitat Evaluation Procedure (HEP) developed by the US Fish and Wildlife Service (1980).
- **Watershed analysis** – Review and determination of limiting habitat factors affecting the productive capacity of fish habitat within and outside of study area watersheds.
- **Regional objectives identification** – A review of federal (e.g., DFO) and provincial (e.g., BC MOE) fisheries management objectives for fish and fish habitat was completed and used to select and evaluate potential compensation projects.
- **Aboriginal groups** – Traditional knowledge and traditional use information, gathered through fisheries working group meetings, consultation, and reports, was used in baseline data collection and incorporated into the process of identifying compensation projects. Further traditional knowledge will be incorporated as the Plan develops.
- **Option compilation** – Conceptual habitat compensation options were identified through desktop analysis and fieldwork.
- **Species at risk and rare ecosystems identification** – Compensation projects were reviewed as they pertain to compliance with federally listed species, under the *Species at Risk Act* (2002), and provincially rare species/ecosystems.
- **Option analysis** – Each compensation option was assessed against a series of environmental and habitat screening criteria. Based on this analysis, the most suitable projects were selected for further analysis. Technical feasibility designs were completed for the most suitable projects.

Details regarding the above procedural approach are discussed in following sections.

2. Project Overview and Fisheries Resources

2.1 PROJECT OVERVIEW

This HADD compensation plan deals specifically with the loss of fish habitat resulting from Project infrastructure such as TMF dams, seepage pond dams, access road and transmission line crossings, and water quantity loss. Habitat effects resulting from filling of the TMF are discussed in the MMER compensation plan (Rescan 2012c).

2.1.1 Tailings Management Facility Infrastructure

The proposed TMF is situated within the South Teigen and North Treaty creeks watersheds (Figure 2.1-1). South Teigen and North Treaty creeks possess watershed areas of 61 and 33 km^2, respectively. Within the South Teigen and North Treaty creeks watersheds, the proposed TMF encompasses 12.6% (7.7 km^2) and 14.5% (4.8 km^2), respectively.

South Teigen Creek originates from a glacier on the eastern hillslope and flows into a broad, flat valley surrounded by wetland fen habitat (Plates 2.1-1 and 2.1-2). The creek gradient then increases, flowing through a confined valley with a 2.5 m falls (Plates 2.1-3 and 2.1-4). Downstream of the falls, the creek flows through an unconfined valley and discharges into Teigen Creek (Plate 2.1-5).

North Treaty Creek originates from two sources: an eastern hillslope and a wetland complex on the valley floor. The eastern hillslope provides a significant water source during the freshet and early summer, after which the flow is reduced (Plate 2.1-6). The wetland complex provides continuous water sources throughout the year (Plate 2.1-7). Both water sources merge to form North Treaty Creek. The creek flows in a low gradient valley surrounded by riparian shrub habitat (Plate 2.1-8). The creek gradient then increases, flowing through a confined valley (Plate 2.1-9) and discharging into a larger tributary. The larger tributary, called Tumbling Creek for the purposes of this report, originates from the eastern hillslope and eventually discharges into Treaty Creek (Plate 2.1-10).

Two dams will be constructed, one on each end of the TMF (north and south dam; Figure 2.1-1), with storage capacity for the life of the Project within an area 8 km long and 1.5 km wide. Two dams will be constructed within the TMF: the Splitter Dam and Saddle Dam. These dams will form a lined pond within the TMF. A temporary Saddle Seepage Collection Dam will be constructed during the operation of the North TMF Cell. When the South TMF Cell is constructed, the Saddle Seepage Collection Dam will be flooded with tailings. Any seepage from the dams will be collected in ponds below the dams and pumped back into the impoundment to reduce any potential effect on downstream drainages. Water diversion channels will be constructed on both flanks of the impoundment, where feasible, to divert clean water away from the impoundment. Supernatant water will be recovered from the impoundment using barge-mounted pumps and recycled to the plant for process water.

2.1.2 Access Roads and Transmission Line

There are two proposed access roads that may produce HADDs of fish habitat: Treaty Creek Access Road and Coulter Creek Access Road (Figures 2.1-2 and 2.1-3). The Treaty Creek Access Road will begin at Highway 37 and terminate at the Treaty tunnel portal. A spur road will commence at North Treaty Creek and terminate at the Process Plant. The Coulter Creek Access Road will commence at km 70 on the Eskay Creek Mine Road and terminate in the Mitchell Creek crossing. The Coulter Creek Access Road is located within the Coulter, Unuk, Sulphurets, and Mitchell watersheds.

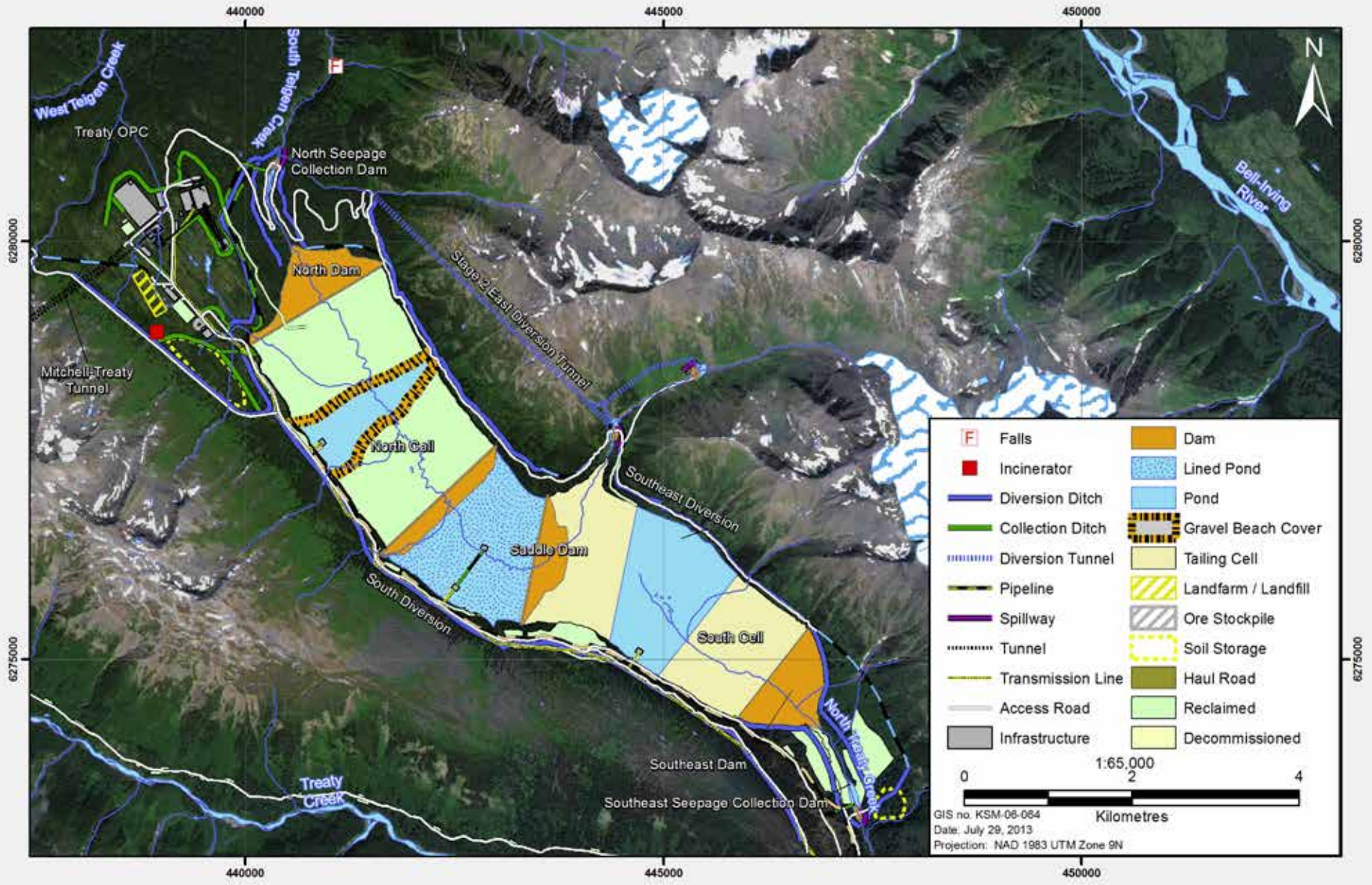


Figure 2.1-1

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Proposed TMF within South Teigen and North Treaty Creeks

Figure 2.1-1

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Plate 2.1-1. South Teigen Creek along eastern hillslope.



Plate 2.1-2. South Teigen Creek within flat valley.



Plate 2.1-3. South Teigen Creek within confined valley.



Plate 2.1-4. South Teigen Creek falls.



Plate 2.1-5. South Teigen Creek downstream of falls.



Plate 2.1-6. North Treaty Creek along eastern hillslope.



Plate 2.1-7. North Treaty Creek wetland complex.



Plate 2.1-8. North Treaty Creek within low gradient valley.



Plate 2.1-9. North Treaty Creek within confined valley.



Plate 2.1-10. Tumbling Creek downstream of North Treaty Creek confluence.

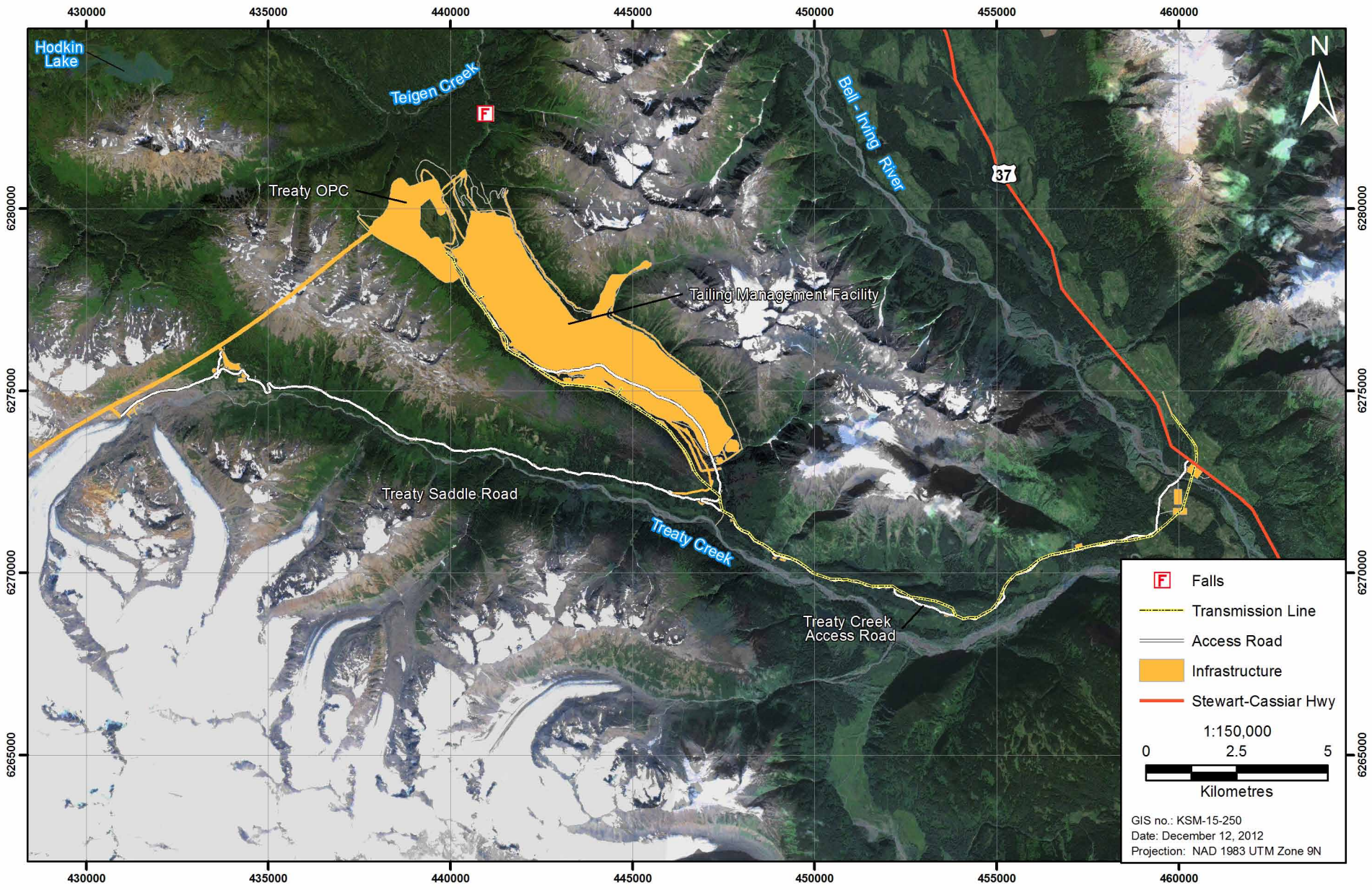


Figure 2.1-2

SEABRIDGE GOLD
KSM PROJECT

Proposed Treaty Access Road and Transmission Line

Figure 2.1-2

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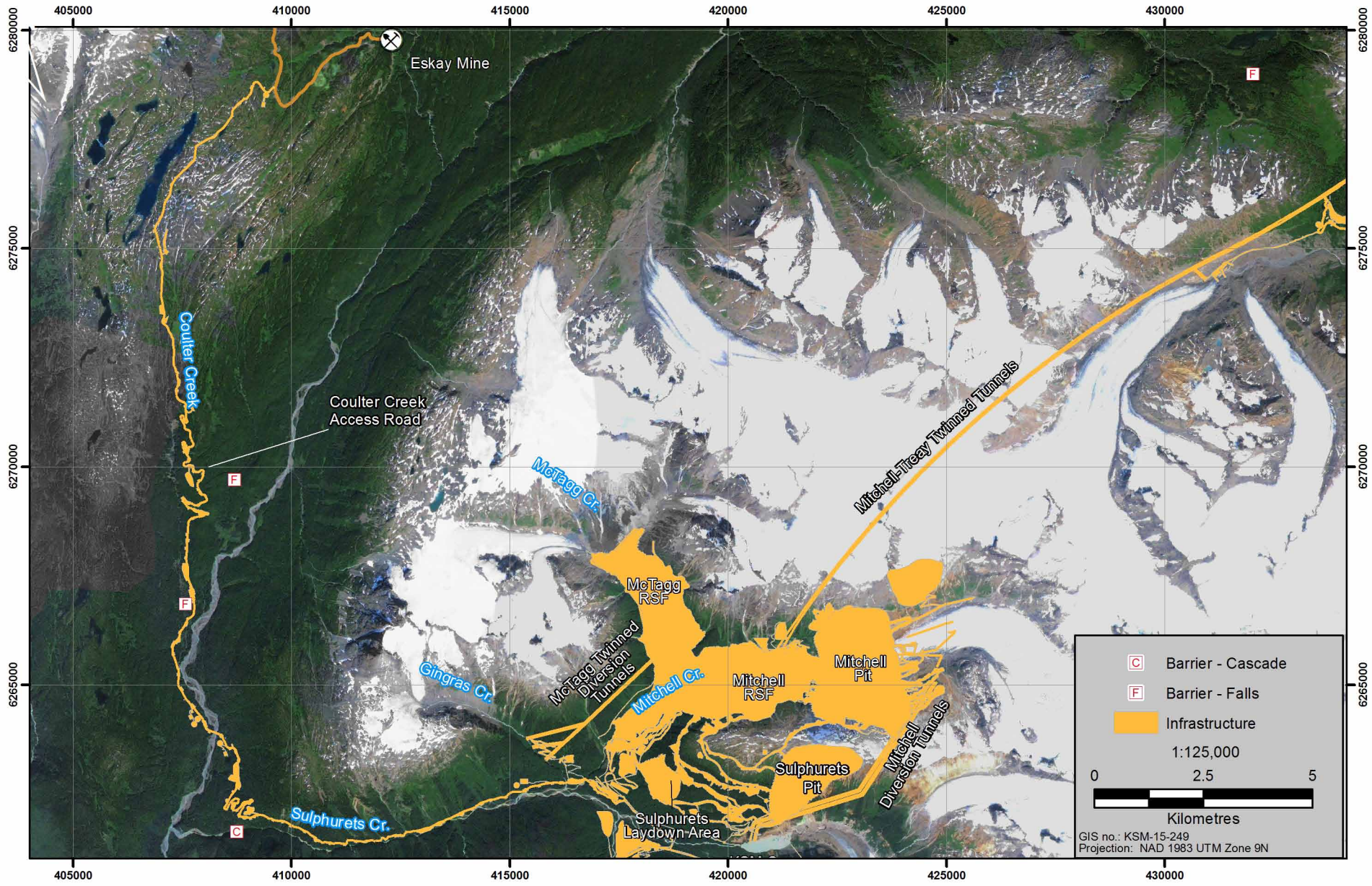


Figure 2.1-3

SEABRIDGE GOLD
KSM PROJECT

Proposed Coulter Creek Access Road

Figure 2.1-3

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The transmission line will parallel the Treaty Creek Access Road from Highway 37 to the Process Plant (Figure 2.1-2).

During the Project's Closure and Post-closure phases, the Coulter Creek Access Road will be decommissioned. The Treaty Creek Access Road will be maintained for TMF access and servicing. The transmission line will be maintained to supply power for the water treatment plant and related facilities, and to transmit surplus power to the provincial grid.

2.2 FISH AND FISH HABITAT RESOURCES

2.2.1 Tailings Management Facility Infrastructure

Dolly Varden (*Salvelinus malma*) is the only fish species present in South Teigen Creek, above the falls, and in North Treaty Creek. Fish habitat will be lost as result of the proposed TMF development. TMF development includes: TMF dams, seepage collection pond dams, the TMF waste pile, and Treaty Creek pipeline outlet watercourses. The fish and fish habitat resources within the South Teigen and North Treaty creeks watersheds are summarized below.

Field assessments of fish and fish habitat within the South Teigen and North Treaty creeks watersheds were conducted in 2008, 2009, 2010, and 2011. Baseline reports present detailed results of these assessments; therefore, only a summary of fish habitat is presented in this compensation plan (Rescan 2009, 2010, 2011a, 2012b). For the purposes of describing and comparing fish habitat within these watersheds, streams were grouped according to watershed location and habitat type: South Teigen Creek, South Teigen tributaries, North Treaty Creek, and North Treaty tributaries.

Channel characteristics vary between mainstem reaches and tributaries. Generally, South Teigen Creek has a larger average bankfull width (7.7 vs. 5.7 m) and depth than North Treaty Creek. North Treaty Creek has a higher average channel gradient than South Teigen Creek. South Teigen tributaries have a larger average bankfull width (1.9 m) and depth (0.3 m) than North Treaty tributaries (1.2 and 0.3 m). South Teigen tributaries have a greater occurrence of residual pools compared to North Treaty tributaries.

South Teigen tributaries have a higher average channel gradient than North Treaty tributaries. Channel morphology varies between mainstem reaches and tributaries (Figure 2.2-1 [map pocket]). There is a higher proportion of riffle-pool morphology in North Treaty Creek (83.7%) compared to South Teigen Creek (46.9%), which is dominated by cascade-pool morphology. There is a higher proportion of riffle pool morphology in North Treaty tributaries (82.4%) compared to South Teigen tributaries (46.0%), which have high proportions of cascade-pool (24.3%) and step-pool (27.1%) morphology.

The habitat unit (HU) ratio is evenly distributed between three habitat types (riffle, pool, cascade) for North Treaty Creek. In comparison, the HU ratio favours riffle and cascade habitat types in South Teigen Creek. There is a higher proportion of riffles in North Treaty tributaries (79.0%) compared to South Teigen tributaries (50.2%), which have a high proportion of cascades.

Substrate is a key component of fish habitat due to its physical properties and its biological functions (e.g., invertebrate habitat, cover for fish, and incubator of fish embryos). The habitat-weighted substrate composition is evenly distributed between three substrate types (fines, gravel, cobble) for South Teigen Creek. In comparison, habitat-weighted substrate composition favours gravel substrates in North Treaty Creek (62.0%). South Teigen tributaries are dominated by gravel substrates and North Treaty tributaries are dominated by fine substrates.

The habitat-weighted cover composition is dominated by overhanging vegetation and pool habitat in both South Teigen and North Treaty creeks. However, the proportions of these habitat types are greater in North Treaty Creek. South Teigen and North Treaty tributaries are dominated by overhanging vegetation, at a proportion of 41.4% and 53.9%, respectively.

In general, the more pools within a reach, the better the rearing and overwintering habitat quality (Johnston and Slaney 1996). A very low pool cover proportion in South Teigen Creek indicates less complex habitat, and reduced rearing and overwintering habitat capability (depending upon winter flows). A low occurrence of pools can be explained by several factors. First, the bed substrate has a high composition of cobble which is resistant to scour and movement at all but peak flows, hence the bed is very stable. Second, the riparian zone lacks trees that strengthen banks and enable large undercuts to develop. In addition, the channel lacks any large woody debris (LWD) because riparian zones are dominated by shrubs. LWD causes horizontal stream energy and laminar flow to be interrupted and deflected into the banks and bed, causing pools to be scoured while also providing cover for fish.

Functional LWD abundance, type, and distribution influence fish habitat quality for all life stages. LWD cover is more abundant in tributaries than mainstem reaches. LWD cover is absent from South Teigen Creek and more prevalent in North Treaty Creek (9.5%).

Since Dolly Varden are the only fish species located within the TMF, habitat quality assessment are focused on the habitat requirements of juvenile and adult Dolly Varden. Good-quality habitat has most or all of the key physical and biological attributes for the life stage and species of interest. Fair-quality habitat has some physical/biological features for the life stage but is missing one or two key attributes. Poor-quality habitat has very few physical/biological features for the life history stage and is missing most of the key attributes. “None” habitat does not have any of the physical/biological features for the life history stage.

Fair or better rearing-habitat quality was observed at 96.6% or better of South Teigen and North Treaty creeks (Figure 2.2-2 [map pocket]). Generally, North Treaty Creek possesses higher-quality rearing habitat because of greater habitat diversity and fish habitat cover compared to South Teigen Creek. Furthermore, the overall rearing habitat for juveniles is of higher quality in North Treaty Creek compared to South Teigen Creek based upon electrofishing sampling data. The fish population density results supported the assessment of fair or better rearing quality throughout these creeks. Summer rearing habitat is not likely a population bottleneck or limiting factor in these creeks because it is abundant, widely dispersed, and supported moderate to high fish densities through the mainstems.

Fair or better rearing-habitat quality is similar between South Teigen and North Treaty tributaries, at 64.5 and 63.8%, respectively (Figure 2.2-2 [map pocket]). Generally, North Treaty tributaries possess higher-quality rearing habitat because of their lower gradient and abundant fish habitat cover compared to South Teigen tributaries. Furthermore, the overall rearing habitat for juveniles is of higher quality in North Treaty tributaries compared to South Teigen tributaries based upon electrofishing sampling data and fish population density results. Typically, as channel gradient increases, the quality of rearing habitat decreases. In South Teigen tributaries along the western hillslopes, upstream reaches flowed subsurface during the summer months, which isolated the upper reaches from the mainstem. Overall, summer rearing habitat is not likely a population bottleneck or limiting factor in these tributaries because it is abundant, widely dispersed, and supports moderate to high fish densities.

In contrast to rearing habitat, which is observed throughout the mainstems and tributaries, South Teigen Creek provides none to poor spawning habitat suitability (Figure 2.2-3 [map pocket]). The high

composition of glacial fine substrate and high flows during the spawning season do not provide suitable spawning habitat for Dolly Varden. Furthermore, the lack of adults observed spawning in the mainstem and absence to low abundance of fry in the mainstem support this assessment. The entire length of North Treaty Creek provides good and abundant Dolly Varden spawning habitat due to habitat characteristics, suitable flow, and good water quality.

Fair or better spawning habitat quality was observed at 49.7% of South Teigen tributaries (Figure 2.2-3 [map pocket]). As channel gradient increases, the quality of spawning habitat typically decreases. South Teigen tributaries possess higher-quality spawning habitat in the lower gradient tributary reaches near the mainstem because suitable spawning habitat is present, and because of the abundance of fry rearing in these reaches based upon electrofishing sampling data. Spawning habitat is not likely a population bottleneck or limiting factor in the South Teigen tributaries. However, the maintenance of winter baseflows to provide sufficient egg incubation along the western and eastern hillslope tributaries is not known, since certain tributaries flow subsurface during the summer months.

Fair or better spawning habitat quality was observed at 34.0% of North Treaty tributaries (Figure 2.2-3 [map pocket]). North Treaty tributaries possess higher-quality spawning habitat near the wetland complex because of suitable flow, cover, substrate, depth, observation of adults spawning in these tributaries, and the abundance of fry rearing in these streams based upon electrofishing sampling data. The wetland complex likely provides maintenance of baseflows to provide sufficient egg incubation during the winter months. Spawning habitat is not likely a population bottleneck or limiting factor in the North Treaty tributaries.

All reaches of South Teigen and North Treaty creeks provide good overwintering habitat for Dolly Varden (Figure 2.2-4 [map pocket]). This assessment was based upon the presence, frequency, and distribution of pools; adequate residual pool depths; instream cover; and maintenance of base flows throughout the winter months.

Fair or better overwintering habitat quality was observed at 54.3% of South Teigen tributaries (Figure 2.2-4 [map pocket]). The majority of tributaries have very few deep pools and deeper runs of less than 20 cm residual depth, with the exception of Streams 1010, 1016, and 1019 (Figure 2.2-4). As noted previously, the channel morphology is shallow with mean water depths during the high-flow summer period less than 20 cm, and even lower predicted winter base flows. The channels are mostly cobble riffles and runs which are anticipated to provide very little space for overwintering fish.

Fair or better overwintering habitat quality was observed at 25.7% for North Treaty tributaries (Figure 2.2-4 [map pocket]). A high percentage of these tributaries possess no overwintering habitat. The majority of tributaries have no residual pools. As noted previously, the channel morphology is shallow with mean water depths during the high-flow summer period less than 15 cm and even lower predicted winter base flows. The channels are mostly fines and gravel riffles and runs which are anticipated to provide very little space for overwintering fish. However, tributaries located downstream of the wetland complex may provide sufficient overwintering habitat, despite the lack of pools.

Overall habitat quality is based upon all the life history stage rankings (i.e., spawning, rearing, overwintering) previously discussed for each stream segment. All reaches of South Teigen and North Treaty creeks provide important fish habitat for Dolly Varden (Figure 2.2-5 [map pocket]). Important habitat quality was observed at 68.2% of South Teigen tributaries and 59.4% of North Treaty tributaries.

Dolly Varden in South Teigen Creek were longer and heavier compared to those in its tributaries, and in North Treaty Creek and its tributaries. Length classes present in South Teigen tributaries tend to be smaller, with fewer larger-length classes, compared to South Teigen Creek. These results support

previous assessments that the tributaries provide the majority of fry (0+) and parr (1+) rearing habitat within South Teigen watershed. Length classes present in North Treaty tributaries tend to be smaller, with fewer larger-length classes, compared to North Treaty Creek. Although this shift was of a smaller magnitude then in South Teigen watershed, it supports previous assessments that North Treaty Creek provides suitable rearing habitat for Dolly Varden fry and parr. Length class modes are similar between watersheds, with approximate length ranges of 25 to 45 mm for fry, 45 to 70 mm for parr, 70 to 85 mm for 2+ fish, and 85 to 105 mm for 3+ fish. The largest fish caught was 210 mm.

Dolly Varden densities are greater in North Treaty Creek (99.34 fish per 100 m^2; standard error [SE] 17.21) compared to South Teigen Creek (8.84 fish per 100 m^2; SE 1.18); however variability is greater in North Treaty Creek. Dolly Varden densities are greater in North Treaty tributaries (50.06 fish per 100 m^2; SE 3.12) compared to South Teigen Creek (29.94 fish per 100 m^2; SE 2.06), for sites assessed with channel gradients less than 5%.

Wetlands are present within the South Teigen and North Treaty creeks watersheds. All wetlands are dominated by sand/fines substrate with gravels as sub-dominant. All wetlands are dominated by pool cover type with instream vegetation (*Carex spp.*) and overhanging vegetation as sub-dominant cover types. All wetlands have tall shrub riparian vegetation, except wetland ST-W1.

All wetlands possess good rearing habitat. Wetland NT-W1 possesses abundant overwintering habitat with water depths greater than 1.5 m in some areas; however, a beaver dam is present which restricts fish passage and use. None of the wetlands possessed spawning habitat, due to the dominance of fine substrates.

2.2.2 Access Roads and Transmission Line

The proposed access roads and transmission line are located within the Treaty Creek and Unuk River watersheds (Figures 2.1-2 and 2.1-3). A small portion of these watercourse crossings will result in fish habitat loss due to the construction of crossing structures and clearing of riparian vegetation. Fish and fish habitat resources are summarized below for each watershed that lies within the proposed access roads and transmission line.

Treaty Creek is a 4th order tributary of the Bell-Irving River and possess a watershed area of 180.6 km^2 (Figure 2.2-6). Treaty Creek is turbid and originates from glacial origins. The creek is unconfined with braided channels near the glacial headwaters; the channel then becomes confined with increased channel substrate size. The middle watershed is unconfined and heavily braided with numerous side channels. In the lower watershed, the creek is partially entrenched with few side channels, and discharges into the Bell-Irving River.

The Treaty Creek Watershed supports a diversity of fish species. Char species, such as Dolly Varden and bull trout (*Salvelinus confluentus*) coexist in the Treaty Creek Watershed. The watershed supports summer-run populations of steelhead, the anadromous form of rainbow trout (*Oncorhynchus mykiss;* LGL 1995; Bockinget al. 2005). Pacific salmon species, such as coho (*Oncorhynchus kisutch*), sockeye (*Oncorhynchus nerka*), and chinook (*Oncorhynchus tshawytscha*) are present in the watershed. Mountain whitefish (*Prosopium williamsoni*) are present in Treaty Creek.

The Unuk River is a large river that originates from glaciers in BC, flows through Alaska, and discharges into the Pacific Ocean (Figure 2.2-6). Sub-watersheds of the Unuk River include: Coulter, Eskay, Storie, Sulphurets, and others (Figure 2.2-6). There are ten reaches within the Unuk River. The majority of these reaches are low gradient, unconfined, and braided. However, sections of the river are entrenched.

Salmon species are present in the Unuk River, with the majority of salmon spawning and rearing occurring in the lower 39 km of the Alaska section (Mecum and Kissner 1989) and in Border Lake, approximately 2 km upstream of the Alaska/BC border (Figure 2.2-6). The lake is known to support recruitment of sockeye, pink (*Oncorhynchus gorbuscha*), coho, and chum salmon (*Oncorhynchus keta*; Tripp 1987; DFO 1987). The canyons located upstream of Border Lake restrict the upstream migration of pink and chum salmon. However, spawning and rearing of sockeye, chinook, and coho salmon are known to extend as far upstream as Storie Creek, which is approximately 15 km upstream of Sulphurets Creek (Reach 7; Knight Piesold and Homestake 1993). Only Dolly Varden was captured—in this study and others—in the Unuk River upstream of Storie Creek.

The majority of stream crossings were considered non-fish bearing due to habitat-limiting conditions, such as high channel gradient (greater than 20%), natural barriers, and poor quality fish habitat present to support various fish life history stages (Rescan 2009, 2010, 2012b, 2012f). The access roads and transmission line alignments cross numerous ephemeral drainages that are not defined as streams. The majority of streams present along the alignments are subject to continuous avalanches and landslides; as a result, channel formation and fish habitat is continuously disturbed.

The majority of the Coulter Creek Access Road is located within the Coulter Creek and Sulphurets Creek watersheds (Figures 2.1-3 and 2.2-6). Fish migration barriers present in the lower reach of these creeks resulted in non-fish bearing classification of stream crossings upstream of these fish migration barriers (Figure 2.1-3). A total of 4,663 seconds of electrofishing effort was exerted above the Coulter Creek falls at six sites over two years without capturing fish (Rescan 2009, 2010). Therefore, all stream reaches above the falls were classified as non-fish-bearing. A total of 3,046 seconds of electrofishing effort was exerted above the Sulphurets Creek cascade at three sites in 2009 and no fish were caught. Furthermore, Sulphurets Creek and its tributaries (McTagg, Mitchell, and Ted Morris creeks) were sampled in 2008 and no fish were caught, despite 6,698 seconds of electrofishing effort above the cascade. Therefore, all stream reaches above the cascade were classified as non-fish-bearing.

Dolly Varden was the dominant species caught and was present along all access roads and the transmission line. Coho salmon were present in certain watercourse crossings along the Coulter Creek Access Road. Larger stream sites (e.g., Bell-Irving and Unuk rivers) supported the most diverse fish communities. Coastal cutthroat trout (*Oncorhynchus clarki clarki*) were caught along the Coulter Creek Access Road.

Presence of a species, either sampled in 2012, 2011, 2009, 2008, or previously known through literature, was used to determine the fish-bearing status of a stream. If fish were observed or caught, then the stream classification was listed as confirmed fish-bearing. If fish were not observed or caught at a site, and fish presence is known downstream (from historical data) and no barriers to fish passage are present, then the stream classification was listed as default fish-bearing.

2.2.3 Water Quantity Loss

Fish habitat will be lost in South Teigen and North Treaty creek as result of the TMF water management during construction, operations, and closure. The construction of the TMF will reduce the overall watershed area (thereby reducing water quantity in the watershed); watercourses will be re-directed around the TMF by ditches which are not 100% efficient at water transfer, resulting in water quantity loss; and water from the ditches will be re-directed into different watersheds at various stages of TMF development, resulting in water quantity loss in certain watersheds. The fish and fish habitat resources within the South Tegien and North Treaty creeks watersheds, downstream of the proposed TMF, are summarized below.

PROJECT # 868-016-09 GIS No. KSM-06-159_T December 12, 2012

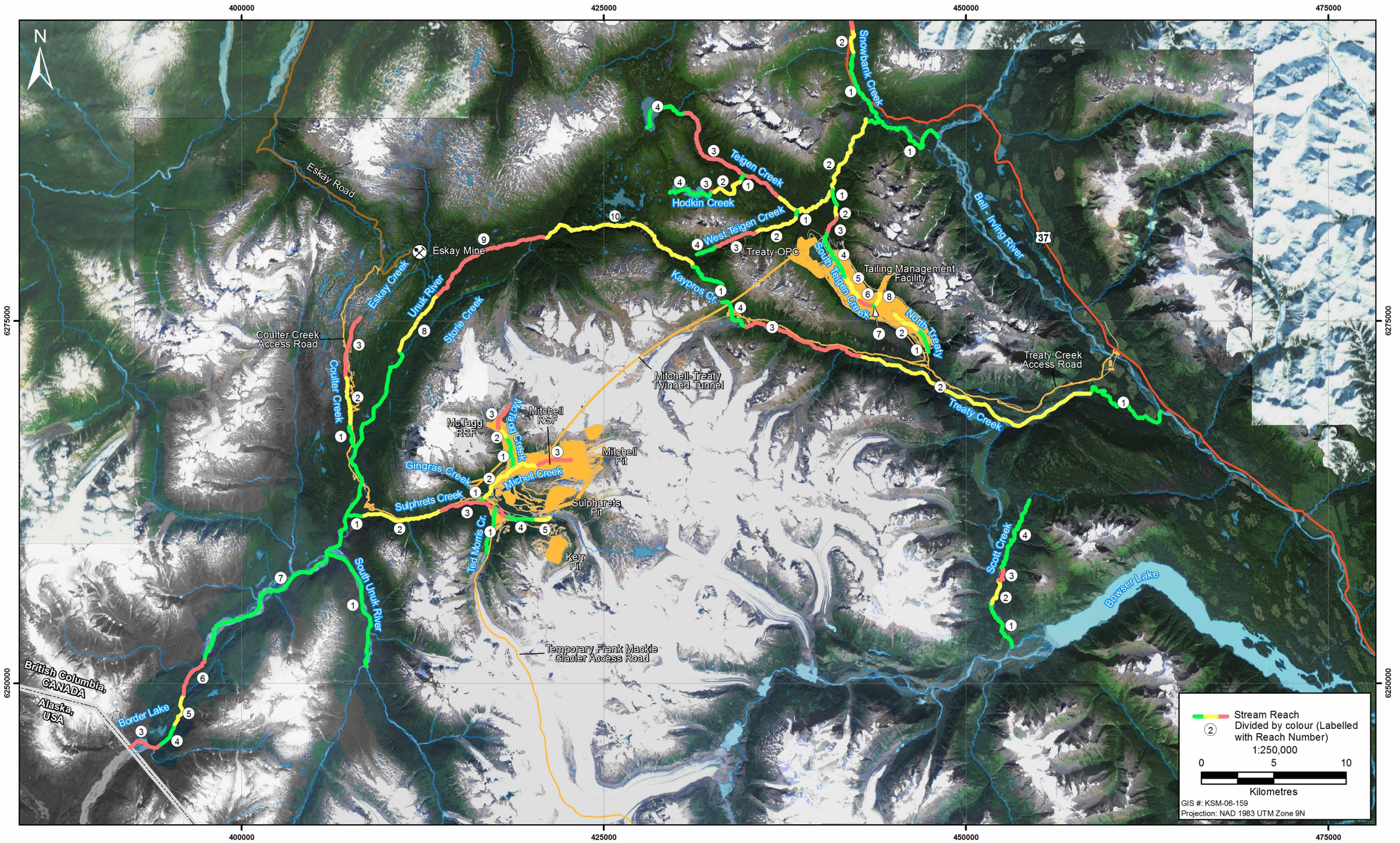


Figure 2.2-6

Stream Reaches within the KSM Fish and Aquatic Habitat Study Area

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A 2.5 m-high falls on South Teigen Creek prevents upstream fish movement (Figure 2.1-2). Dolly Varden are present above and below the falls. Dolly Varden, bull trout, mountain whitefish, and rainbow trout are present in South Teigen Creek downstream of a 2.5 m-high falls and outside of the TMF.

Catch-per-unit-effort is significantly higher for Dolly Varden compared to the other fish species within South Teigen Creek (Rescan 2011a, 2012b). Dolly Varden are present in North Treaty and Tumbling creeks downstream of the TMF. One mountain whitefish was sampled in North Treaty Creek at the confluence with Treaty Creek.

In 2010 and 2011, relative abundance of Dolly Varden was estimated by single pass electrofishing in North Treaty and South Teigen mainstem, downstream of the TMF. Sites were stratified within stream reaches deemed representative of the stream reach habitat composition. Dolly Varden parr were the dominant life history stage caught in South Teigen Creek. Dolly Varden adults were the dominant life history stage caught in North Treaty Creek. Catch per unit effort is higher in South Teigen Creek (below falls) than South Teigen Creek (above falls).

No salmon species are present within South Teigen, North Treaty, and Tumbling creeks, based upon electrofishing sampling data (2008 to 2011), spawning surveys (2009 and 2010), and habitat assessments. Salmon have not been observed or sampled in the lower reach of South Teigen Creek, below the falls, with considerable electrofishing effort in 2008 (635 s), 2009 (1,194 s), and 2010 (10,198 s). Steelhead do not utilize South Teigen Creek for spawning based upon sampling data, spawning surveys (2010 and 2011), and habitat assessments. Steelhead do not utilize North Treaty or Tumbling creeks for spawning based upon sampling data, spawning surveys (2010 and 2011), and habitat assessments. Bull trout utilize South Teigen Creek (below the falls) for spawning in highly localized sites (two locations) based upon snorkel spawning assessments.

Cascade HUs are the dominant HU type in reach 1 and 0 for North Treaty Creek. The HU ratio is 30% riffle, 56% cascade, and 14% pool in reach 1 from the dam to Tumbling Creek confluence. The HU ratio is 2% riffle, 92% cascade, and 6% pool in reach 0 from Tumbling Creek confluence to Treaty Creek confluence. Similarly, cascade HUs are the dominant HU type in reaches 1 and 2 for South Teigen Creek. The HU ratio is 10% riffle, 85% cascade, and 5% pool in reach 1 from the falls to Teigen Creek confluence. The HU ratio is 10% riffle, 75% cascade, and 15% pool in reach 2 from the dam to the falls.

Mean velocity and discharge is less in North Treaty Creek than South Teigen Creek. Boulders and deep pools are the dominant cover types in South Teigen Creek. Cobble and boulders are the dominant substrate types in South Teigen Creek. Boulders, deep pools, and overhanging vegetation are the dominant cover types in North Treaty Creek. Cobble, small gravel, and boulders are the dominant substrate types in North Treaty Creek.

3. Habitat Evaluation Procedures and Habitat Budget

3.1 HABITAT EVALUATION PROCEDURE

The Habitat Evaluation Procedure (HEP) is a tool for developing habitat budgets for compensation planning, and has been used widely in Canada (e.g., Diavik 1998; Dillon Consulting Ltd. 2002; RL&L/Golder 2003; Rescan 2005, 2007; AMEC 2008). The HEP approach has two advantages. First, it provides an objective method to characterize the quality or importance of affected habitats to fish species and aquatic resources. Second, it allows standardization of habitat quality ratings relative to other habitats that have different physical characteristics (e.g., riffle-pool versus wetland). This facilitates comparisons among habitat types and ultimately allows affected habitats to be evaluated as a single group for the compensation calculation.

For the Plan, the HEP will be used to construct a habitat budget (US Fish and Wildlife Service 1980). The HEP is a generalized procedure for assessing habitat suitability in streams and lakes. By multiplying habitat area (measured in m^2) by a Habitat Suitability Index (HSI; no units), the HEP produces HUs that are indices of both habitat quantity and quality. HU are the currency of habitat budgeting and compensation planning.

Project-affected habitats are quantified and characterized in terms of their importance to fish. The Plan is based on the type of habitat affected. Compensation of lost habitat for created habitat is based upon the estimation of HUs lost. Overall, the HEP is based upon the suitability of a habitat type to support different life history stages of a species. HSIs, derived primarily from scientific literature, are used to quantify the suitability of the habitat type to support each critical life history stage.

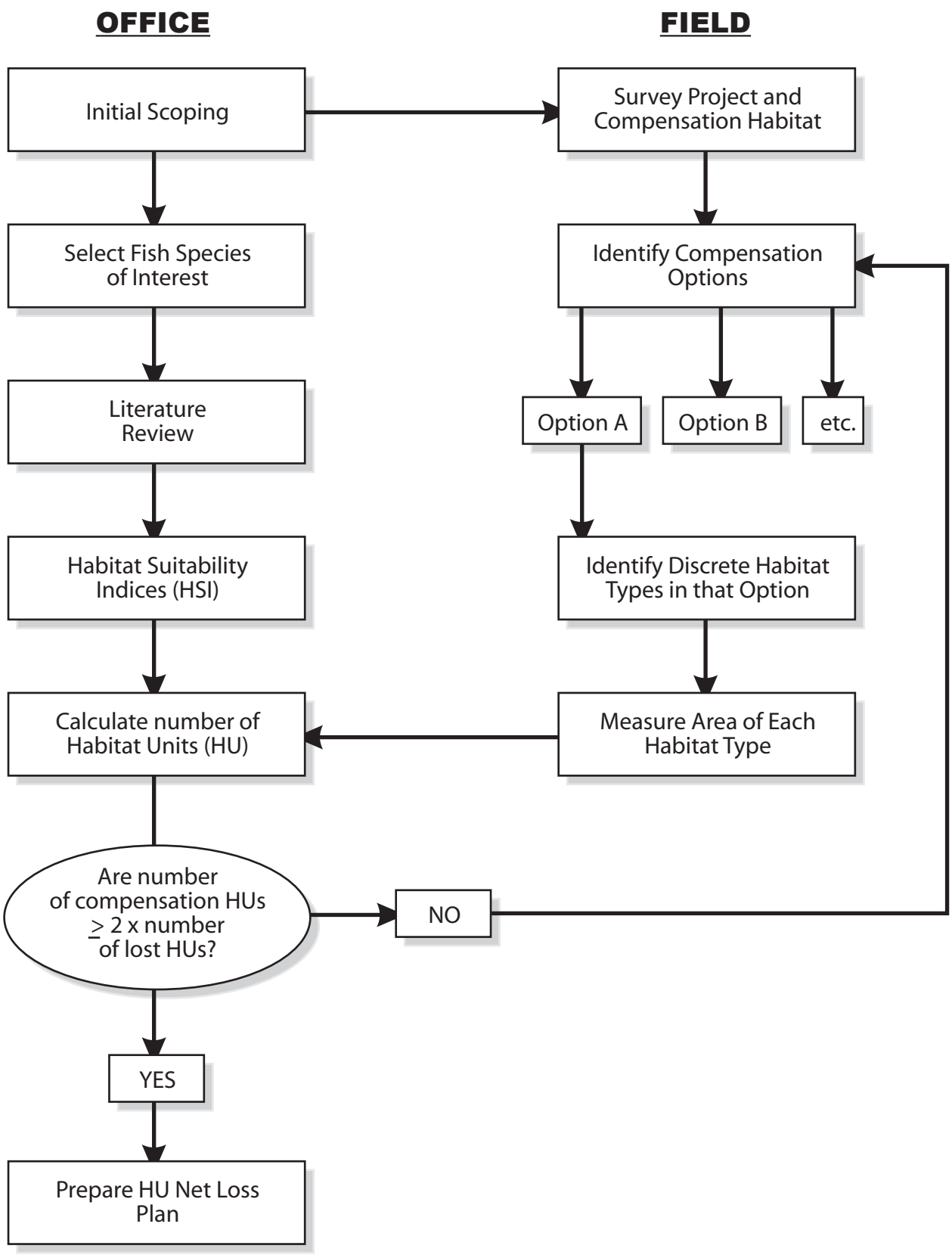
There are four key steps in HEP that are followed in the development of a fish habitat compensation plan (Figure 3.1 1):

- initial scoping of the study area and relevant species in the study area. It includes brief reviews of the life histories of relevant species, followed by justification of the decision to base habitat compensation planning on certain species habitat requirements;
- use and/or development of HSI models for affected and target fish species;
- habitat assessment of the Project area and of the proposed compensatory works; and
- preparation of a budget of lost and gained HUs.

The ratio of compensation area to impacted habitat area is dependent on the value of the habitat destroyed as well as the value of the proposed compensation habitat. For example, high-quality habitat may require additional compensation area to ensure no net loss of productive capacity. Alternatively, low-quality habitat may be replaced with a smaller area of higher-quality habitat. The value of the habitat is multiplied by the area of the compensation or affected habitat to create HUs which are used to construct the habitat budget.

Multiple species may benefit from compensation projects. Where multiple species are known to benefit, the primary target species was selected for HU calculation.

The HU budget for the Plan assumes a 2:1 ratio of compensatory habitat to affected habitat, which is a typical ratio requested by DFO. In other words, the budget is designed to provide at least two HUs of compensation habitat for every HU of affected habitat.



Links between Steps in the Calculation of Habitat Units

FIGURE 3.1-1

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3.2 HABITAT SUITABILITY INDICES MODELS

3.2.1 Species Scoping

Dolly Varden is the only species present in the TMF dam footprints, and the most abundant species along access road and transmission line crossings. A search of the scientific literature found that HSI models are currently available for over 157 species of aquatic and terrestrial animals (US Geological Survey 2010). No HSI exist for Dolly Varden, presumably because of a lack of sufficient information on Dolly Varden habitat requirements and because of the wide range of potential habitats that can be exploited by Dolly Varden.

Keeley and Slaney (1996) reviewed the spawning and rearing characteristics of habitat for stream-dwelling salmonids and found only two papers that described Dolly Varden rearing habitat: Dolloff and Reeves (1990) and Bugert, Bjornn, and Meehan (1991). No scientific papers described Dolly Varden spawning habitat. Over the last 10 years, more papers have been published on Dolly Varden; however, not enough to allow the development of a full HSI model.

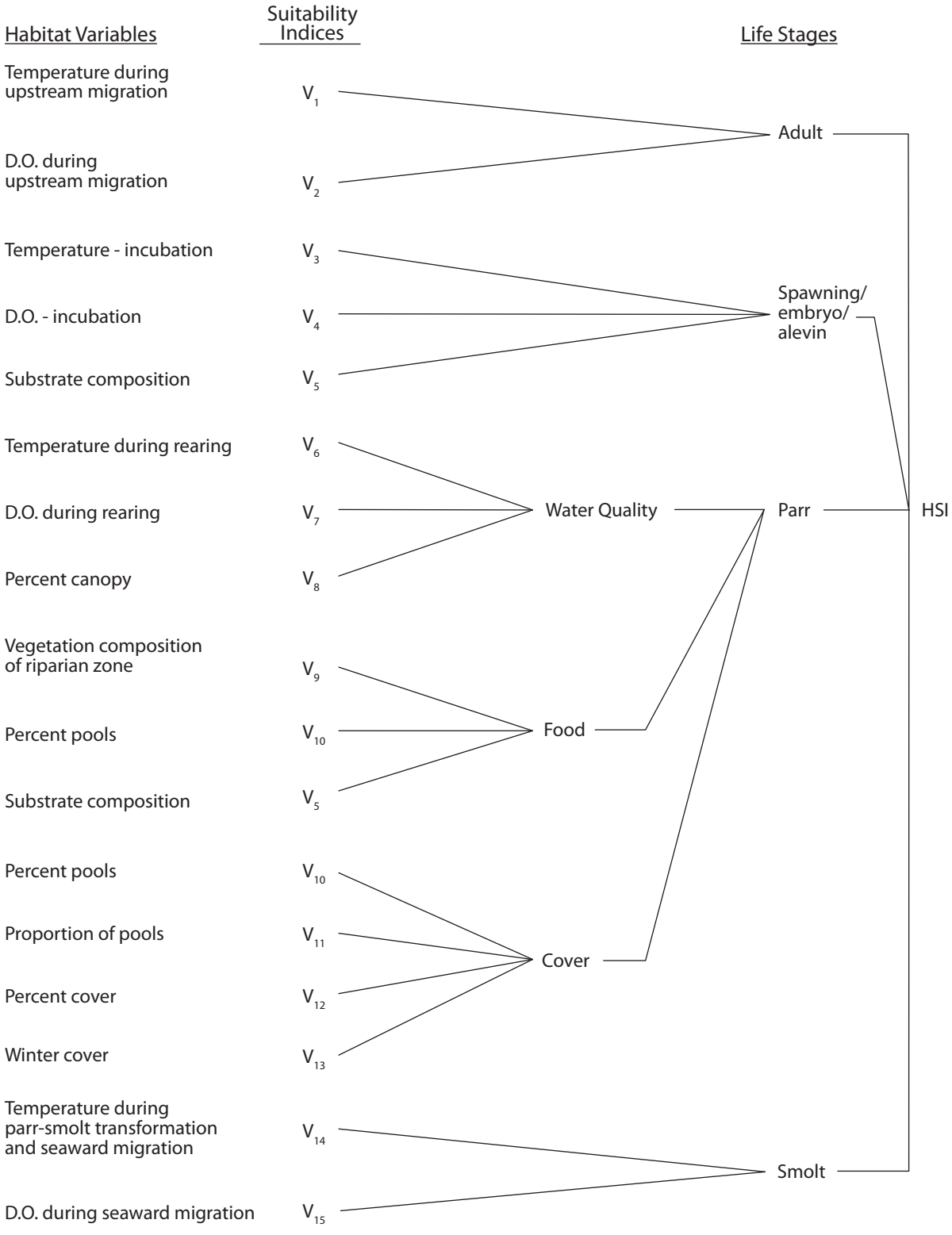
A generalized HSI model for Dolly Varden was adopted for this Plan (Rescan 2007). This model was peer reviewed by regulators and peer approved during the review process of a neighbouring mine, Galore Creek (Rescan 2007). The members of the Galore Creek technical fisheries working group who participated in meetings and reviews of the Galore Creek Fish Habitat Compensation Plan, including the Dolly Varden HSI model, were: Karen Diemert (MOE), Pat Lim (DFO), Gordon Glova (LGL), Jack Love (DFO), Paul Christensen (DFO), and Eero Karanka (DFO). Their acceptance of the Galore Creek Fish Habitat Compensation Plan constitutes review and approval of the Dolly Varden HSI model. The Dolly Varden model was primarily based upon comparison with existing HSI models for other stream dwelling salmonids, published scientific papers (Appendix 3.2-1), project-specific data (if applicable), and field observations. Details regarding the development of the Dolly Varden HSI model are summarized in the following sections.

Dolly Varden are the only species present in the TMF; however, the proposed compensation projects were designed to benefit multiple salmonid species. Therefore, coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Oncorhynchus mykiss*), and chinook salmon (*Oncorhynchus tshawytscha*) were identified for comparisons of HSI models and for preparation of habitat budgets for selected species. HSI models exist for all of these species (McMahon 1983; Raleigh et al. 1984; Raleigh, Miller, and Nelson 1986). All three models are based on a comprehensive review of the published scientific literature, and are described as being applicable to streams within and surrounding the fisheries study area.

3.2.2 Coho Salmon Habitat Suitability Index

McMahon's (1983) HSI model for coho salmon included 15 variables (Figure 3.2-1). For each habitat variable, a graph was provided that showed how the suitability index (SI), a unitless number from 0 (unsuitable) to 1 (optimal), changed over that variable. For example, the composition of spawning substrate (i.e., variable V5 in Figure 3.2-1) was shown to have a SI of 0.0 at 0% gravel and cobble (where gravel was defined as particles with diameters of 10 to 60 mm and cobble with diameters of 61 to 250 mm), and an SI of 1.0 at 60 to 100% gravel and cobble (Figure 3.2-2). This plot was accompanied by a plot of SI on percent fines (defined as particles less than 6 mm in diameter) that showed SI falling from 1.0 at 0% fines to 0.0 at 50% fines (Figure 3.2-2). Either plot can be used alone, depending on what is measured during a habitat survey, or together, in which case an average SI is calculated from the two plots.

McMahon's (1983) HSI model assumed that a stream's carrying capacity for any life stage of coho salmon was limited by the lowest SI score for any of the variables associated with that life stage. For example, if the percent fines in the spawning substrate for a stream reach were greater than 50%, then the HSI for that reach would have a value of 0.0 and the habitat would be classified as unsuitable for spawning, regardless of the SI values for other variables associated with spawning habitat.



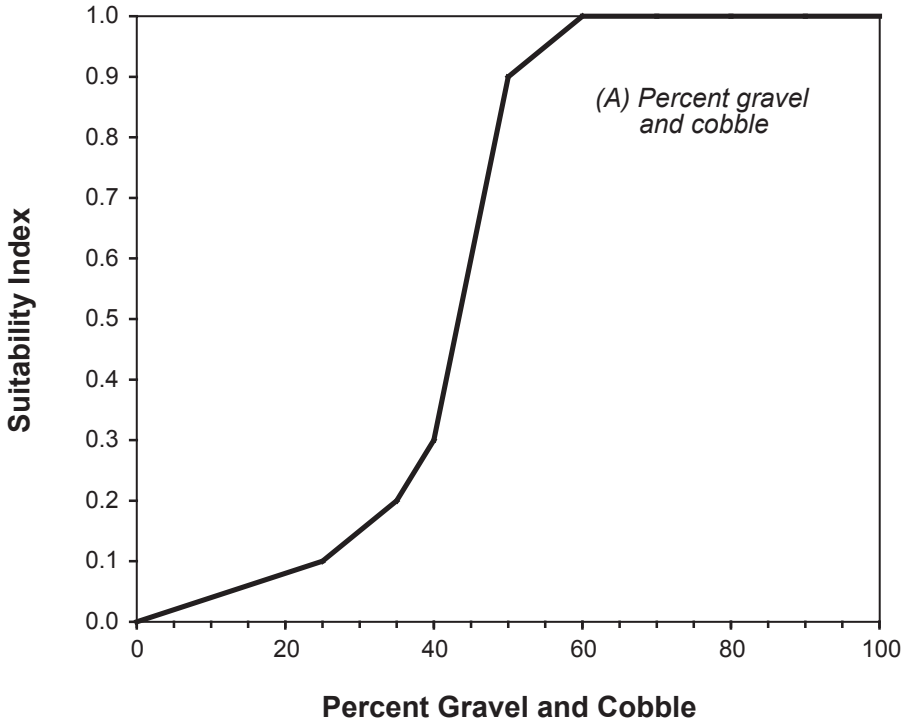
(Source: McMahon, 1983)

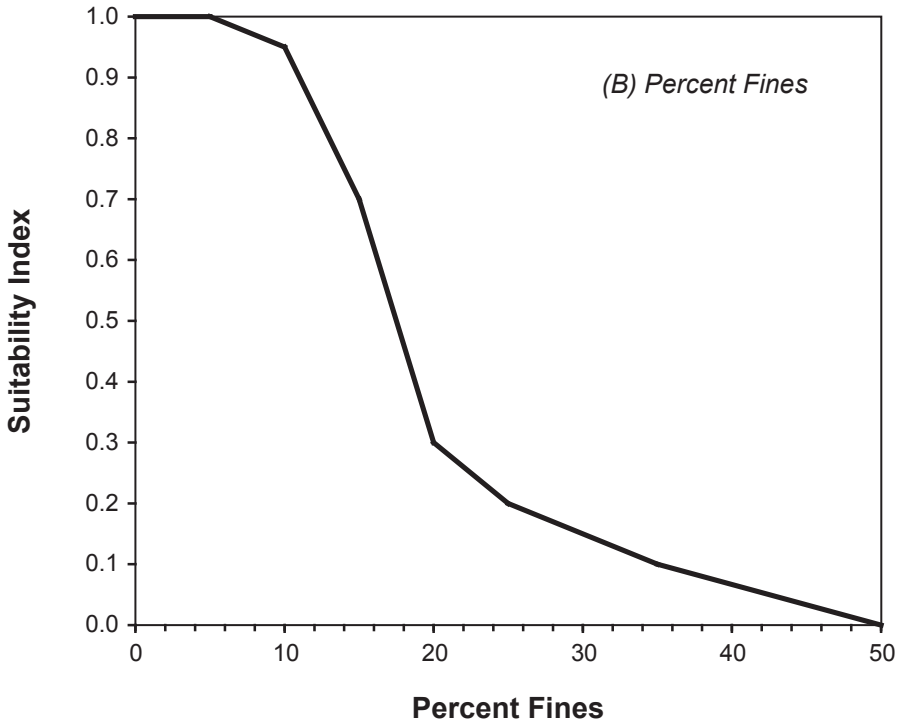
Tree Diagram Showing how Habitat Variables were Linked into an HSI for Coho Salmon

FIGURE 3.2-1

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(Source: McMahon, 1983)

Plots of Suitability Indices for Coho Salmon Spawning Substrate on Percent Gravel and Cobble and Percent Fines

FIGURE 3.2-2

This limiting-factor approach was used in all of the HSI models, mainly because it is the most conservative approach. The limiting-factor approach assumes that all variables are equally important, which may not be the real case. However, since the calculations of habitat lost and gained use the same approach, it may be assumed that any inherent errors cancel each other out.

The 15 variables for the coho salmon HSI model were reduced to five-category tables (i.e., excellent to unsuitable) for each of the four key life history stages (Table 3.2-1). The four life stages recognized for coho salmon were (McMahon 1983):

- migration of pre-spawning adults to the spawning grounds during spring, summer, or fall;
- spawning, egg incubation, and emergence of fry;
- rearing of fry and juveniles during spring, summer, and fall; and
- overwintering of fry and juveniles in refuge habitat.

Table 3.2-1. Habitat Suitability Indices for Coho Salmon in Stream Environments

Habitat variable	V_X	Excellent	Above average	Average	Below Average	Unsuitable
HSI value		0.80 to 1.00	0.60 to 0.79	0.40 to 0.59	0.20 to 0.39	0.00 to 0.19
Adult Migration						
Max. temperature (°C)	V_1	5 to 10	10 to 12	12 to 13.5	13.5 to 16	>16
Min. diss. oxygen (mg/L)	V_2	>6.5	5.5 to 6	5 to 5.5	4.7 to 5.2	<4.7
Spawning/Incubation/Emergence						
Max. temperature (°C)	V_3	4.5 to 13.5	4 to 13.5	3.5 to 14.5	3 to 15	0 to >18
Min. diss. oxygen (mg/L)	V_4	>65	60 to 65	55 to 60	45 to 55	<55
Substrate (% gravel/cobble)	V_5	>50	45 to 50	40 to 45	35 to 40	<35
Substrate (% fines)	V_5	<15%	15 to 17.5	17.5 to 20	20 to 25	>25
Rearing						
Max. temperature (°C)	V_6	7.5 to 14.5	7 to 15	6 to 17	5 to 20	4 to 24
Min. diss. oxygen (mg/L)	V_7	>6.5	6 to 6.5	5.5 to 6	4.5 to 5.5	<4.5
Substrate (% gravel/cobble)	V_5	>50	45 to 50	40 to 45	35 to 40	<35
Substrate (% fines)	V_5	<15%	15 to 17.5	17.5 to 20	20 to 25	>25
Percent canopy	V_8	35 to 85	30 to 90	20 to 100	0 to 20	none
Riparian zone index	V_9	>125	100 to 125	75 to 100	50 to 75	0 to 50
Percent pools	V_{10}	35 to 70	30 to 75	25 to 80	20 to 90	0 to 15
Percent pools with canopy	V_{11}	55 to 100	50 to 55	35 to 50	0 to 35	none
Percent cover	V_{12}	30 to 50	25 to 30	20 to 25	0 to 20	none
Overwintering						
Max. temperature (°C)	V_{14}	7 to 11	6 to 11	5 to 12	4 to 13	12 to 16
Winter cover	V_{13}	25 to 50	20 to 25	12.5 to 20	0 to 12.5	none

Source: McMahon (1983).
Riparian zone index = 2(% cover by trees and shrubs) + (% cover by grasses and forbs) + (% conifer cover).*
V_X are the habitat variables shown in Figure 3.2-1.

These four life stages differ from McMahon (1983) for coho salmon (adult, spawning/embryo/alevin, parr, and smolt) because they include an overwintering stage. Research since the early 1980s has shown that the presence or absence of overwintering habitat is a key factor in survival of salmonids in

small coastal streams during the long, dark, and cold winters of northern BC (e.g., Sandercock 1991; Cunjak 1995). Winters are characterized by low food abundance, highly variable flows, and, in the smaller streams, extreme events such as debris slides and the formation of ice jams. During winter, stream-resident juvenile salmonids actively seek out deep, sheltered pools and side channels with canopy cover that provide stable, safe environments.

3.2.3 Rainbow Trout Habitat Suitability Index

Raleigh et al.'s (1984) HSI model for rainbow trout included a total of 18 variables and was organized in a slightly different manner than the model for coho salmon (Figure 3.2-3). As with the coho model, the carrying capacity of a stream for a life stage of rainbow trout was assumed to be limited by the lowest SI score for any of the variables associated with that life stage.

There are more options in the SI plots for rainbow trout than for coho salmon because of the greater plasticity of rainbow trout life history.

The 18 variables for rainbow trout HSI model were reduced to 14 variables in five-category tables (i.e., excellent to unsuitable) for each of the four key life history stages (Table 3.2-2). Four life stages were recognized for rainbow trout (Raleigh et al. 1984):

- adults;
- spawning, egg incubation, and emergence of fry;
- rearing of fry during spring, summer, and fall; and
- rearing of juveniles during spring, summer, and fall.

3.2.4 Chinook Salmon Habitat Suitability Index

Raleigh, Miller, and Nelson's (1986) HSI model for chinook salmon included a total of 18 variables (Figure 3.2-4). As with the coho model, the carrying capacity of a stream for a life stage of chinook salmon was assumed to be limited by the lowest SI score for any of the variables associated with that life stage.

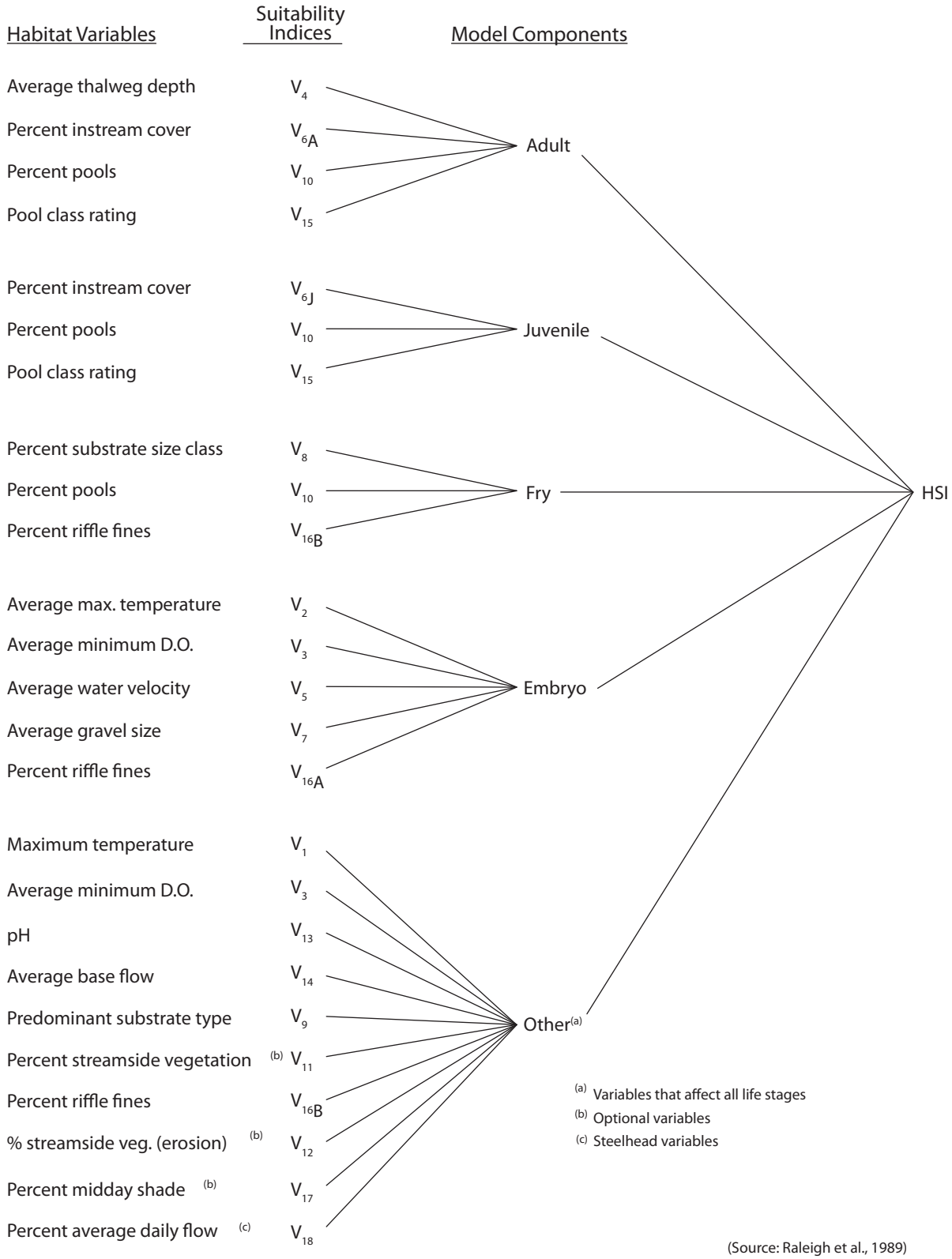
The 18 variables for chinook Salmon HSI model were reduced to 14 variables to five-category tables (i.e., excellent to unsuitable) for each of the three key life history stages (Table 3.2-3). Three life stages were recognized for chinook salmon (Raleigh, Miller, and Nelson 1986):

- adults;
- spawning, egg incubation, and emergence of fry; and
- rearing of juveniles during spring, summer, and fall.

3.2.5 Dolly Varden Habitat Suitability Index

3.2.5.1 HSI Model Development

A complete literature review of Dolly Varden habitat preferences and studies are presented in Appendix 3.2-1. To develop the Dolly Varden HSI model, comparisons with various HSI models and suitability curves was completed for other species of stream-dwelling salmonids using a weight of evidence approach. Three stream-dwelling species were compared in this process. These species include rainbow trout, coho salmon, and chinook salmon. The results of the comparisons are discussed below. Furthermore, the model results are consistent with the literature review of Dolly Varden habitat preferences and studies, and field observations.



Tree Diagram Showing how Habitat Variables were Linked into an HSI for Rainbow Trout

FIGURE 3.2-3

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Table 3.2-2. Habitat Suitability Indices for Rainbow Trout in Stream Environments

Habitat variable	V_X	Excellent	Above Average	Average	Below Average	Unsuitable
HSI value		0.80 to 1.00	0.60 to 0.79	0.40 to 0.59	0.20 to 0.39	0.00 to 0.19
Adult						
Max. temperature (°C)	V_1	7 to 20	5 to 22	3 to 23	2 to 24	0 to 25
Min. diss. oxygen (mg/L)	V_3	5.5 to 7	4.5 to 5.5	4 to 4.5	3.5 to 4	<3
Average thalweg depth (cm)	V_4	35 to 45	30 to 35	25 to 30	20 to 25	<10
Percent adult cover	V_6	14 to 24	8 to 14	4 to 8	0 to 4	none
Percent pools	V_{10}	20 to 85	12.5 to 90	5 to 100	none	none
pH	V_{13}	6 to 8.5	6 to 8.5	5.5 to 9.0	5.5 to 9.2	5.5 to 9.4
Base flow as % of MAF	V_{14}	40 to 100	30 to 40	20 to 30	10 to 20	0 to 10
Pool class rating (A/B/C)	V_{15}	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.33/0.33/0.33
Dominant substrate (A/B/C)	V_9	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Percent riffle fines	V_{16}	5 to 15	15 to 20	20 to 30	30 to 60	>60
Spawning/Incubation/Emergence						
Max. temperature (°C) eggs	V_2	5 to 15	4 to 16	3 to 17	2 to 18	0 to 20
Min. diss. oxygen (mg/L)	V_3	5.5 to 7	4.5 to 5.5	4 to 4.5	3.5 to 4	<3
Water velocity (cm/sec)	V_5	25 to 75	20 to 80	15 to 85	12 to 85	10 to 90
Average gravel size (cm)	V_7	1 to 7.5	0.5 to 8	0.3 to 8.5	0.2 to 9	0 to >10
pH	V_{13}	6 to 8.5	6 to 8.5	5.5 to 9.0	5.5 to 9.2	5.5 to 9.4
Percent riffle fines	V_{16}	5 to 15	15 to 20	20 to 30	30 to 60	>60
Fry Rearing						
Max. temperature (°C)	V_1	7 to 20	5 to 22	3 to 23	2 to 24	0 to 25
Min. diss. oxygen (mg/L)	V_3	5.5 to 7	4.5 to 5.5	4 to 4.5	3.5 to 4	<3
Percent substrate size	V_8	8 to 10	6 to 8	4 to 6	2 to 4	0 to 2
Dominant substrate (A/B/C)	V_9	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Percent pools	V_{10}	20 to 85	12.5 to 90	5 to 100	none	none
pH	V_{13}	6 to 8.5	6 to 8.5	5.5 to 9.0	5.5 to 9.2	5.5 to 9.4
Base flow as % of MAF	V_{14}	40 to 100	30 to 40	20 to 30	10 to 20	0 to 10
Percent riffle fines	V_{16}	10 to 25	25 to 35	35 to 45	45 to 60	>60
Juvenile Rearing						
Max. temperature (°C)	V_1	8 to 18	5 to 19	3 to 20	2 to 21	0 to 21
Min. diss. oxygen (mg/L)	V_3	5.5 to 7	4.5 to 5.5	4 to 4.5	3.5 to 4	<3.5
Percent juvenile cover	V_6	7 to 14	4 to 7	2 to 4	0 to 2	none
Percent substrate size	V_8	8 to 10	6 to 8	4 to 6	2 to 4	0 to 2
Dominant substrate (A/B/C)	V_9	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Percent pools	V_{10}	20 to 85	12.5 to 90	5 to 100	none	none
Pool class rating (A/B/C)	V_{15}	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.33/0.33/0.33
pH	V_{13}	6 to 8.5	6 to 8.5	5.5 to 9.0	5.5 to 9.2	5.5 to 9.4
Base flow as % of MAF	V_{14}	40 to 100	30 to 40	20 to 30	10 to 20	0 to 10
Percent riffle fines	V_{16}	10 to 20	20 to 35	35 to 45	45 to 60	>60

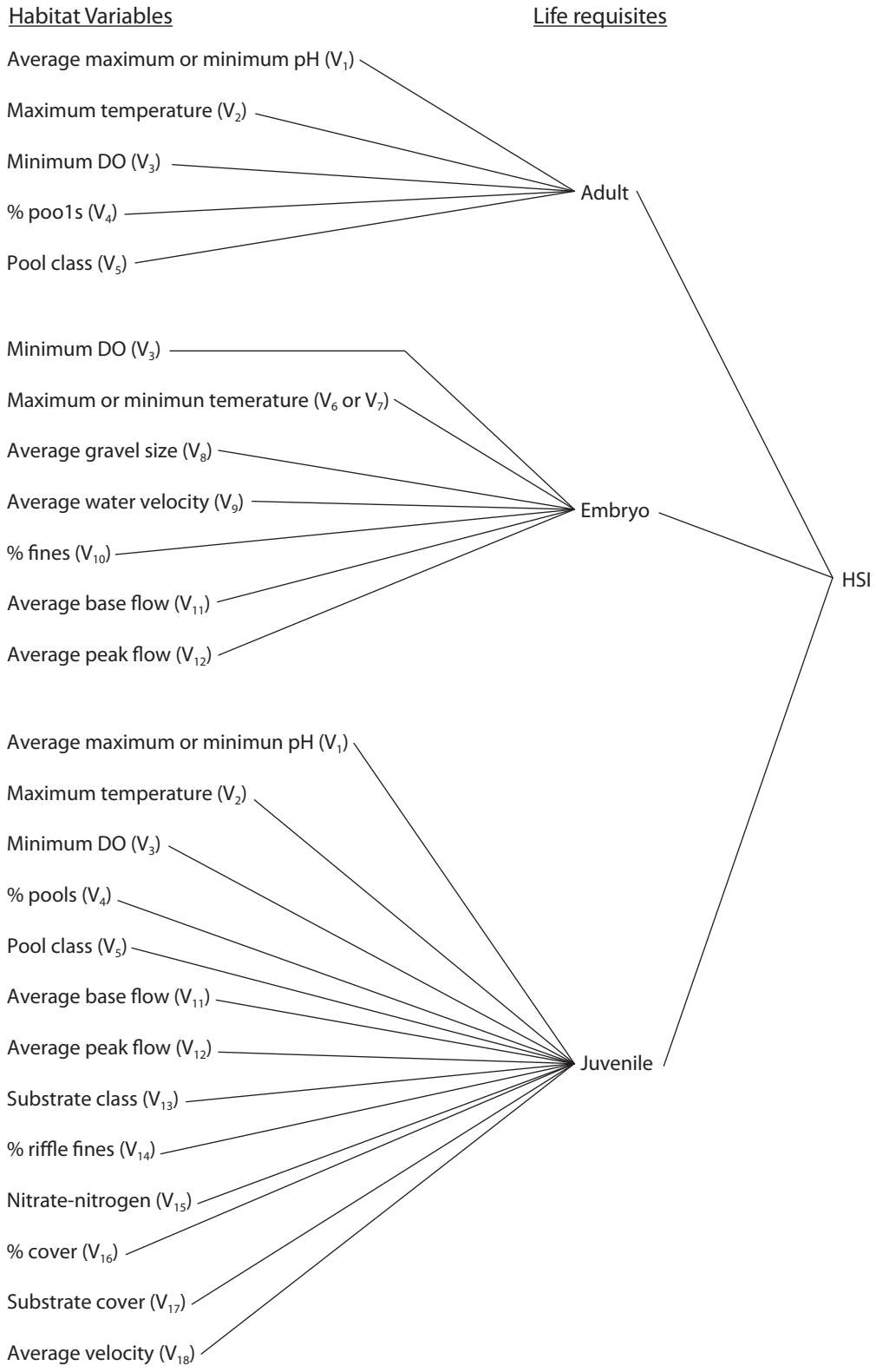
Source: Raleigh et al. (1984).

V_X are the habitat variables shown in Figure 3.2-3.

MAF = Mean Annual Flow.

Substrate rating (V_9): A = cobble or boulders or small vegetation; B = silt, gravel, cobble, boulders in equal amounts; and C = fines, boulders and bedrock dominate.

Pool rating: A = large, deep (>1.5 m), 30% obscure; B = moderate size and depth, 5 to 30% obscure; and C = small, shallow, clear.



Tree Diagram Showing how Habitat Variables were Linked into an HSI for Chinook Salmon

FIGURE 3.2-4

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Table 3.2-3. Habitat Suitability Indices for Chinook Salmon in Stream Environments

Habitat Variable	V_X	Excellent	Above average	Average	Below Average	Unsuitable
HSI value		0.80 to 1.00	0.60 to 0.79	0.40 to 0.59	0.20 to 0.39	0.00 to 0.19
Adult						
Average max. or min. pH	V_1	7.5 to 8.2	6.3 to 7.4; 8.3 to 8.4	6.0 to 6.2; 8.5 to 8.6	5.7 to 5.9; 8.7 to 8.8	<5.7 ; >8.8
Temperature	V_2	6 to 14	5 to 5.9; 15.1 to 17	3 to 4.9; 17.1 to 19	2 to 2.9; 19.1 to 21.5	<2 ; >22
Minimum Dissolved Oxygen	V_3					
	< 5 °C	7.5 to 9.0	6.5 to 7.4	5.0 to 6.4	4.0 to 4.9	2.5 to 3.9
	5 to 10 °C	8.0 to 9.0	7.3 to 7.9	6.5 to 7.2	5.5 to 6.4	4.5 to 5.4
	> 10 °C	11.5 to 13.0	10.0 to 11.4	8.0 to 9.9	6.5 to 7.9	4.5 to 6.4
Percent Pools	V_4	30 to 59	20 to 29; 60 to 79	10 to 19; 80 to 89	0 to 9; 90 to 100	none
Pool class rating (A/B/C)	V_5	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Spawning/Incubation/Emergence						
Minimum Dissolved Oxygen	V_3					
	< 5 °C	7.5 to 9.0	6.5 to 7.4	5.0 to 6.4	4.0 to 4.9	2.5 to 3.9
	5 to 10 °C	8.0 to 9.0	7.3 to 7.9	6.5 to 7.2	5.5 to 6.4	4.5 to 5.4
	> 10 °C	11.5 to 13.0	10.0 to 11.4	8.0 to 9.9	6.5 to 7.9	4.5 to 6.4
Max. or min. temperature (°C)	V_7	5.5 to 15.0	5.0 to 5.4; 15.1 to 15.5	4.0 to 4.9; 15.6 to 16	3.5 to 3.9; 16.4 to 17	<3.5 or >17
Percent Spawning Gravel	V_8					
	A	> 2	1.0 to 2.0	0.5 to 0.9	0.2 to 0.4	<0.1
	B	none	>3	1.3 to 3.0	0.5 to 1.2	<0.4
Average water velocity (cm/s)	V_9	30 to 85	26 to 29; 86 to 95	25 to 25.9; 96 to 105	24 to 24.9; 106 to 115	<24 ; >115
Percent fines	V_{10}					
	silt	5 to 8	9 to 10	11 to 12	13 to 15	16 to 30
	sand	5 to 15	16 to 21	22 to 25	26 to 30	27 to 30
Base flow as % of MAF	V_{11}	45 to 100	30 to 44	22 to 29	10 to 21	0 to 9
Peak flow as % of MAF	V_{12}	1.5 to 4.2	1.1 to 1.5; 4.3 to 5	<1.1 ; 5 to 5.5	5.5 to 6	>6
Juvenile Rearing						
Temperature	V_2	10 to 19	7 to 9.9; 19.1 to 20.5	5 to 6.9; 20.6 to 22	2.5 to 4.9; 22.1 to 22.5	<2.5 ; >22.5
Minimum Dissolved Oxygen	V_3					
	< 5 °C	7.5 to 9.0	6.5 to 7.4	5.0 to 6.4	4.0 to 4.9	2.5 to 3.9
	5 to 10 °C	8.0 to 9.0	7.3 to 7.9	6.5 to 7.2	5.5 to 6.4	4.5 to 5.4
	> 10 °C	11.5 to 13.0	10.0 to 11.4	8.0 to 9.9	6.5 to 7.9	4.5 to 6.4
Percent Pools	V_4	30 to 59	20 to 29; 60 to 79	10 to 19; 80 to 89	0 to 9; 90 to 100	none
Pool class rating (A/B/C)	V_5	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Base flow as % of MAF	V_{11}	45 to 100	30 to 44	22 to 29	10 to 21	0 to 9
Peak flow as % of MAF	V_{12}	1.5 to 4.2	1.1 to 1.5; 4.3 to 5	<1.1 ; 5 to 5.5	5.5 to 6	>6
Substrate class	V_{13}	1.0/0.0/0.0	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
Percent riffle fines	V_{14}	10 to 20	21 to 30	31 to 40	41 to >50	none
Percent cover	V_{16}	16 to 100	12 to 15	8 to 11	4 to 7	<3

MAF = Mean Annual Flow.

Source: Raleigh et al. (1986).

V_X are the habitat variables shown in Figure 3.2-4

Substrate rating (V_{13}): A = cobble or boulders or small vegetation; B = silt, gravel, cobble, boulders in equal amounts; and C = fines, bouldes and bedrock dominate.

Pool class rating (V5): A = large, deep (>1.5 m), 30% obscure; B = moderate size and depth, 5 to 30% obscure; and C = small, shallow, clear.

Number of Life Stages

Comparison of the published HSI models for coho salmon, chinook salmon and rainbow trout showed that each model has at least three life history stages (Table 3.2-4). The coho model has four stages (adult, embryo, parr, and smolt), as does the rainbow trout model (adult, embryo, fry, and juvenile); however, the chinook model has only three stages (adult, embryo, and juvenile). Since there is no smolt stage for the freshwater-resident Dolly Varden of the study area, the appropriate life stages are adult, embryo, fry, and parr (Table 3.2-5).

Number of Habitat Classes

The number of habitat variables ranges from a minimum of 16 for coho salmon to a maximum of 18 for rainbow trout, perhaps reflecting the amount of information available for each species. Professional judgement may also play a role in these differences. All habitat variables can be grouped into nine classes: substrate, cover, flow, depth, velocity, temperature, dissolved oxygen, pH, and water quality. Therefore, as a first approximation, the Dolly Varden model must have at least one variable in each of those nine habitat classes.

In recognition of its well-known ability to occupy higher gradient streams than most salmonids, a tenth class—percent gradient—was introduced for Dolly Varden adults, fry, and parr.

Habitat Variables

Substrate is considered important for embryos and juveniles of all three species, although a substrate variable is only listed for adult rainbow trout, and not adult coho or chinook salmon. Therefore, substrate is considered a relevant variable for Dolly Varden embryos, fry, and parr, but not adults. Four different measurements of substrate quality are used: predominant substrate type, average gravel size, percent fines, and percent riffle fines. The first three variables are important for feeding of fry and parr, and the last two variables are important for embryo survival. Therefore, two substrate variables are defined for Dolly Varden. Percent substrate type is used for juveniles and is presented as the fraction of substrate from three general size classes: rubble/boulder, gravel, and fines. For example, a substrate classification of 0.50/0.35/0.15 represents 50% boulder, 35% gravel and 15% fines. The percent fines measurement is used for embryos.

Cover is considered important for adults and juveniles of all three species, but not for embryos (because they are buried in gravel). Six different measurements of cover are used in the various HSI models: percent cover, percent instream cover, percent substrate cover, percent pools, pool class rating, and percent winter cover. Many of these forms of cover are interrelated and redundant if all were used for the Dolly Varden HSI model; therefore, two cover variables are defined for Dolly Varden: percent instream cover and percent pools.

Riparian cover and habitat are considered important for adults and juveniles of all three species, but not for embryos. Two interrelated measurements, percent canopy and vegetation of riparian zone, are related to riparian functions. However, many of the other measurements (previously identified as variables for Dolly Varden) are related to riparian functions, such as instream cover (in the form of LWD), percent pools (from LWD recruitment), and water temperature (related to canopy cover and stream shading). Therefore, one riparian variable was defined for Dolly Varden: vegetation index of riparian zone. This variable is related to the allochthonous inputs from riparian vegetation and reduces redundancy of the variables.

Table 3.2-4. Habitat Variables of HSI Models for Rainbow Trout, Chinook Salmon and Coho Salmon

Life Stage	Habitat Class	Habitat Variable	Rainbow Trout	Chinook Salmon	Coho Salmon
Adult	Substrate	Predominant substrate type	X	-	-
		Percent riffle fines	X	-	-
	Cover	Percent instream cover	X	-	-
		Percent pools	X	X	-
		Pool classs rating (A/B/C)	X	X	-
	Flow	Average base flow (percent of MAF)	X	-	-
	Depth	Average thalweg depth	X	-	-
	Velocity	-	-	-	-
	Temperature	Maximum temperature	X	X	-
		Temperature during migration	X	-	X
	Diss. oxygen	Average minimum dissolved oxygen	X	X	X
	pH	Average maximum or minimum pH	X	X	-
	Water quality	-	-	-	-
Embryo	Substrate	Average gravel size	X	X	X
		Percent fines	-	X	-
		Percent riffle fines	X	-	-
		Predominant substrate type	X	-	-
	Cover	-	-	-	-
	Flow	Average base flow (percent of MAF)	X	X	-
		Average peak flow (percent of MAF)	-	X	-
	Depth	-	-	-	-
	Velocity	Average water velocity	X	X	-
	Temperature	Average temperature	-	-	X
		Average maximum temperature	X	X	-
	Diss. oxygen	Average dissolved oxygen	-	-	X
		Average minimum dissolved oxygen	X	X	-
	pH	Average maximum or minimum pH	X	-	-
	Water quality	-	-	-	-
Juvenile	Substrate	Average substrate size class	X	X	X
		Predominant substrate type	X	-	-
		Percent riffle fines	X	X	-
	Cover	Percent cover	-	X	X
		Percent instream cover	X	-	-
		Percent substrate cover	-	X	-
		Percent canopy	-	-	X
		Vegetation of riparian zone	X	-	X
		Percent pools	X	X	X
		Pool class rating	X	X	X
		Percent winter cover	-	-	X
	Flow	Average base flow (percent of MAF)	X	X	-
		Average peak flow (percent of MAF)	-	X	-
	Depth	-	-	-	-
	Velocity	Average water velocity	-	X	-
	Temperature	Average temperature	-	-	X
		Maximum temperature	X	X	-
		Temperature during seawater migration	-	-	X
	Diss. oxygen	Average dissolved oxygen	-	-	X
		Average minimum dissolved oxygen	X	X	-
		Average dissolved oxygen during migration	-	-	X
	pH	Average maximum or minimum pH	X	X	-
	Water quality	Concentration of nitrate-nitrogen	-	X	-

Sources: McMahon (1983), Raleigh et al. (1984, 1986).

MAF = Mean Annual Flow.

Substrate rating: A = cobble or boulders or small vegetation; B = silt, gravel, cobble, boulders in equal amounts; and C = fines, bouldes and bedrock dominate.

Pool rating: A = large, deep (>1.5 m), 30% obscure; B = moderate size and depth, 5 to 30% obscure; and C = small, shallow, clear.

Dashes inddicate not applicable

Table 3.2-5. HSI Model for Dolly Varden in Project Area

Life Stage	Habitat Class	Habitat Variable	Units	Rating			
				High	Moderate	Low	Poor
Adult	Stream gradient	Percent stream gradient	%	0 to 4	5 to 9	10 to 14	15 to 19
	Substrate	NA	NA	NA	NA	NA	NA
	Cover	Percent instream cover	%	>20	10 to 19	5 to 9	<5
		Percent pools	%	35 to 70	1-34 and 71-99	none	none
	Riparian	Vegetation index of riparian zone	-	>150	149 to 75	74 to 49	<49
	Flow	Average base flow	% of MAF	50 to 100	35 to 49	20 to 34	0 to 19
	Velocity	NA	NA	NA	NA	NA	NA
	Temperature	Average temperature	˚C	7 to 13	4.5-6.9/13.1-15.6	2-4.5/15.7-18.5	0-1.9/18.6-20
	Dissolved oxygen	Average dissolved oxygen	mg/L	>7	6 to 6.9	5 to 5.9	<5
	pH	Average pH	log units	6.5 to 8.0	6.0-6.4/8.1-8.5	5.5-5.9/8.6-8.9	<5.5 and >9.0
Embryo	Stream gradient	NA	NA	NA	NA	NA	NA
	Substrate	Percent fines	%	<15	15 to 20	20 to 25	>25
	Cover	NA	NA	NA	NA	NA	NA
	Flow	Average base flow	% of MAF	50 to 100	35 to 49	20 to 34	0 to 19
	Velocity	Average velocity	cm/s	30 to 70	20-29 and 71-79	10-19 and 80-89	0-9 and >90
	Temperature	Average temperature	˚C	7 to 13	4.5-6.9/13.1-15.6	2-4.5/15.7-18.5	0-1.9/18.6-20
	Dissolved oxygen	Average dissolved oxygen	mg/L	>7	6 to 6.9	5 to 5.9	<5
	pH	Average pH	log units	6.5 to 8.0	6.0-6.4/8.1-8.5	5.5-5.9/8.6-8.9	<5.5 and >9.0
Fry	Stream gradient	Percent stream gradient	%	0 to 4	5 to 9	10 to 14	15 to 19
	Substrate	Percent gravel and rubble (A/B/C)	%	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
	Cover	Percent instream cover	%	>20	10 to 19	5 to 9	<5
		Percent pools	%	35 to 70	1-34 and 71-99	none	none
	Riparian	Vegetation index of riparian zone	-	>150	149 to 75	74 to 49	<49
	Flow	Average base flow	% of MAF	50 to 100	35 to 49	20 to 34	0 to 19
	Velocity	NA	NA	NA	NA	NA	NA
	Temperature	Average temperature	˚C	7 to 13	4.5-6.9/13.1-15.6	2-4.5/15.7-18.5	0-1.9/18.6-20
	Dissolved oxygen	Average dissolved oxygen	mg/L	>7	6 to 6.9	5 to 5.9	<5
	pH	Average pH	log units	6.5 to 8.0	6.0-6.4/8.1-8.5	5.5-5.9/8.6-8.9	<5.5 and >9.0
Parr	Stream gradient	Percent stream gradient	%	0 to 4	5 to 9	10 to 14	15 to 19
	Substrate	Percent gravel and rubble (A/B/C)	%	1.0/0.0/0.0	0.5/0.5/0.0	0.4/0.4/0.2	0.3/0.3/0.3
	Cover	Percent instream cover	%	>20	10 to 19	5 to 9	<5
		Percent pools	%	35 to 70	1-34 and 71-99	none	none
	Riparian	Vegetation index of riparian zone	-	>150	149 to 75	74 to 49	<49
	Flow	Average base flow	% of MAF	50 to 100	35 to 49	20 to 34	0 to 19
	Velocity	NA	NA	NA	NA	NA	NA
	Temperature	Average temperature	˚C	7 to 13	4.5-6.9/13.1-15.6	2-4.5/15.7-18.5	0-1.9/18.6-20
	Dissolved oxygen	Average dissolved oxygen	mg/L	>7	6 to 6.9	5 to 5.9	<5
	pH	Average pH	log units	6.5 to 8.0	6.0-6.4/8.1-8.5	5.5-5.9/8.6-8.9	<5.5 and >9.0

Notes:

NA = not applicable, MAF = mean annual flow.

Substrate rating: A = cobble or boulders or small vegetation; B = silt, gravel, cobble and boulders (equal amounts); and C = fines, boulders and bedrock dominate.

Flow is considered important for all three life stages of rainbow trout and chinook salmon, but not for coho salmon. Therefore, the weight of evidence indicates that flow is also important for Dolly Varden. Two interrelated measurements of flow are used: average base flow, defined as the percent of mean annual flow (MAF), and average peak flow, also defined as a percent of MAF. Average base flow (as a percent of MAF) was chosen for Dolly Varden since both variables are interrelated and redundant if all were used.

Depth is only considered important for adult rainbow trout and is defined as the depth of the thalweg—the deepest part of a stream or river. Therefore, depth was not included for Dolly Varden, reducing the total number of habitat classes to eight.

Velocity is considered important for embryos of rainbow trout and chinook salmon and for juvenile chinook salmon. Therefore, velocity was included in the Dolly Varden HSI model, but only for embryos. In all cases, velocity is measured as average velocity, which is included in the Dolly Varden model.

Temperature is considered important for all three life stages of all three species; therefore, it is included in all four life stages of the Dolly Varden model. Four temperature variables are used: average temperature, maximum temperature, temperature during spawning migration, and temperature during seaward migration. Average temperature is used in the Dolly Varden model.

The concentration of dissolved oxygen is considered important for all three life stages of the three species; therefore, it is included in all four life stages of the Dolly Varden model. Four variables are used: average dissolved oxygen, average minimum dissolved oxygen, and average dissolved oxygen during seaward migration. Average dissolved oxygen is used in the Dolly Varden model.

pH is considered important for all life stages of rainbow trout and for two of the three life stages of chinook salmon, but not for coho salmon. Therefore, pH is included in the Dolly Varden model. In all cases, pH is expressed as the habitable range.

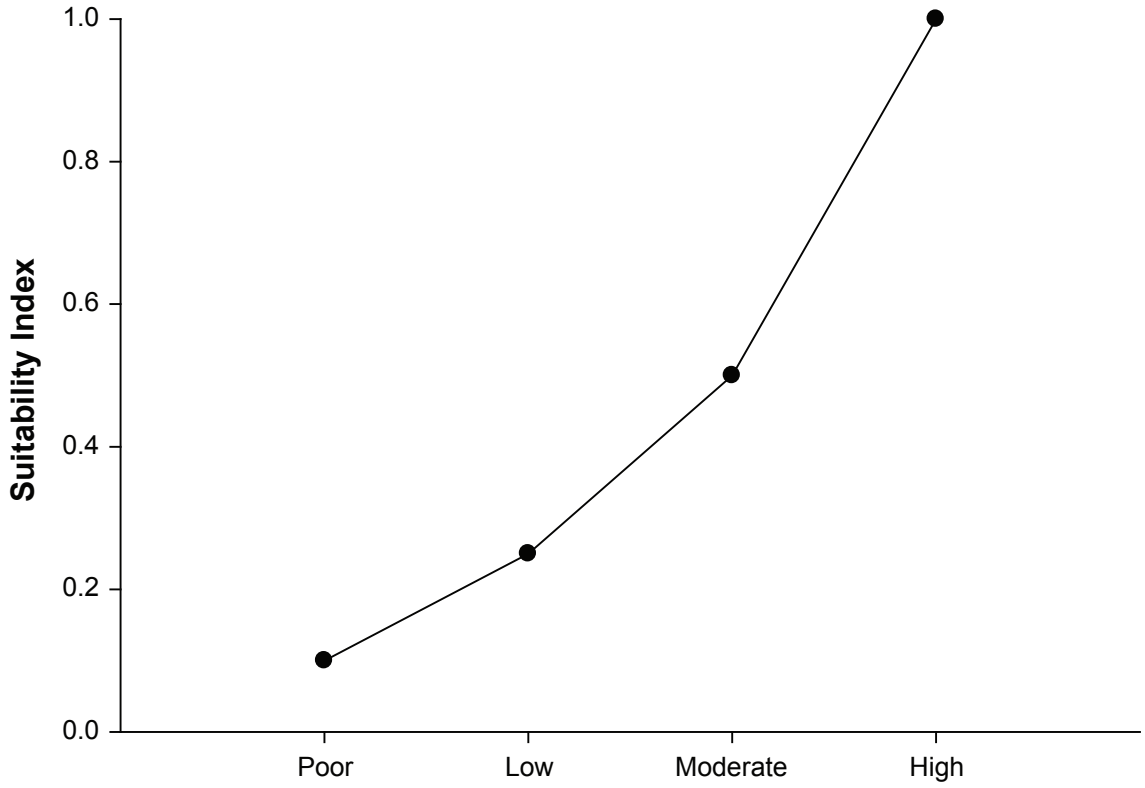
Only one additional water quality variable—average concentration of nitrate-nitrogen—is used in the three models, and only for juvenile chinook salmon. Nitrate is not an important habitat variable in natural waters such as in the Project area—only in waters adversely affected by human wastewater. Therefore, no other water quality variables (other than temperature, dissolved oxygen, and pH) are used in the Dolly Varden model.

In summary, based on the HSI models for rainbow trout, coho salmon, and chinook salmon, a Dolly Varden model was developed that is assumed to have four life stages (adult, embryo, fry, and parr) and eight habitat classes with one to two variables in each class (Table 3.2-5).

3.2.5.2 Habitat Suitability Index Models

Simplified Habitat Suitability Curve

The simplified HSI model for Dolly Varden has only one generalized habitat suitability curve (Figure 3.2-5). The y-axis is an HSI with values from 0 to 1.0 and the x-axis consists of four classes of habitat value: poor, low, moderate, and high. Poor habitat is assigned an SI value of 0.10, low has a value of 0.25, moderate has a value of 0.50, and high has a value of 1.0.



low complexity	high complexity
high gradient or stagnant	low to moderate gradient
no cover	abundant cover
no pools	abundant pools and eddies
temperature <> optimal range	optimal temperature
high turbidity	clear or low turbidity
low oxygen	high oxygen

Generalized Habitat Suitability Curve for Dolly Varden

FIGURE 3.2-5

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In narrative terms, poor-quality habitat is characterized by high gradient, low complexity (e.g., no canopy or instream cover, no LWD, etc.), water temperatures and pH outside the optimal range, and low concentrations of dissolved oxygen. High-quality habitat is characterized by moderate gradient and gravel substrate, high complexity (i.e., abundant cover and much LWD), water temperatures and pH within the optimal range, and high concentrations of dissolved oxygen.

The rest of this section provides numerical definitions of those four classes for each of four life stages: adult, embryo, fry, and parr (Table 3.2-5).

Gradient

Information on gradients of Dolly Varden streams is scattered throughout the literature (e.g., Bryant 1984), but few studies sampled a sufficiently wide range of gradients to show preferences. The exception is a study of 11 headwater streams on Prince of Wales Island in southeast Alaska by Bryant, Zymonas, and Wright (2004) that sampled gradients over a range of 2.4 to 22%. Dolly Varden fry and parr were found over the range of 2.4 to 17%. Adults were not sampled, and are assumed in this study to follow the same gradient distribution as juveniles. The frequency distributions of juvenile density with gradient were similar for both fry and parr, hence those data were pooled. The highest densities of juvenile Dolly Varden were in the gradient range of 5 to 9%. Dolly Varden, however, occupy high gradient streams due to inter-specific competition (e.g., coho salmon; Bryant, Zymonas, and Wright 2004).

In the Project area, higher densities of Dolly Varden were present in lower gradient streams without competition for resources with other species (Rescan 2010). Therefore, a low gradient of 0 to 4% was defined by this study as high quality, followed in order of decreasing average density by the gradient range of 5 to 9% (moderate), 10 to 14% (low), and 15 to 19% (poor).

Substrate

Percent Fines

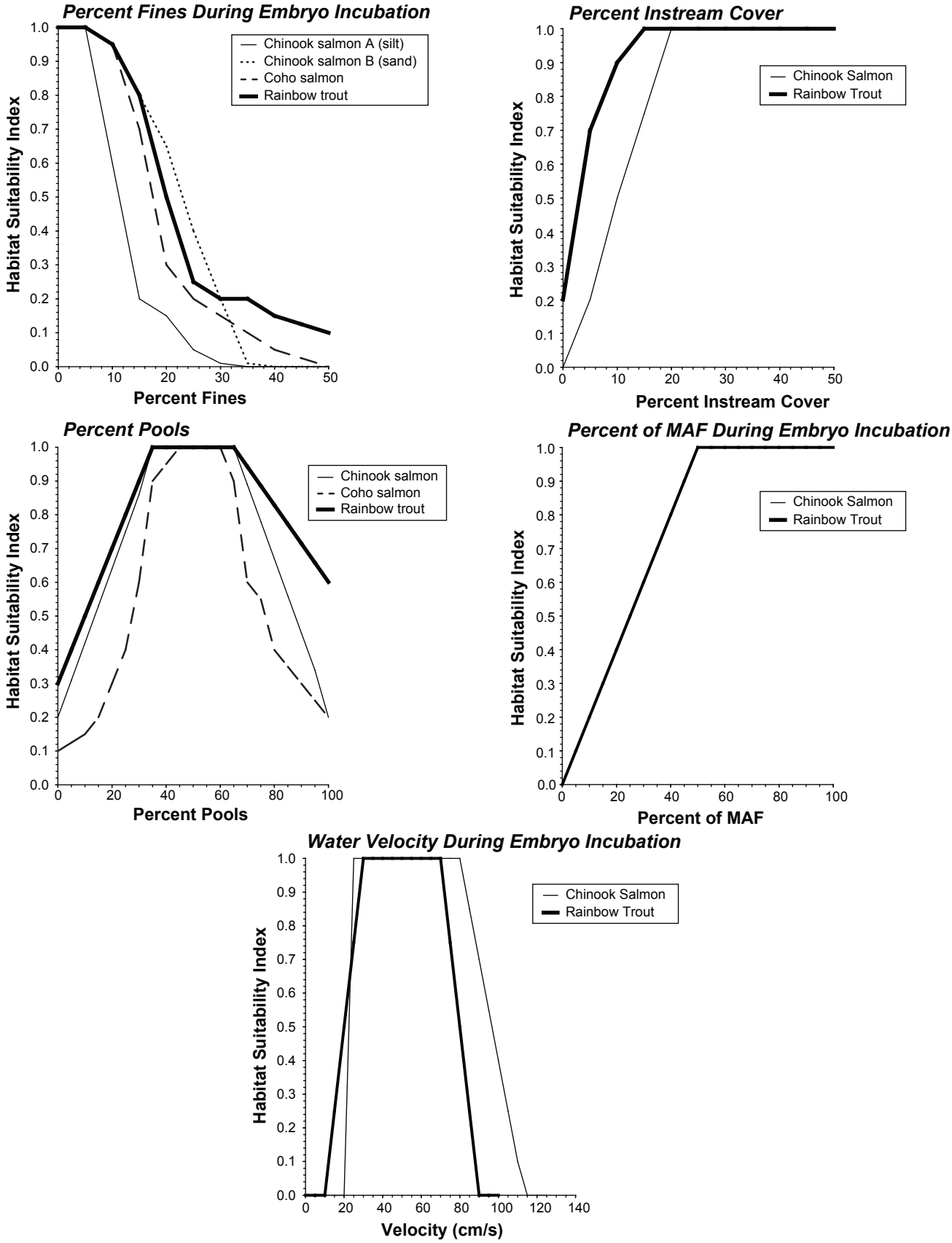
The relationship between suitability indices and percent fines was reported for chinook salmon, coho salmon, and rainbow trout (Figure 3.2-6), based on studies conducted by Burner (1951); Cordone and Kelly (1961); McNeil and Ashell (1964); Koski (1966); McNeil (1968); Orcutt, Pulliam, and Arp (1968); Bjornn (1969); Phillips et al. (1975); Cloern (1976); and Platts, Shirazi, and Lewis (1979). All of the suitability curves showed the same rapid decrease in suitability with increasing percentages of fines. The curve for coho salmon fell between the curves for rainbow trout and chinook salmon, hence it was adopted for Dolly Varden. Therefore, lower than 15% fines is considered high quality, between 15 and 20% fines is moderate quality, 20 to 25% fines is low quality, and greater than 25% fines is poor quality.

Substrate Composition for Juvenile Feeding

Raleigh, Miller, and Nelson (1986) defined three classes of substrate type in riffle-run areas that support juvenile chinook salmon. Class A consisted of rubble and small boulders with limited amounts of gravel and was assigned a suitability rating of 1. Class B consists of rubble, boulders, and gravel in roughly equal amounts and was assigned a suitability of 0.6. Class C consists of fines, bedrock, or very large boulders and was assigned a suitability of 0.3.

Raleigh et al. (1984) used the same substrate composition for food production for rainbow trout.

McMahon (1983) defined the preferred substrate composition of coho salmon parr as the “percent of rubble and gravel”, defined as the sum of the percent of gravel and rubble and the percent of fines (or percent embeddedness, whichever was lower) divided by 2. Suitability was assumed to be zero at 0% rubble and gravel and rise to a value of 1 at 60% gravel and rubble.



Habitat Suitability and Percent Fines, Percent Instream Cover, Percent Pools, Percent Mean Annual Flow (MAF) and Water Velocity

FIGURE 3.2-6

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Many of these forms of substrate composition are interrelated and redundant if all were used for the Dolly Varden HSI model; therefore the method used by Raleigh et al. (1984) and Raleigh, Miller, and Nelson (1986) was adopted for Dolly Varden.

Cover

Percent Instream Cover

Both chinook salmon and rainbow trout rearing habitat is considered high quality if at least 20% of the area is classified as cover (Figure 3.2-6), whether the cover comes from boulders, instream vegetation, cutbanks, or LWD. The most conservative suitability curve is for chinook salmon because it assumes zero suitability at 0% habitat, which was applied to the Dolly Varden HSI model.

Percent Pools

For coho salmon, chinook salmon, and rainbow trout, habitat suitability rises rapidly with the percent of stream areas classified as pool habitat (Figure 3.2-6). Maximum suitability occurs when pools make up between approximately 35 and 70% of stream area. Suitability falls, however, when pool area increases above 70% because of the absence of riffle habitat, which is the most productive habitat in terms of production of insect drift and benthic invertebrates. The suitability curve for chinook salmon falls between the curves for coho salmon and rainbow trout, hence it was chosen for Dolly Varden. That means that high quality in terms of percent pools habitat is defined as 35 to 70%, moderate is defined as the shoulders of the suitability curve (1 to 34% and 71 to 99%), and both low and poor habitat have no pools.

Riparian

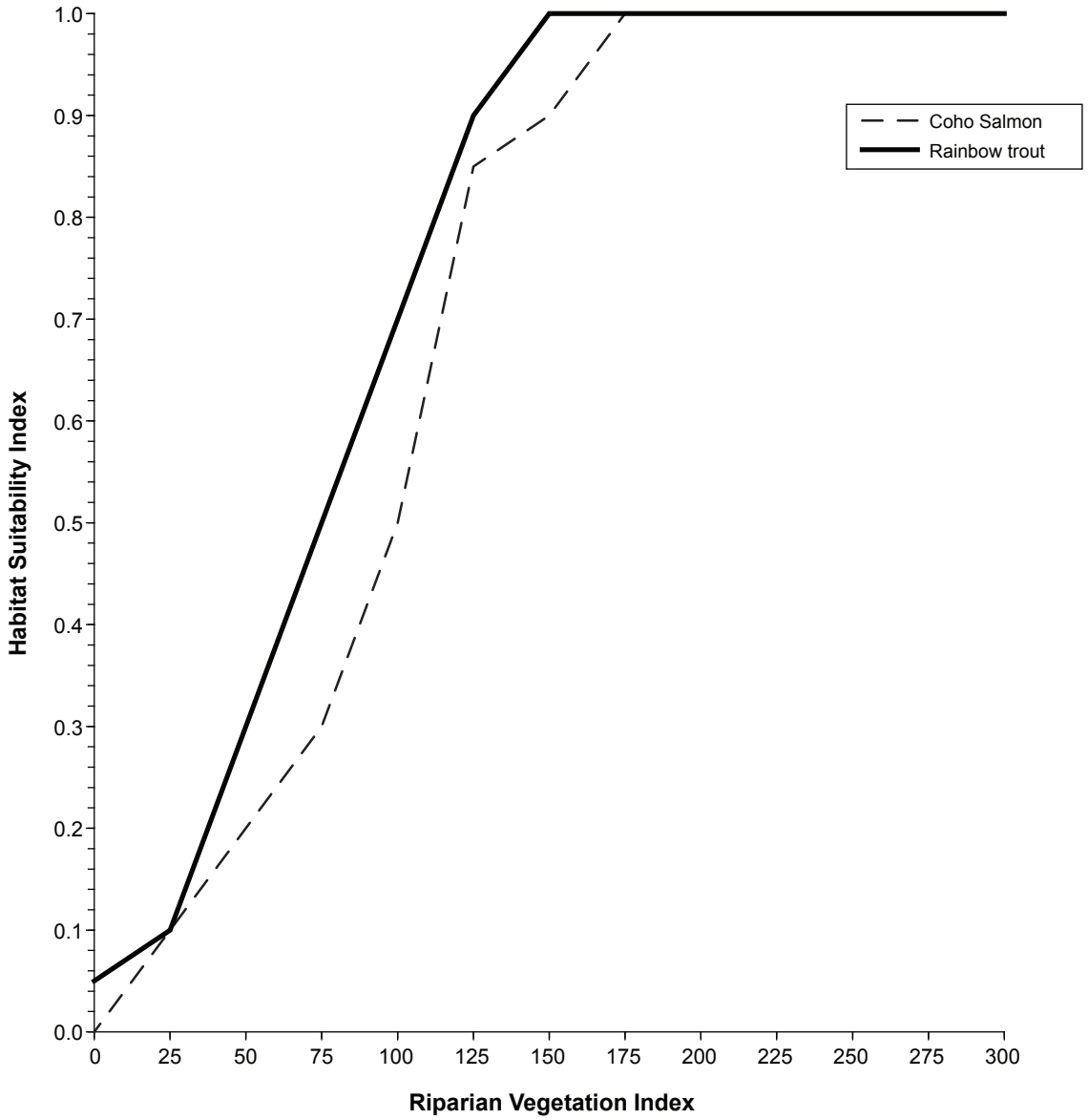
For coho salmon and rainbow trout, habitat suitability rises rapidly with the percent of riparian habitat classified as shrubs or deciduous trees (Figure 3.2-7). Maximum suitability occurs when the riparian index is at 150. Shrubs and deciduous riparian habitat are the most productive habitat in terms of production of allochthonous inputs. The suitability curves for coho salmon and rainbow trout are similar, hence it was chosen for Dolly Varden. That means that high quality in terms of riparian vegetation index is defined as greater than 150, moderate is 149 to 75, low is 74 to 49, and poor is less than 49.

Flow

Suitability of habitat for chinook salmon and rainbow trout both increased with the percent of MAF to maximum suitability at 50% MAF and greater (Figure 3.2-6). This single curve was used to define habitat suitability classes for Dolly Varden. High-quality habitat is 50 to 100% MAF, moderate is 35 to 39% MAF, low is 20 to 34% MAF, and poor is 0 to 19% MAF.

Water Velocity during Incubation

Suitability of habitat for chinook salmon and rainbow trout embryos followed similar dome-shaped relationships with water velocity (Figure 3.2-6). The curve for rainbow trout was chosen for Dolly Varden, only because the life histories of Dolly Varden and rainbow trout share more commonalities than either do with chinook salmon. Therefore, high-quality habitat is defined as 30 to 70 cm/s, moderate is 20 to 29 cm and 71 to 79 cm/s, low is 10 to 19 cm and 80 to 89 cm/s, and poor is 0 to 19 cm and greater than 90 cm/s.



Habitat Suitability and Riparian Vegetation Index

FIGURE 3.2-7

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Temperature

Chinook salmon, coho salmon, and rainbow trout showed similar envelopes of HSI for temperature (Figure 3.2-8). Incubating embryos had the lowest temperature ranges, juveniles had the widest ranges, and the ranges of migrating adults lay in-between. All three sets of temperature HSI envelopes bracketed the 7 to 13°C range that was cited by Hicks (2002) as optimum for Dolly Varden, but all showed maxima that exceeded the temperature (16°C) at which Dolly Varden cease eating, and the temperature ranges for some life stages exceeded the lethal temperature (20°C) for Dolly Varden (Takami, Kitano, and Nakano 1997). For all life stages, coho salmon had lower maxima than chinook salmon or rainbow trout.

Based on these data, the Dolly Varden HSI envelopes for temperature HSI are based on a simplified version of the coho salmon model. For all life stages, HSI rose from zero at 0°C to an optimum range of 7 to 13°C, and then declined to zero at 20°C (Figure 3.2-8). Therefore, Dolly Varden's high suitability is from 7 to 13°C, moderate is from 4.5 to 6.9°C and from 13.1 to 15.6°C, low is from 2 to 4.5°C and from 15.7 to 18.5°C, and poor is from 0 to 1.9°C and from 18.6 to 20°C.

Dissolved Oxygen

The dissolved oxygen suitability curves for chinook salmon, coho salmon, and rainbow trout are similar (Figure 3.2-9). Suitability is zero until the range of 3 to 4.5 mg/L, whereupon it increases linearly to optimal within the range of 6.5 to 9.0 mg/L.

Based on these data, dissolved oxygen suitability for Dolly Varden is assumed to be zero at 4 mg/L and to increase linearly to a maximum at 7 mg/L. Therefore, high suitability is greater or equal to 7 mg/L, moderate suitability is 6 to 6.9 mg/L, low suitability is 5 to 5.9 mg/L, and poor suitability is less than 5 mg/L.

pH

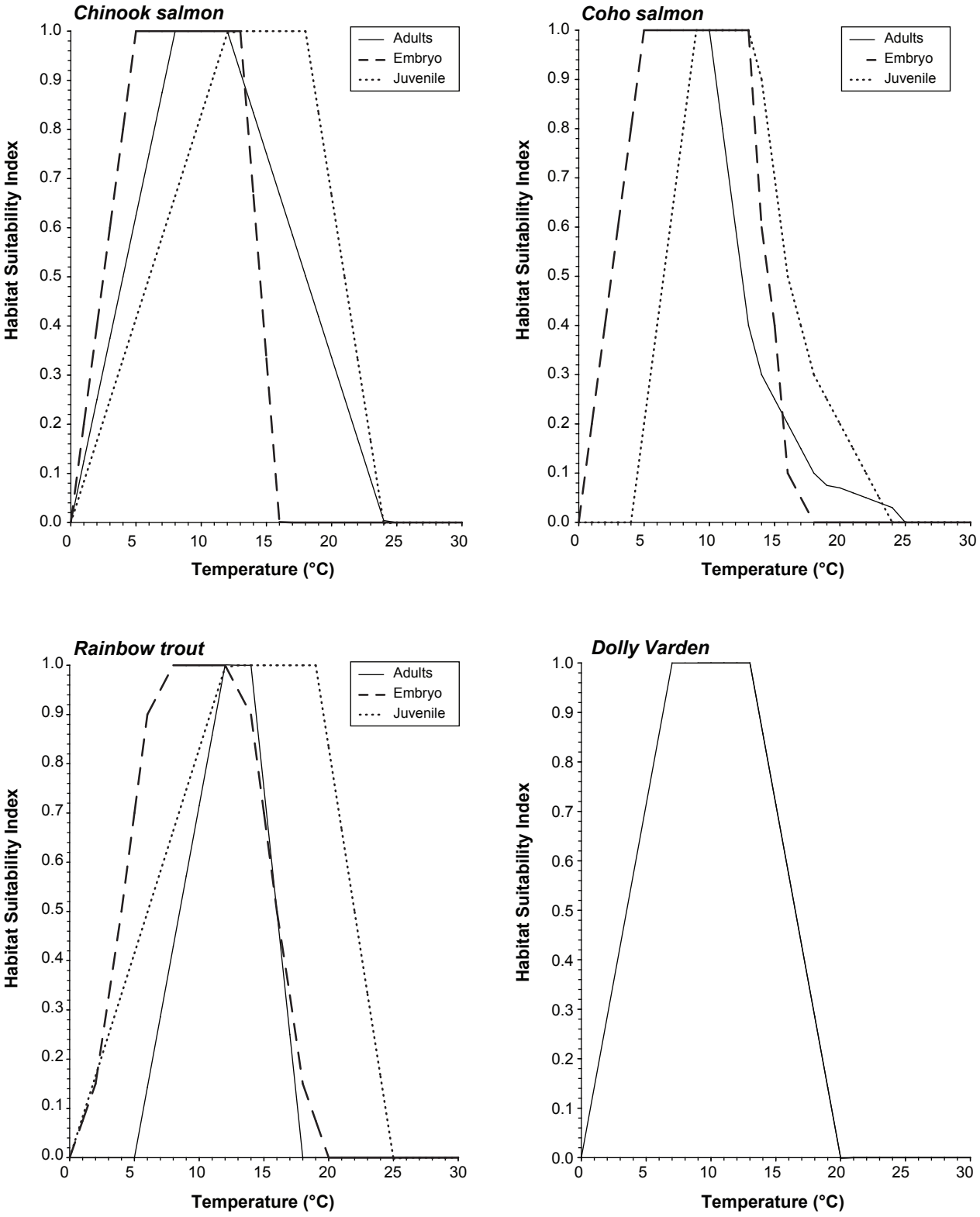
Suitability curves for pH were very similar for chinook salmon and rainbow trout (Figure 3.2-9). Based on these curves, high suitability for Dolly Varden is defined as 6.5 to 8.0, moderate is 6.0 to 6.4 and 8.1 to 8.5, low is 5.5 to 5.9 and 8.6 to 8.9, and poor is less than 5.5 and greater than 9.0.

3.2.6 Wetland Habitat Suitability Index

A search of scientific literature found that wetland HSI models are not available for any salmonid species. HSI models developed for streams are not applicable for wetland habitat. Wetlands and beaver ponds play an important role in the rearing and overwintering of salmonids, in particular coho salmon and Dolly Varden (Slaney and Zaldokas 1997). These species use the same off-channel wetland habitats in the Project study area (Rescan 2009, 2010). Therefore, a generalized habitat suitability curve (similar to the Dolly Varden HSI) was adopted for species in wetland environments (Figure 3.2-10). The y-axis is an HSI with values from 0 to 1.0 and the x-axis consists of five classes of habitat value: poor, low, moderate, above average, and high. Poor habitat is assigned a SI value of 0.10, low has a value of 0.25, moderate has a value of 0.50, above average has a value of 0.75, and high has a value of 1.0.

Research to date suggests that ideal wetland and beaver pond habitats, which provide optimal salmonid production, possess the following features (Slaney and Zaldokas 1997):

- small individual wetland/pond complexes;
- diverse water depths for fish growth and overwinter security;
- sufficient water depth for overwintering survival;

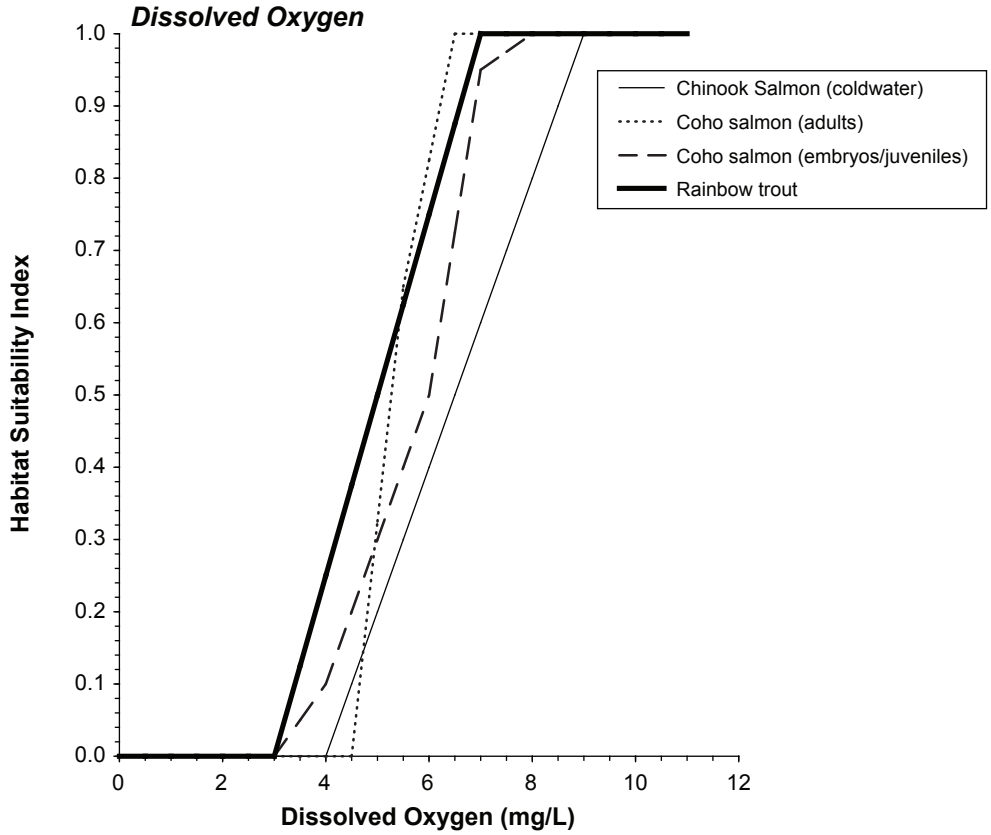


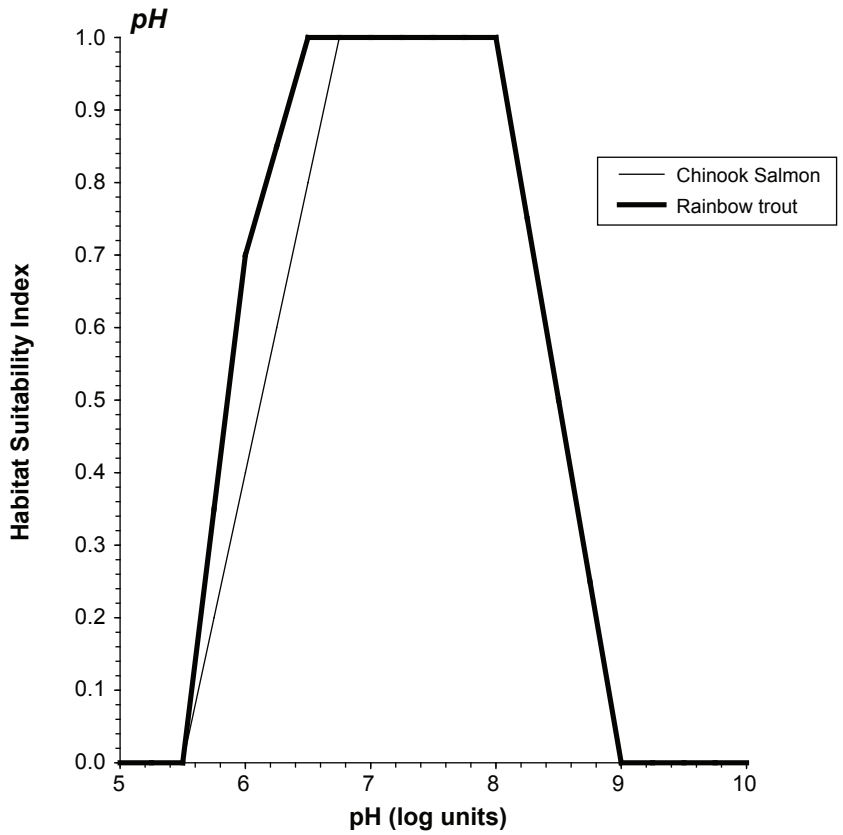
Habitat Suitability and Water Temperature

FIGURE 3.2-8

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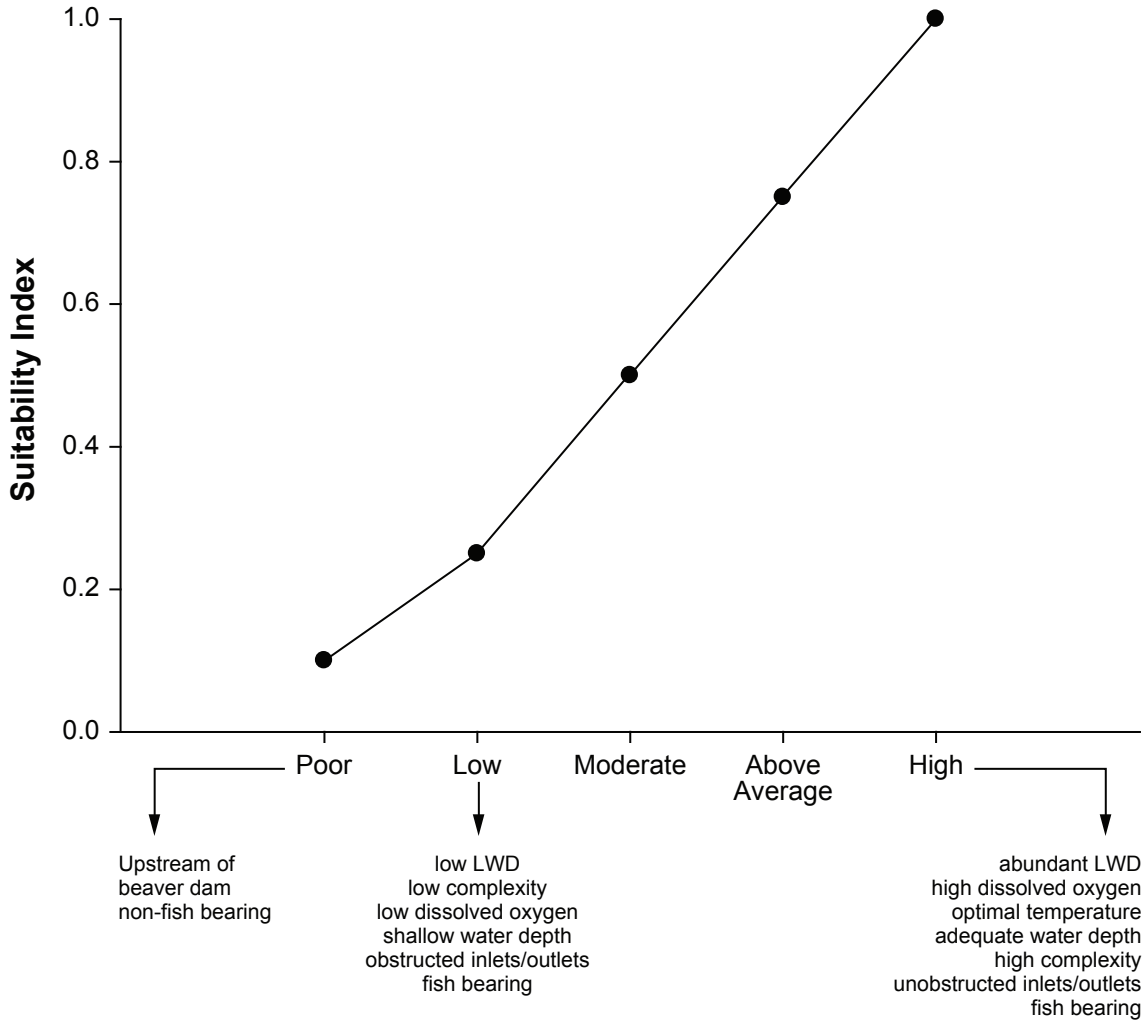


Habitat Suitability and Dissolved Oxygen and pH

FIGURE 3.2-9

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Generalized Habitat Suitability Curve for Wetland Species

FIGURE 3.2-10

SEABRIDGE GOLD

Rescan™

- suitable water temperatures and dissolved oxygen levels;
- defined inlet and outlet channels for water exchange and to allow for fish passage; and
- abundant LWD cover for improved rearing and overwintering capability.

In narrative terms, poor-quality habitat is characterized by absent/restricted inlet and outlet channels, shallow water depth, low LWD cover, water temperatures and pH outside the optimal range, and low concentrations of dissolved oxygen. High-quality habitat is characterized by defined and unobstructed inlet and outlet channels, sufficient water depth, high LWD cover complexity, water temperatures and pH within the optimal range, and high concentrations of dissolved oxygen.

Comparison of stream HSI models for coho salmon and Dolly Varden showed that each model has four life history stages. Each of these stages broadly relate to spawning, migration, rearing, and overwintering habitat. These life history stages were simplified for wetlands because of the lack of peer-reviewed wetland HSI models. Since there is no spawning or embryo development, or migration stages for Dolly Varden and coho salmon in wetland/pond habitats, these life stages were not included.

Wetland habitat suitability for each life stage was assessed, based upon characteristics that provide optimal salmonid production (see above), professional experience, site-specific habitat data, and site-specific biological fisheries data.

3.2.7 Riparian Habitat Suitability Index

The above mentioned HSI models take into consideration both instream and riparian habitat variables. However, Project infrastructure that only impacts riparian habitat (e.g., transmission line) warrants the development of a riparian habitat HSI model. Riparian habitat provides four basic functions: bank stability, shade, LWD recruitment, and allochthonous input source. Of these, LWD recruitment will be lost at the crossing location. Existing riparian vegetation will still provide bank stability, shade, and an allochthonous input source. A review of existing HSI models for chinook salmon, coho salmon, cutthroat trout (Hickman and Raleigh 1982) and rainbow trout identified that 19% of the HSI habitat variables for these species were related to LWD recruitment (i.e., percent cover, percent pools, percent juvenile cover, percent winter cover, and pool class). Therefore, an HSI value of 0.2 is assigned to riparian habitat loss.

4. Project Habitat Impact Assessment

4.1 HABITAT LOSS DETERMINATION

This Plan deals specifically with the loss of fish habitat resulting from Project infrastructure such as TMF dams, the TMF waste pile, seepage collection pond dams, Treaty Creek pipeline outlet, access road and transmission line crossings, and losses due to loss of water quantity.

For TMF dams, seepage pond dams, the TMF waste pile, Treaty Creek pipeline outlet, water quantity loss, and access road crossings, HSI models incorporated both instream and riparian habitat variables to develop the habitat budgets for habitat loss. Instream habitat consists of any part of a stream that is below the mean annual high water mark (HWM). The HWM is typically a natural line or "mark" impressed on the bank or shore, indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics. This definition generally corresponds to the elevations of the 1:5 year flood interval (DFO 2010).

For access roads assessments, instream habitat was considered any part of the stream below the one-in-one-hundred year flood (Q100) elevation because the professional surveyors surveyed Q100, not HWM. Calculations of lost habitat represent the area of the alteration below Q100 flood elevation. The Q100 is greater than the SWM; therefore, final habitat loss determination and calculation will be conducted after crossings structures are built because area of alteration below the Q100 and above the HWM is not considered fish habitat.

Most of the instream habitat alterations will arise as a result of instream placement of rip-rap to stabilize banks and protect bridge abutments below the Q100 elevation, and through the construction of instream pilings. Riparian habitat will be lost within the road right-of-way at stream crossings. Road right-of-way was considered as 30-m wide for this assessment.

For transmission line crossings, riparian function will be impaired during the Project's Construction and Maintenance phases. Stream crossings that possessed riparian shrub vegetation were not considered habitat loss/alteration for the Plan because shrubs meet clearance standards for overhead transmission lines. Stream crossings that possessed deciduous and/or coniferous trees as riparian habitat were considered habitat loss. At this point in time, it was assumed that line clearance standards will not be met for these crossings, until detailed transmission line engineering is completed, and habitat loss determination will be revisited once the detailed engineering is complete.

The loss of riparian habitat area was calculated as the width of the riparian zone (15 m) multiplied by the width of the transmission line right-of-way (30 m) for each bank of the stream (i.e., 15 m x 30 m x 2= 900 m^2).

4.2 HABITAT LOSS IDENTIFICATION

4.2.1 Tailings Management Facility Infrastructure

For the purposes of describing fish habitat impacted by the TMF dams, seepage collection pond dams, TMF waste pile, and Treaty Creek pipeline outlet, watercourses are presented in tabular format by watershed and watercourse type (i.e., mainstem, tributary, and wetland). Sensitive Habitat Inventory Mapping (SHIM) was used to characterize fish habitat within the TMF in 2009 (Rescan 2010). Mainstem and tributary tables present channel characteristics; such as bankfull width (m), bankfull depth (m), residual pool depth (m), etc. Mainstem and tributary tables present size, instream, riparian, and habitat quality characteristics; such as area (m^2), HU ratio (%), habitat weighted cover composition (% by unit area),

riparian vegetation type (% by stream length), rearing habitat quality (% of stream length), etc. Wetland tables present size, instream, riparian, and habitat quality characteristics; such as area (m^2), bed composition (%), instream cover presence, etc. Detailed descriptions of impacted watercourses, from a watershed perspective, were previously provided in Section 2.2. Locations of these watercourses are shown in Figures 2.2-1 to 2.2-5 (see Map Pockets). Photographs of the watercourses are provided in Appendix 4.2-1.

Mapped watercourses were sampled to confirm fish presence (Rescan 2009, 2010). Sampling crews commenced electrofishing at the tributary confluence and proceeded upstream to determine the point of "end of fish use."

No fish were caught in Wetland NT-W2, despite 125 hours of minnow trap effort in 2009 and 52 hours of minnow trap and 850 seconds of electrofishing effort in 2008 (Rescan 2009, 2010). The presence of a beaver dam likely restricts upstream fish movement into this wetland and other watercourses upstream of it. However, this wetland and other watercourses upstream of it are considered fish habitat because beaver dams are temporary barriers to fish movement.

There are five mainstem reaches that will be impacted by dam construction in South Teigen Creek, representing a total fish habitat area of 25,073 m^2 (Tables 4.2-1 and 4.2-2; Figures 2.2-1 to 2.2-5 [map pockets]). There are 22 tributaries that will be impacted by dam construction in South Teigen Creek, representing a total fish habitat area of 7,145 m^2 (Tables 4.2-3 and 4.2-4; Figures 2.2-1 to 2.2-5 [map pocket]). There is one wetland that will be impacted by dam construction in South Teigen Creek, representing a total fish habitat area of 314 m^2 (Tables 4.2-5 and 4.2-6; Figures 2.2-1 to 2.2-5 [map pockets]).

Table 4.2-1. Impacted South Teigen Mainstem Creek: Channel Characteristics

	Reach					
Attribute	**4 (North Seepage Dam)**	**4 (North Dam)**	**5 (Splitter Dam)**	**6 (Saddle Dam)**	**7 (Saddle Dam)**	**8 (Saddle Dam)**
Bankfull Width (m)						
Mean	11.33	7.67	6.44	5.06	6.00	8
SE	0.67	0.46	0.77	0.27	-	-
Wetted Width (m)						
Mean	10.67	6.28	6.14	4.61	6.00	7.8
SE	0.83	0.40	0.75	0.08	-	-
Bankfull Depth (m)						
Mean	0.99	0.97	0.84	0.55	0.30	0.7
SE	0.25	0.16	0.14	0.13	-	-
Wetted Depth (m)						
Mean	0.55	0.56	0.51	0.28	0.30	0.5
SE	0.21	0.11	0.09	0.02	-	-
Residual Pool Depth (m)						
Mean	-	0.97	0.93	-	-	-
SE	-	0.44	0.18	-	-	-
Gradient (%)						
Mean	3.50	2.75	1.00	5.00	-	6.00
SE	0.33	0.55	-	-	-	1.00

Dashes indicate not present or not applicable

Table 4.2-2. Affected South Teigen Mainstem: Instream, Riparian, and Habitat Quality Characteristics

		Reach					
Attribute	Descriptor	4 (North Seepage Dam)	4 (North Dam)	5 (Splitter Dam/Waste Pile)	6 (Saddle Dam)	7 (Saddle Dam)	8 (Saddle Dam)
Stream Length Mapped	m	190.0	1079.0	1430.0	450.0	261.0	200.0
Mean Channel Width	m	11.33	7.67	6.44	5.06	6.00	8.00
Stream Area Mapped	m^2	2152.7	8275.9	9202.1	2277.0	1566.0	1600.0
Habitat Unit Ratio (%)	Riffle	34.0	60.0	35.0	90.0	100.0	0.0
	Cascade	44.0	13.0	0.0	10.0	0.0	100.0
	Pool	22.0	21.0	25.0	0.0	0.0	0.0
	Glide	0.0	6.0	40.0	0.0	0.0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	0.0	7.9	25.3	52.1	100.0	0.0
	Gravel	16.5	35.2	63.5	47.9	0.0	0.0
	Cobble	77.1	52.2	7.8	0.0	0.0	80.0
	Boulder	6.5	4.7	3.4	0.0	0.0	20.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	28.2	10.3	19.4	0.0	0.0	10.0
	Boulder	6.5	2.5	1.3	0.0	0.0	20.0
	Instream Vegetation	0.0	0.0	0.0	0.0	0.0	0.0
	Overhanging Vegetation	3.2	6.4	5.0	12.1	100.0	0.0
	Undercut Bank	0.0	3.3	6.0	5.0	0.0	0.0
	Large Woody Debris	3.5		0.0	0.0	0.0	0.0
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	100.0	100.0	100.0	0.0
	Shrubs	41.1	23.3	0.0	0.0	0.0	0.0
	Coniferous Forest	58.9	76.7	0.0	0.0	0.0	0.0
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	0.0	0.0	100.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	0.0	0.0	0.0
	Tall Shrub (2-10m)	41.1	23.3	100.0	100.0	100.0	0.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	28.8	60.9	0.0	0.0	0.0	0.0
	Mature Forest	30.1	15.7	0.0	0.0	0.0	100.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	40.4	5.4	100.0	100.0	100.0	0.0
	1-20%	59.6	94.6	0.0	0.0	0.0	85.4
	21-40%	0.0	0.0	0.0	0.0	0.0	14.6
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	100.0	85.3	0.0	100.0	0.0	100.0
	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0
	Riffle Pool	0.0	14.7	100.0	0.0	100.0	0.0
	Step Pool	0.0	0.0	0.0	0.0	0.0	0.0
Bank Stability - % by stream length	Stable - Undercut	0.0	25.2	100.0	100.0	0.0	0.0
	Stable - No Undercut	100.0	74.8	0.0	0.0	0.0	0.0
	Aggrading	0.0	0.0	0.0	0.0	0.0	14.6
	Eroding	0.0	0.0	0.0	0.0	100.0	85.4
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0	0.0	0.0
	Fines	0.0	15.7	100.0	100.0	100.0	100.0
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0
	Cobble	95.1	79.1	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	4.9	5.1	0.0	0.0	0.0	0.0

(continued)

Table 4.2-2. Affected South Teigen Mainstem: Instream, Riparian, and Habitat Quality Characteristics (completed)

		Reach					
Attribute	Descriptor	4 (North Seepage Dam)	4 (North Dam)	5 (Splitter Dam/Waste Pile)	6 (Saddle Dam)	7 (Saddle Dam)	8 (Saddle Dam)
Spawning Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0
	Good	0.0	0.0	0.0	0.0	0.0	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	100.0	100.0	100.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0
	Good	100.0	100.0	100.0	100.0	0.0	100.0
	None	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	0.0	0.0	0.0	0.0	100.0	0.0
OverWintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0
	Good	100.0	100.0	100.0	100.0	0.0	100.0
	None	0.0	0.0	0.0	0.0	100.0	0.0
	Poor	0.0	0.0	0.0	0.0	0.0	0.0
Potential Spawning Habitat - % of stream length	Abundant	0.0	0.0	0.0	0.0	0.0	0.0
	Micropatches	0.0	0.0	0.0	0.0	0.0	0.0
	Moderate	0.0	0.0	0.0	0.0	0.0	0.0
	None	100.0	100.0	100.0	100.0	100.0	100.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0
	Important	100.0	100.0	100.0	100.0	0.0	100.0
	Marginal	0.0	0.0	0.0	0.0	100.0	0.0

Table 4.2-3. Affected South Teigen Watershed Tributaries: Channel Characteristics

Attribute		1002	1003	1004	1012	1013	1014	1015	1016	1017	1018	1205	1027	1029	1030	1110	1150	1151	1152	1088	1090	1091	1207
Bankfull Width (m)																							
	Mean	1.10	0.91	2.17	3.60	2.00	0.65	0.90	3.45	3.50	1.50	1.40	0.91	3.00	2.61	5.25	1.29	0.50	1.22	1.00	0.50	0.82	1.25
	SE	0.11	0.08	0.57	0.06	-	-	-	0.54	-	0.50	0.90	0.28	0.00	0.45	0.25	0.05	-	-	-	-	-	-
Wetted Width (m)																							
	Mean	1.38	1.10	2.60	3.40	1.10	0.63	0.70	2.69	3.50	1.50	0.50	0.64	3.00	3.04	5.25	1.42	1.03	1.22	1.00	0.50	0.82	1.25
	SE	-	-	-	0.15	-	-	-	0.10	-	-	-	0.19	-	0.36	-	0.04	-	-	-	-	-	-
Bankfull Depth (m)																							
	Mean	0.30	0.30	0.30	0.35	-	0.17	0.70	0.41	-	-	0.10	0.19	0.40	0.52	-	0.31	0.17	0.15	-	0.15	-	-
	SE	-	-	-	0.08	-	-	-	0.10	-	-	-	0.01	-	0.14	-	0.05	-	-	-	-	-	-
Wetted Depth (m)																							
	Mean	0.18	0.16	0.10	0.26	0.25	0.13	0.08	0.26	-	-	0.05	0.14	0.29	0.35	-	0.21	0.13	0.05	-	0.12	-	0.08
	SE	-	-	0.00	0.05	0.05	0.02	0.01	0.02	-	-	0.00	0.00	0.02	0.04	-	0.01	0.02	0.00	-	0.00	-	-
Residual Pool Depth (m)																							
	Mean	0.10	0.17	-	0.28	0.33	-	0.10	-	-	-	-	0.07	0.16	-	-	-	-	-	-	-	-	-
	SE	-	0.02	-	0.07	0.09	-	0.00	-	-	-	-	0.01	0.07	-	-	-	-	-	-	-	-	-

Dashes indicate not present or not applicable

Table 4.2-4. Affected South Teigen Watershed Tributaries: Instream, Riparian, and Habitat Quality Characteristics

Attribute	Descriptor	1002	1003	1004	1012	1013	1014	1015	1016	1017	1018	1205	1027	1029	1030	1110	1150	1151	1152	1088	1090	1091	1207
Stream Length Mapped	m	42	87	455	120.0	14.0	55.0	75.0	520.0	70.0	24.0	62	112	250	600	125	50	51	24	40.0	28	40	24.0
Mean Channel Width	m	1.1	0.91	2.17	3.60	2.00	0.65	0.90	3.45	3.50	1.50	1.4	0.91	3	2.61	5.25	1.29	0.5	1.22	1.00	0.5	0.82	1.25
Stream Area Mapped	m^2	46.0	78.7	985.1	432.0	28.0	35.8	67.5	1,794.0	245.0	36.0	86.8	101.5	750.0	1,566.0	656.3	64.5	25.5	29.3	40.0	14.0	32.8	30.0
Habitat Unit Ratio (%)	Riffle	0	0	100	10	0	0	100	40	-	-	100	70	100	82	-	42	0	100	100.0	100	100	0.0
	Cascade	100	100	0	60	0	0	0	50	-	-	0	30	0	0	-	30	0	0	0.0	0	0	100.0
	Pool	0	0	0	30	0	0	0	10	-	-	0	0	0	2	-	5	0	0	0.0	0	0	0.0
	Glide	0	0	0	0	100	100	0	0	100	-	0	0	0	17	-	23	100	0	0.0	0	0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	0	70	0	4	0	100	75	0	-	-	30	0	60	13	-	38	100	10	100.0	10	10	0.0
	Gravel	30	30	30	57	0	0	25	81	-	-	70	100	40	73	-	37	0	90	0.0	90	90	20.0
	Cobble	70	0	70	27	0	0	0	19	-	-	0	0	0	14	-	22	0	0	0.0	0	0	80.0
	Boulder	0	0	0	12	100	0	0	0	-	-	0	0	0	0	-	3	0	0	0.0	0	0	0.0
	Bedrock	0	0	0	0	0	0	0	0	-	-	0	0	0	0	-	0	0	0	0.0	0	0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	0	0	0	28	0	0	0	7	-	-	0	0	0	1	-	3	0	0	0.0	0	0	0.0
	Boulder	0	0	0	12	50	0	0	0	-	-	0	0	0	0	-	3	0	0	0.0	0	0	0.0
	Instream Vegetation	0	0	0	0	0	25	0	0	-	-	0	0	0	0	-	0	30	0	0.0	0	0	0.0
	Overhanging Vegetation	70	70	80	0	0	90	25	4	-	-	100	5	100	27	-	49	95	90	0.0	80	80	60.0
	Undercut Bank	0	0	0	0	0	0	0	0	-	-	0	0	0	0	-	2	0	0	0.0	5	0	0.0
	Large Woody Debris	5	5	0	14	0	0	0	7	-	-	0	0	0	0	-	7	0	0	0.0	0	0	0.0
Riparian Vegetation Type - % by stream length	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Natural Wetland	0	0	67	0	0	100	0	0	0	100	100	0	100	68	0	14	100	100	100.0	100	0	0.0
	Shrubs	100	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Coniferous Forest	0	100	0	100	0	0	100	100	100	0	0	100	0	0	100	86	0	0	0.0	0	100	100.0
	Deciduous Forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Mixed Forest	0	0	33	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0.0	0	0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2 m)	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Tall Shrub (2-10 m)	100	0	67	0	100	100	0	0	0	0	100	0	100	68	0	14	100	100	100.0	100	0	0.0
	Sapling (>10 m)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Young Forest	0	100	0	0	0	0	100	0	0	0	0	0	0	14	0	73	0	0	0.0	0	0	0.0
	Mature Forest	0	0	33	100	0	0	0	100	100	0	0	100	0	18	100	13	0	0	0.0	0	100	100.0
	Old Growth Forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
Riparian Crown Closure - % by stream length	0	0	0	67	0	0	100	0	0	0	100	100	0	100	82	0	14	100	100	100.0	0	0	0.0
	1-20%	100	100	0	100	100	0	100	100	100	0	0	100	0	18	100	86	0	0	0.0	100	100	0.0
	21-40%	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	100.0
	41-70%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	71-90%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	>90%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
Channel Morphology - % by stream length	Cascade Pool	0	0	33	40	0	0	0	58	0	0	0	33	0	18	0	36	0	0	0.0	0	0	100.0
	Large Channel	0	0	0	0	100	100	0	0	100	100	66	0	0	0	0	0	0	0	100.0	0	0	0.0
	Riffle Pool	100	100	67	0	0	0	100	0	0	0	34	0	100	82	100	64	100	100	0.0	100	100	0.0
	Step Pool	0	0	0	60	0	0	0	42	0	0	0	67	0	0	0	0	0	0	0.0	0	0	0.0

(continued)

Table 4.2-4. Affected South Teigen Watershed Tributaries: Instream, Riparian, and Habitat Quality Characteristics (completed)

Attribute	Descriptor	1002	1003	1004	1012	1013	1014	1015	1016	1017	1018	1205	1027	1029	1030	1110	1150	1151	1152	1088	1090	1091	1207
Bank Stability - % by stream length	Stable - Undercut	0	100	0	100	100	100	0	0	0	0	66	67	0	53	0	14	0	0	0.0	100	0	0.0
	Stable - No Undercut	100	0	67	0	0	0	100	0	100	100	34	0	100	29	100	86	100	100	100.0	0	100	100.0
	Aggrading	0	0	33	0	0	0	0	58	0	0	0	33	0	0	0	0	0	0	0.0	0	0	0.0
	Eroding	0	0	0	0	0	0	0	42	0	0	0	0	0	18	0	0	0	0	0.0	0	0	0.0
Dominant Bank Substrate - % by stream length	Organics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Fines	100	100	33	40	100	100	100	58	100	100	100	67	100	71	100	100	100	0	100.0	100	100	100.0
	Gravel	0	0	0	0	0	0	0	0	0	0	0	33	0	29	0	0	0	100	0.0	0	0	0.0
	Cobble	0	0	67	0	0	0	0	42	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Boulder	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Bedrock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
Spawning Habitat Quality - % of stream length	Fair	0	29	0	0	0	0	0	42	0	0	34	33	100	0	54	23	0	100	0.0	0	0	0.0
	Good	0	0	0	93	0	0	0	58	0	0	0	0	0	15	0	50	0	0	0.0	100	100	0.0
	None	0	0	0	7	100	100	100	0	100	100	66	67	0	0	0	0	100	0	100.0	0	0	0.0
	Poor	100	71	100	0	0	0	0	0	0	0	0	0	0	85	46	27	0	0	0.0	0	0	100.0
Rearing Habitat Quality - % of stream length	Fair	0	0	0	7	100	0	0	0	0	0	66	0	0	53	100	0	0	0	0.0	0	0	0.0
	Good	0	0	0	93	0	0	0	100	0	0	0	0	100	29	0	55	0	0	0.0	0	0	0.0
	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Poor	100	100	100	0	0	100	100	0	100	100	34	100	0	18	0	45	100	100	100.0	100	100	100.0
OverWintering Habitat Quality - % of stream length	Fair	0	0	0	47	0	0	0	100	0	0	0	0	100	100	0	0	0	0	0.0	0	0	0.0
	Good	0	0	0	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	None	0	0	0	0	0	100	100	0	100	0	34	0	0	0	0	0	100	0	100.0	0	0	100.0
	Poor	100	100	100	0	100	0	0	0	0	100	66	100	0	0	100	100	0	100	0.0	100	100	0.0
Potential Spawning Habitat - % of stream length	Abundant	0	0	0	93	0	0	0	58	0	0	0	0	0	15	0	5	0	0	0.0	100	0	0.0
	Micropatches	100	100	67	0	0	0	100	0	0	0	0	67	0	0	0	73	0	0	0.0	0	0	100.0
	Moderate	0	0	0	0	0	0	0	42	0	0	34	33	0	67	54	22	0	100	0.0	0	100	0.0
	None	0	0	33	7	100	100	0	0	100	100	66	0	100	18	46	0	100	0	100.0	0	0	0.0
Overall Habitat Quality - % of stream length	Critical	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0.0
	Important	0	0	0	100	0	0	0	100	0	0	0	0	100	100	100	88	0	0	0.0	100	100	0.0
	Marginal	100	100	100	0	100	100	100	0	100	100	100	100	0	0	0	12	100	100	100.0	0	0	100.0

Dashes indicate not present or not applicable.

Table 4.2-5. Summary of Affected Wetland Characteristics within South Teigen Watershed

Watershed	Wetland Name	Pond No.	Open Water (%)	Max Water Depth (m)	Area (m^2)
South Teigen	ST-W2	7	40	0.5	314

Dashes indicate no data available.

Table 4.2-6. Summary of Affected Wetland Habitat within South Teigen Watershed

Watershed	Wetland Name	Pond No.	Bed Composition (%)					Instream Cover Presence						Riparian	Fish Habitat	Fish Present	Comments
			Sand	Gravel	Cobble	Boulder	Bedrock	Pool	Boulder	IV	OV	UB	LWD	Vegetation	(Y/N)	(Y/N)	
South Teigen	ST-W2	7	70	30	0	0	0	D	-	SD	SD	-	-	Tall Shrub	Y	Y	Direct connection to stream 1152

IV = instream vegetation
OV = overhanging vegetation
UB = undercut bank
LWD = large woody debris
D = dominant
SD = sub-dominant
T = trace
Dashes indicate not applicable

There are two mainstem reaches that will be affected by dam construction in North Treaty Creek, representing a total fish habitat area of 5,841 m^2 (Tables 4.2-7 and 4.2-8; ; Figures 2.2-1 to 2.2-5 [map pockets]). There are seven tributaries that will be affected by dam construction in North Treaty Creek, representing a total fish habitat area of 1,042 m^2 (Tables 4.2-9 and 4.2-10; Figures 2.2-1 to 2.2-5 [map pockets]). No wetlands will be impacted by dam construction in North Treaty Creek.

Treaty Creek mainstem will be affected by the Treaty Creek pipeline outlet. The area of fish habitat lost will be 100 m^2 due to the rip-rap apron.

Table 4.2-7. Affected North Treaty Mainstem: Channel Characteristics

	Reach		
Attribute	**1 (Southeast Seepage Dam)**	**1 (TMF Dam)**	**2 (Southeast TMF Dam)**
Bankfull Width (m)			
Mean	6.12	5.50	6.07
SE	0.40	0.50	0.53
Wetted Width (m)			
Mean	5.90	5.50	5.69
SE	0.48	0.50	0.36
Bankfull Depth (m)			
Mean	0.64	0.40	0.65
SE	0.08	-	0.12
Wetted Depth (m)			
Mean	0.39	-	0.42
SE	0.03	-	0.08
Residual Pool Depth (m)			
Mean	0.30	0.50	0.45
SE	-	-	0.15
Gradient (%)			
Mean	4.8	5.8	2.0
SE	0.25	1.49	-

Dashes indicate not present or not applicable

4.2.2 Access Roads and Transmission Line

For the purposes of describing fish habitat at access road and transmission line watercourse crossings, data is presented in tabular format by Project infrastructure type and watercourse type (i.e., stream, side-channel, and wetland). Table 4.2-11 presents crossing habitat details such as location, channel measurements, channel characteristics (bed substrate and morphology), habitat types (e.g., riparian vegetation), and habitat quality. Locations of these watercourses are shown in Figures 4.2-1 and 4.2-2. Photographs of the watercourses are provided in Appendix 4.2-1.

Table 4.2-12 presents fish-bearing status and fish species present for each watercourse. Watercourses were sampled to confirm fish presence (Rescan 2009, 2010, 2012b, 2012f). Historical fish presence data were also used if available. Sampling crews commenced electrofishing at the stream confluence, and proceeded upstream beyond the crossing location.

Table 4.2-8. Affected North Treaty Mainstem: Instream, Riparian and Habitat Quality Characteristics

		Reach		
Attribute	**Descriptor**	**1 (Southeast Seepage Dam)**	**1 (TMF Dam)**	**2 (Southeast TMF Dam)**
Stream Length Mapped	m	122	357.0	517.0
Mean Channel Width	m	6.12	5.50	6.07
Stream Area Mapped	m^2	746.6	1,958.0	3,136.5
Habitat Unit Ratio (%)	Riffle	30.0	0.0	58.9
	Cascade	56.0	60.0	8.3
	Pool	14.0	40.0	32.8
	Glide	0.0	0.0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	0.0	7.7	13.8
	Gravel	29.5	55.5	68.6
	Cobble	57.8	27.7	16.0
	Boulder	12.8	9.1	1.6
	Bedrock	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	15.2	10.0	33.1
	Boulder	11.7	11.4	1.0
	Instream Vegetation	0.0	0.0	0.0
	Overhanging Vegetation	40.1	56.8	32.4
	Undercut Bank	0.8	0.0	0.0
	Large Woody Debris	9.0	10.0	8.9
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	0.0
	Shrubs	14.6	30.8	44.5
	Coniferous Forest	0.0	69.2	55.5
	Deciduous Forest	0.0	0.0	0.0
	Mixed Forest	85.4	0.0	0.0
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0
	Tall Shrub (2-10m)	37.8	30.8	44.5
	Sapling (>10m)	0.0	0.0	0.0
	Young Forest	0.0	0.0	0.0
	Mature Forest	62.2	69.2	55.5
	Old Growth Forest	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	100	30.8	24.9
	1-20%	0.0	69.2	75.1
	21-40%	0.0	0.0	0.0
	41-70%	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0
	>90%	0.0	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	100.0	13.8	0.0
	Large Channel	0.0	0.0	0.0
	Riffle Pool	0.0	30.8	100.0
	Step Pool	0.0	55.5	0.0
Bank Stability - % by stream length	Stable - Undercut	54.9	0.0	24.9
	Stable - No Undercut	45.1	100.0	75.1
	Aggrading	0.0	0.0	0.0
	Eroding	0.0	0.0	0.0
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0
	Fines	0.0	0.0	77.5
	Gravel	100.0	30.8	0.0
	Cobble	0.0	44.2	22.5
	Boulder	0.0	0.0	0.0
	Bedrock	0.0	25.0	0.0

(continued)

Table 4.2-8. Affected North Treaty Mainstem: Instream, Riparian and Habitat Quality Characteristics (completed)

		Reach		
Attribute	**Descriptor**	**1 (Southeast Seepage Dam)**	**1 (TMF Dam)**	**2 (Southeast TMF Dam)**
Spawning Habitat Quality - % of stream length	Fair	0.0	0.0	29.4
	Good	100.0	100.0	67.0
	None	0.0	0.0	0.0
	Poor	0.0	0.0	3.6
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0
	Good	100.0	100.0	100.0
	None	0.0	0.0	0.0
	Poor	0.0	0.0	0.0
OverWintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0
	Good	100.0	100.0	96.4
	None	0.0	0.0	0.0
	Poor	0.0	0.0	3.6
Potential Spawning Habitat - % of stream length	Abundant	45.1	75.0	68.5
	Micropatches	0.0	0.0	3.6
	Moderate	54.9	25.0	27.9
	None	0.0	0.0	0.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0
	Important	100.0	100.0	100.0
	Marginal	0.0	0.0	0.0

Table 4.2-9. Affected North Treaty Watershed Tributaries: Channel Characteristics

Attribute		1051	1052	1053	1082	1072	1059	1070
Bankfull Width (m)								
	Mean	1.8	1.42	1.80	1.75	0.94	1.88	0.81
	SE	0.3	0.02	-	0.15	0.24	0.13	-
Wetted Width (m)								
	Mean	1.76	1.42	1.80	2.17	0.94	1.85	0.81
	SE	0.27	0.02	-	0.03	-	0.45	-
Bankfull Depth (m)								
	Mean	0.3	0.21	0.20	0.42	-	0.33	-
	SE	0.1	0.01	-	0.08	-	0.18	-
Wetted Depth (m)								
	Mean	0.2	0.15	0.05	0.22	-	0.24	-
	SE	0.0	0.01	0.00	0.03	-	0.00	-
Residual Pool Depth (m)								
	Mean	-	-	-	0.16	-	-	-
	SE	-	-	-	-	-		

Dashes indicate not present or not applicable

Table 4.2-10. Affected North Treaty Watershed Tributaries: Instream, Riparian Habitat, and Habitat Quality Characteristics

Attribute	Descriptor	1051	1052	1053	1082	1072	1059	1070
Stream Length Mapped	m	71.0	23.0	90.0	160.0	130.0	160.0	25.0
Mean Channel Width	m	1.8	1.42	1.80	1.75	0.94	1.88	0.81
Stream Area Mapped	m^2	124.7	32.7	162.0	279.8	121.6	300.6	20.3
Habitat Unit Ratio (%)	Riffle	86.7	75.0	100.0	95.0	100.0	100.0	100.0
	Cascade	13.3	25.0	0.0	0.0	0.0	0.0	0.0
	Pool	0.0	0.0	0.0	5.0	0.0	0.0	0.0
	Glide	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Substrate Composition - % by unit area	Fines	40.5	82.7	20.0	51.3	90.0	74.2	100.0
	Gravel	59.5	17.3	80.0	48.7	10.0	25.8	0.0
	Cobble	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Habitat Weighted Cover Composition - % by unit area	Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Instream Vegetation	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Overhanging Vegetation	95.8	70.0	100.0	71.7	10.0	52.4	10.0
	Undercut Bank	0.0	0.0	0.0	1.6	0.0	1.8	0.0
	Large Woody Debris	8.4	36.3	0.0	6.8	50.0	1.8	50.0
Riparian Vegetation Type - % by stream length	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Natural Wetland	0.0	0.0	0.0	51.7	0.0	5.3	0.0
	Shrubs	100.0	100.0	100.0	0.0	0.0	12.4	0.0
	Coniferous Forest	0.0	0.0	0.0	22.1	100.0	82.2	100.0
	Deciduous Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mixed Forest	0.0	0.0	0.0	26.2	0.0	0.0	0.0

(continued)

Table 4.2-10. Affected North Treaty Watershed Tributaries: Instream, Riparian Habitat, and Habitat Quality Characteristics (completed)

Attribute	Descriptor	1051	1052	1053	1082	1072	1059	1070
Riparian Structural Stage - % by stream length	Low Shrub (<2m)	0.0	0.0	0.0	5.1	0.0	0.0	0.0
	Tall Shrub (2-10m)	100.0	100.0	100.0	46.5	0.0	17.8	100.0
	Sapling (>10m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Young Forest	0.0	0.0	0.0	36.9	0.0	82.2	0.0
	Mature Forest	0.0	0.0	0.0	11.5	100.0	0.0	0.0
	Old Growth Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Riparian Crown Closure - % by stream length	0	100.0	100.0	100.0	7.3	0.0	12.4	0.0
	1-20%	0.0	0.0	0.0	46.5	0.0	87.6	0.0
	21-40%	0.0	0.0	0.0	46.1	100.0	0.0	100.0
	41-70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	71-90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Channel Morphology - % by stream length	Cascade Pool	43.7	100.0	0.0	0.0	0.0	0.0	0.0
	Large Channel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Riffle Pool	56.3	0.0	100.0	100.0	100.0	100.0	100.0
	Step Pool	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bank Stability - % by stream length	Stable - Undercut	0.0	100.0	100.0	11.5	0.0	94.7	100.0
	Stable - No Undercut	100.0	0.0	0.0	88.5	100.0	5.3	0.0
	Aggrading	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Eroding	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dominant Bank Substrate - % by stream length	Organics	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fines	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Gravel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cobble	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spawning Habitat Quality - % of stream length	Fair	100.0	0.0	100.0	37.7	0.0	32.7	0.0
	Good	0.0	0.0	0.0	0.0	0.0	12.4	0.0
	None	0.0	0.0	0.0	53.9	0.0	5.3	100.0
	Poor	0.0	100.0	0.0	8.4	100.0	49.5	0.0
Rearing Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	5.3	0.0
	Good	0.0	0.0	0.0	100.0	100.0	94.7	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Poor	100.0	100.0	100.0	0.0	0.0	0.0	100.0
OverWintering Habitat Quality - % of stream length	Fair	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Good	0.0	0.0	0.0	11.5	0.0	82.2	0.0
	None	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Poor	100.0	100.0	100.0	88.5	100.0	17.8	0.0
Potential Spawning Habitat - % of stream length	Abundant	56.3	0.0	0.0	0.0	0.0	12.4	0.0
	Micropatches	0.0	100.0	0.0	15.8	100.0	49.5	0.0
	Moderate	43.7	0.0	100.0	37.7	0.0	32.7	0.0
	None	0.0	0.0	0.0	46.5	0.0	5.3	100.0
Overall Habitat Quality - % of stream length	Critical	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Important	100.0	0.0	0.0	100.0	100.0	94.7	0.0
	Marginal	0.0	100.0	100.0	0.0	0.0	5.3	100.0

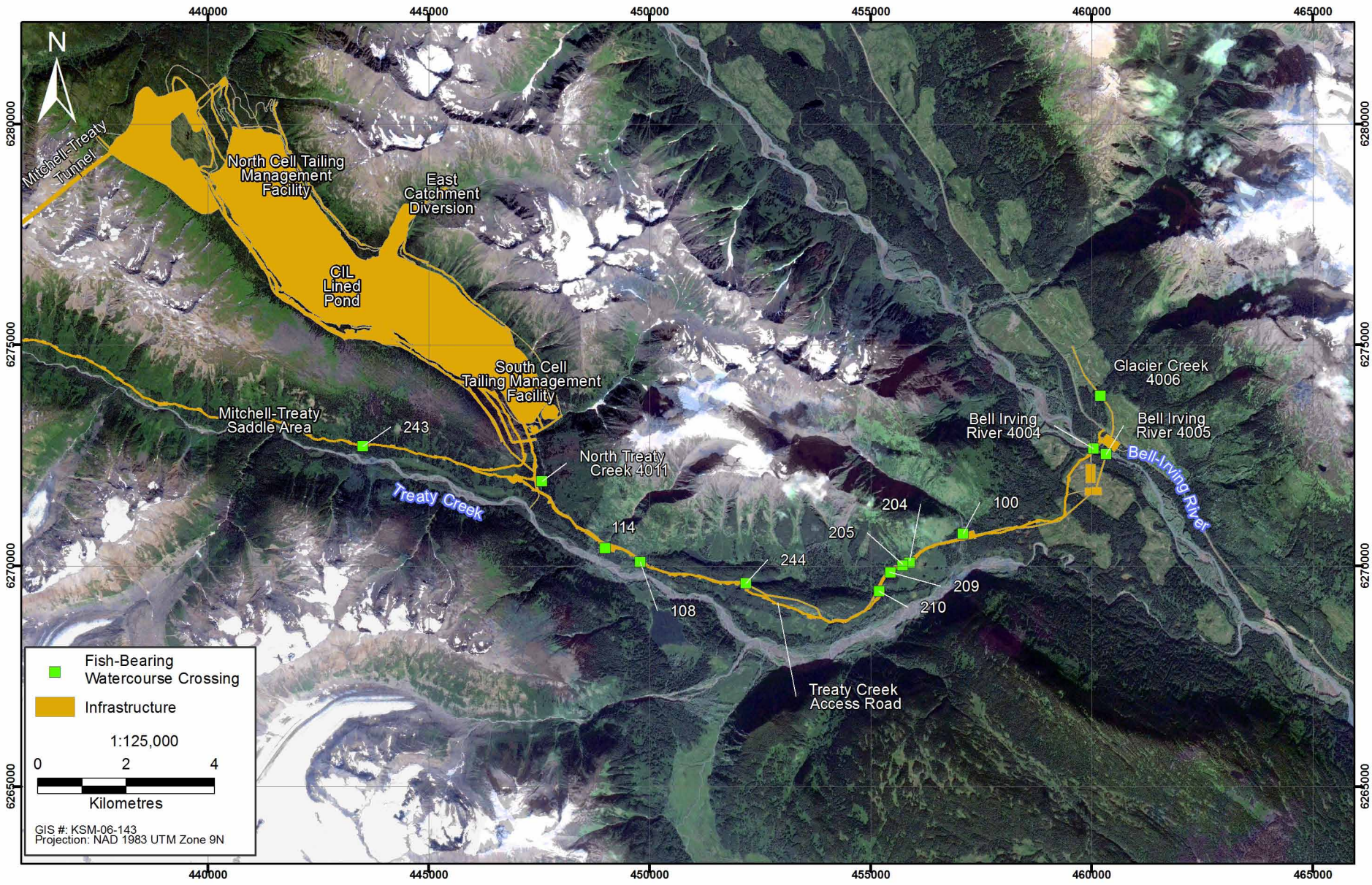


Figure 4.2-1

SEABRIDGE GOLD
KSM PROJECT

Location of Treaty Access Road
Fish-Bearing Watercourse Crossings

Figure 4.2-1

Rescan
Engineers & Scientists

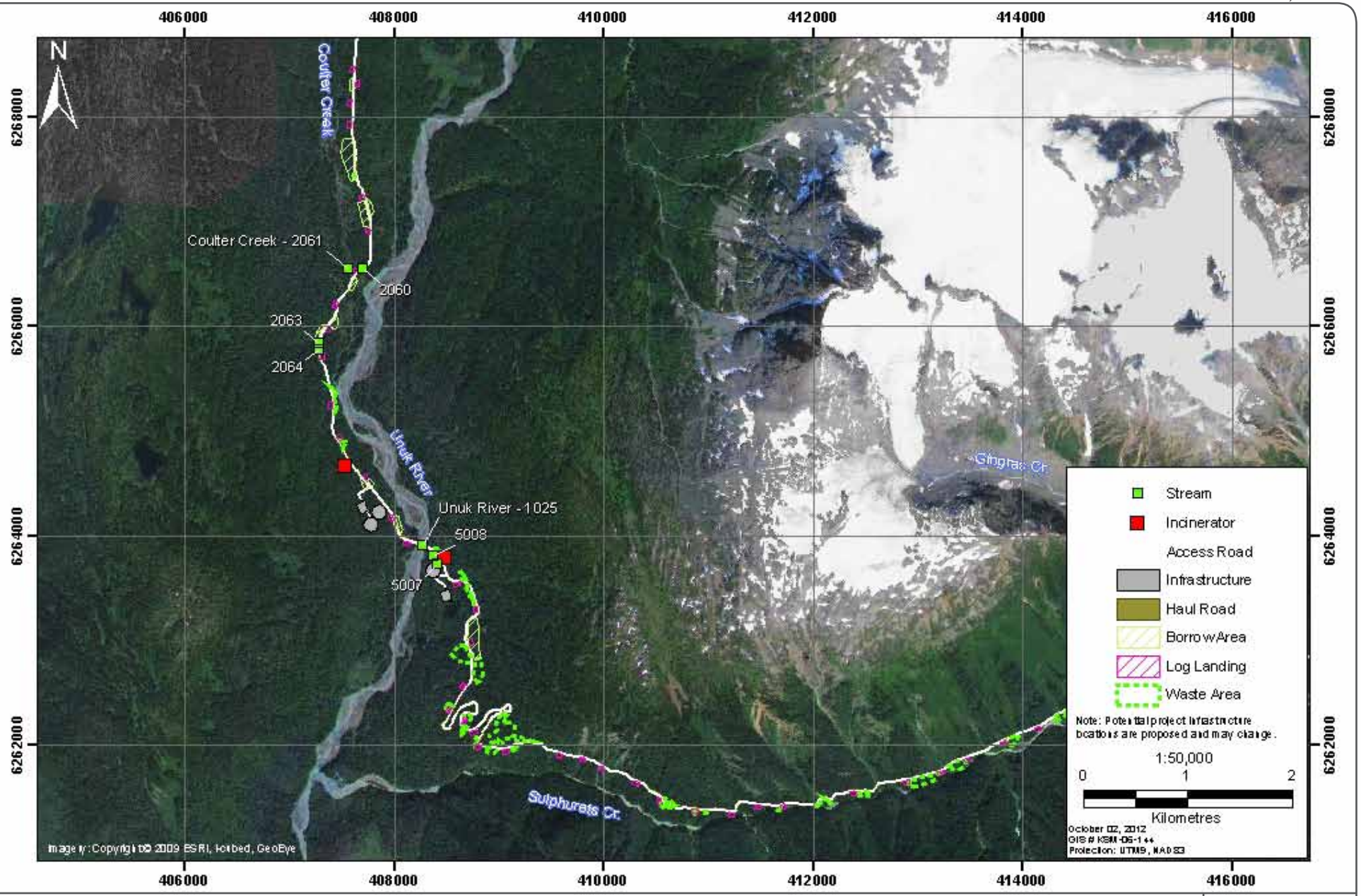


Figure 4.2-2

SEABRIDGE GOLD
KSM PROJECT

Location of Coulter Creek Access Road Fish Bearing Watercourse Crossings

Figure 4.2-2

Rescan
Engineers & Scientists

Eleven fish bearing crossings are proposed for the Treaty Creek Access Road. For the Coulter Creek Access Road, there are seven fish bearing crossings (Table 4.2-11). The majority of fish-bearing stream crossings will result in a HADD (Table 4.2-12), primarily due to the use of rip-rap below the Q100 flood elevation to protect bridge abutments. This HADD determination is conservative because the HWM is lower than the Q100 elevation data. The area of fish habitat affected, below the HWM, will be refined and recalculated when the crossing is built. Access road bridge crossing designs are shown in Appendix 4.2-2. All other crossings are culverts which were determined to be HADDs.

Dolly Varden and coho salmon habitat will be lost, as well as minor habitat for chinook salmon as a result of access road crossings.

Ten of the eleven transmission line crossings will result in a HADD due the loss of deciduous and coniferous trees in the riparian zone. These crossings are identified in Table 4.2-12.

4.2.3 Water Quantity Loss

4.2.3.1 Approach

The KSM project TMF will be located within the upper reaches of South Teigen and North Treaty creeks. As a result the quantity of water in the lower reaches of these creeks will be reduced, resulting in a loss of fish habitat.

Potential changes in stream flow in South Teigen and North Treaty creeks due to the TMF development were assessed quantitatively. The physical fish habitat analyses in this study follow the British Columbia Instream Flow Assessment Methods (Lewis et al. 2004). Dolly Varden was selected as the target species for this physical habitat impact study due to its abundance in the study area.

Each instream flow transect is divided into several segments. Given the velocity and depth suitability criteria for Dolly Varden, and simulated values of depth, velocity and width of each cell, the weighted usable width of Dolly Varden for each transect was calculated. Knowing the value of Dolly Varden weighted usable width at all transects, weighted usable area (WUA) of stream reaches was calculated by multiplying the weighted usable width and the length of the reach. Comparing the WUA of the baseline and developed conditions provides a quantified measure to estimate the effects of the Project on physical fish habitat in North Treaty (Reach 1 and 0) and South Teigen (Reach 1 and 2) creeks.

4.2.3.2 North Treaty Creek

The mean annual discharge (MAD) in North Treaty Creek upstream of the Tumbling Creek confluence (Reach 1) is predicted to change over the duration of TMF development. Similarly, the MAD in North Treaty Creek downstream of the Tumbling Creek confluence (Reach 0) is predicted to change over the duration of TMF development. For Reach 1, MAD is predicted to vary between increases of 27% in Years 30-45 to a reduction of 75% in Years 51 to 56. For Reach 0, MAD is predicted to vary between increases of 10% in Years 30-45 to a reduction of 30% in Years 51 to 56 (Figure 4.2-3). As MAD changes, so does the suitability or area of Dolly Varden habitat.

WUA of Dolly Varden habitat depends on the HU type (Tables 4.2-13 and 4.2-14). Cascade HUs will be affected the greatest by changes in discharge relative to that of riffles and pools HUs. Riffle HUs will be affected greater than pool HUs. Based on baseline observations, Dolly Varden parr use pool and cascade habitats more frequently than riffles, which are typically occupied by Dolly Varden fry.

Table 4.2-11. Individual Fish Bearing Stream Crossing Details

Road	Waterbody Name	Habitat Type	Infrastructure Type	Stream Class	Location		Channel Measurements				Channel Characteristics		Habitat		Habitat Quality		
					Easting	Northing	Mean Channel Width (m)	Mean Gradient (%)	Mean Residual Pool Depth (m)	Mean Bankfull Depth (m)	Dominant Substrate	Morphology	Dominant Cover Type	Riparian Vegetation Type	Over-wintering	Rearing	Spawning
Coulter Creek Access Road	2060	Stream	Culvert	S3	407703	6266547	1.9	0.5	-	0.3	F	RP	OV	C	F	G	N
	Coulter Creek - 2061	Stream	Bridge	S2	407561	6266553	16.0	1.5	0.6	-	G	RP	LWD	C	G	G	G
	2063	Stream	Bridge	S2	407277	6265832	12.7	3.5	0.3	-	G	RP	LWD	C	P	F	N
	2064	Stream	Bridge	S4	407274	6265770	1.4	14.0	0.2	0.3	C	SP	OV	C	P	F	N
	Unuk River - 1025	Stream	Bridge	S1	408275	6263910	71.0	1.0	-	1.9	G	RP	LWD	C	G	G	P
	5008	Stream	Culvert	S4	408373	6263805	0.8	5.0	0.1	0.2	F	RP	U	C	P	G	F
	5007	Stream	Bridge	S2	408404	6263727	9.7	1.0	0.2	0.4	G	RP	LWD	C	G	G	G
Treaty Creek Access Road	100	Stream	Bridge, Transmission Line	S1	457091	6270729	63.3	19.0	-	3.0	C	RP	B	S	P	F	P
	108	Stream	Culvert, Transmission Line	S3	449782	6270082	2.0	24.0	0.2	0.4	C	CP	SWD	C	P	F	P
	114	Stream	Bridge, Transmission Line	S2	448987	6270402	15.5	20.0	-	0.6	B	CP	B	D, M	P	F	P
	204	Stream	Culvert, Transmission Line	S4	455882	6270066	0.3	18.0	0.4	0.1	C	CP	SWD,OV	S,C	P	P	P
	205	Stream	Culvert, Transmission Line	S4	455723	6270012	0.4	15.0	-	0.1	C	CP	OV	S,M	P	P	P
	209	Stream	Culvert, Transmission Line	S4	455448	6269847	0.9	9.0	-	8.7	C	CP	SWD,OV	M	P	F	P
	243	Stream	Bridge	S3	443508	6272703	2.1	18.0	0.1	0.5	C	CP	SWD	C	P	G	F
	244	Stream	Bridge, Transmission Line	S2	452180	6269610	5.5	18.0	-	1.2	C	CP	OV	C	P	F	P
	210	Stream	Bridge, Transmission Line	S3	455190	6269430	4.0	16.0	-	-	-	CP	OV	M	P	F	P
	North Treaty Creek - 4011	Stream	Bridge, Transmission Line	S2	447556	6271912	8.9	2.7	-	1.1	B	CP	B	D	G	F	P
	Bell Irving River - 4004	Stream	Bridge	S1	460039	6272653	70.0	0.5	-	-	G	RP	SWD	M	G	G	F
	Bell Irving River - 4005	Stream	Transmission Line	S1	460325	6272531	65.0	0.5	-	-	G	RP	SWD	M	G	G	F
	Glacier Creek - 4006	Stream	Transmission Line	S3	460192	6273853	3.0	14.0	0.2	0.6	C	CP	LWD	D	F	P	P

Dashes indicate not applicable or no data available.

Dominant Substrate:	*Morphology:*	*Riparian Vegetation Type:*	*Habitat:*
F = fines	*CP = cascade pool*	*D = deciduous*	*G = good*
C = cobble	*RP = riffle pool*	*C = coniferous*	*P = poor*
B = boulder	*SP = step pool*	*S = shrubs*	*F = fair*
G = gravel	*LC = large channel*	*G = grass*	*N = none*
		M = mixed	

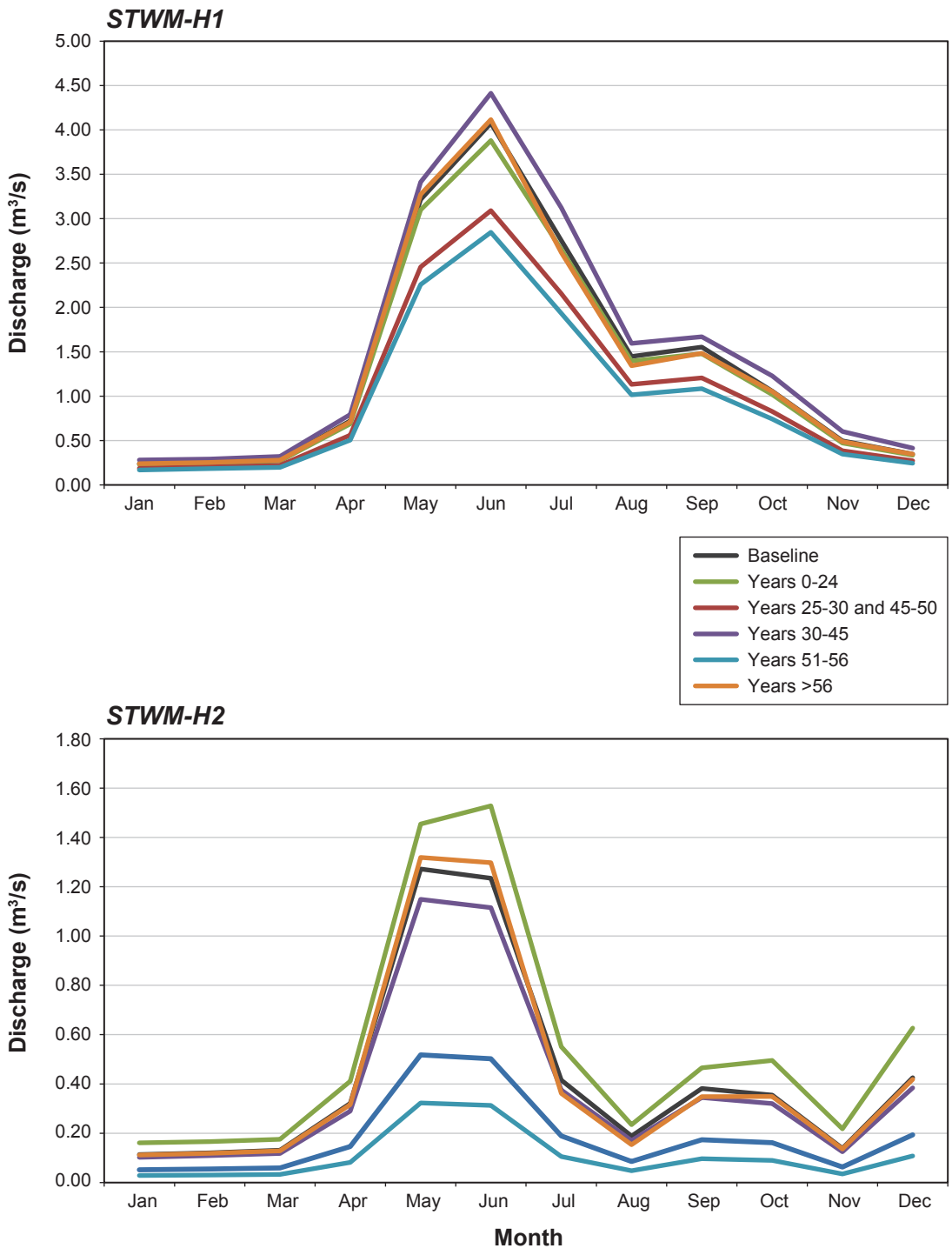
Table 4.2-12. Individual Fish Bearing Stream Crossing Details

Road	Waterbody Name	Habitat Type	Infrastructure Type	Stream Class	Year Sampled					Fish		HADD Determination	
					2008	2009	2010	2011	2012	Fish Bearing Status	Species Present	Access Road	Transmission Line
Coulter Creek Access Road	2060	Stream	Culvert	S3	X	X				Confirmed	CO, DV	Yes	NA
	Coulter Creek - 2061	Stream	Bridge	S2	X	X				Confirmed	CO, DV	Yes	NA
	2063	Stream	Bridge	S2	X	X				Confirmed	DV, CO, CCT	Yes	NA
	2064	Stream	Bridge	S4	X	X				Default	DV*	No	NA
	Unuk River - 1025	Stream	Bridge	S1	X	X				Confirmed	CO, CH, SK, DV, CCT	Yes	NA
	5008	Stream	Culvert	S4		X				Default	DV*	Yes	NA
	5007	Stream	Bridge	S2		X				Confirmed	DV, CO, CCT	No	NA
Treaty Creek Access R	100	Stream	Bridge, Transmission Line	S1					X	Default	DV*	Yes	No
	108	Stream	Culvert, Transmission Line	S3					X	Default	RB, DV*	Yes	Yes
	114	Stream	Bridge, Transmission Line	S2			X	X		Confirmed	DV	No	Yes
	204	Stream	Culvert, Transmission Line	S4					X	Default	DV*	Yes	Yes
	205	Stream	Culvert, Transmission Line	S4					X	Default	DV*	Yes	Yes
	209	Stream	Culvert, Transmission Line	S4					X	Default	DV*	Yes	Yes
	243	Stream	Bridge	S3					X	Default	DV*	No	NA
	244	Stream	Bridge, Transmission Line	S2			X			Confirmed	RB, DV	No	Yes
	210	Stream	Bridge, Transmission Line	S3					X	Confirmed	RB, DV	Yes	Yes
	North Treaty Creek - 4011	Stream	Bridge, Transmission Line	S2	X	X				Confirmed	DV, MWF	Yes	Yes
	Bell Irving River - 4004	Stream	Bridge	S1		X	X			Confirmed	BT, CH, CO, DV, MWF, SK, RB	Yes	NA
	Bell Irving River - 4005	Stream	Transmission Line	S1		X	X			Confirmed	BT, CH, CO, DV, MWF, SK, RB	NA	Yes
	Glacier Creek - 4006	Stream	Transmission Line	S2			X			Confirmed	DV	NA	Yes

Species: BT = bull trout; CH = Chinook salmon; CO = coho salmon; DV = Dolly Varden; MWF = mountain whitefish; SK = sockeye salmon; RB = rainbow trout/steelhead

Astericks indicates species not confirmed but likely present based upon habitat characteristics

NA = not applicable



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Average Monthly Discharges in North Treaty Creek (STWM-H1 and STWM-H2) for Baseline and Tailing Management Facility Developed Conditions

Figure 4.2-3

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Table 4.2-13. Estimated Dolly Varden Habitat Effects on Weighted Usable Area in North Treaty Creek (Reach 1)

		Mesohabitat Unit		WUA		
Month	TMF Phase	Type	Length (m)	Baseline (m^2)	Developed (m^2)	Change (%)
August	0 - 24	Riffles	58	113.2	106.8	-5.7
		Cascades	109	74.9	66.3	-11.5
		Pools	27	81.4	78.9	-3.1
October	0 - 24	Riffles	58	202.7	198.4	-2.1
		Cascades	109	286.5	284.1	-0.8
		Pools	27	97.3	95.6	-1.8
August	25 - 30 and 45 - 50	Riffles	58	113.2	83.2	-26.5
		Cascades	109	74.9	36.5	-51.3
		Pools	27	81.4	55.9	-31.3
October	25 - 30 and 45 - 50	Riffles	58	202.7	171.8	-15.2
		Cascades	109	286.5	280.4	-2.1
		Pools	27	97.3	92.1	-5.3
August	30 - 45	Riffles	58	113.2	123.8	9.4
		Cascades	109	74.9	109.5	46.2
		Pools	27	81.4	88.2	8.3
October	30 - 45	Riffles	58	202.7	214.3	5.7
		Cascades	109	286.5	270.7	-5.5
		Pools	27	97.3	104.2	7.1
August	51 - 56	Riffles	58	113.2	53.3	-52.9
		Cascades	109	74.9	17.1	-77.1
		Pools	27	81.4	36.4	-55.2
October	51 - 56	Riffles	58	202.7	148.1	-26.9
		Cascades	109	286.5	264.1	-7.8
		Pools	27	97.3	86.9	-10.7
August	> 56	Riffles	58	113.2	103.6	-8.5
		Cascades	109	74.9	61.3	-18.1
		Pools	27	81.4	76.1	-6.5
October	> 56	Riffles	58	202.7	203	0.1
		Cascades	109	286.5	290.7	1.5
		Pools	27	97.3	97.3	0

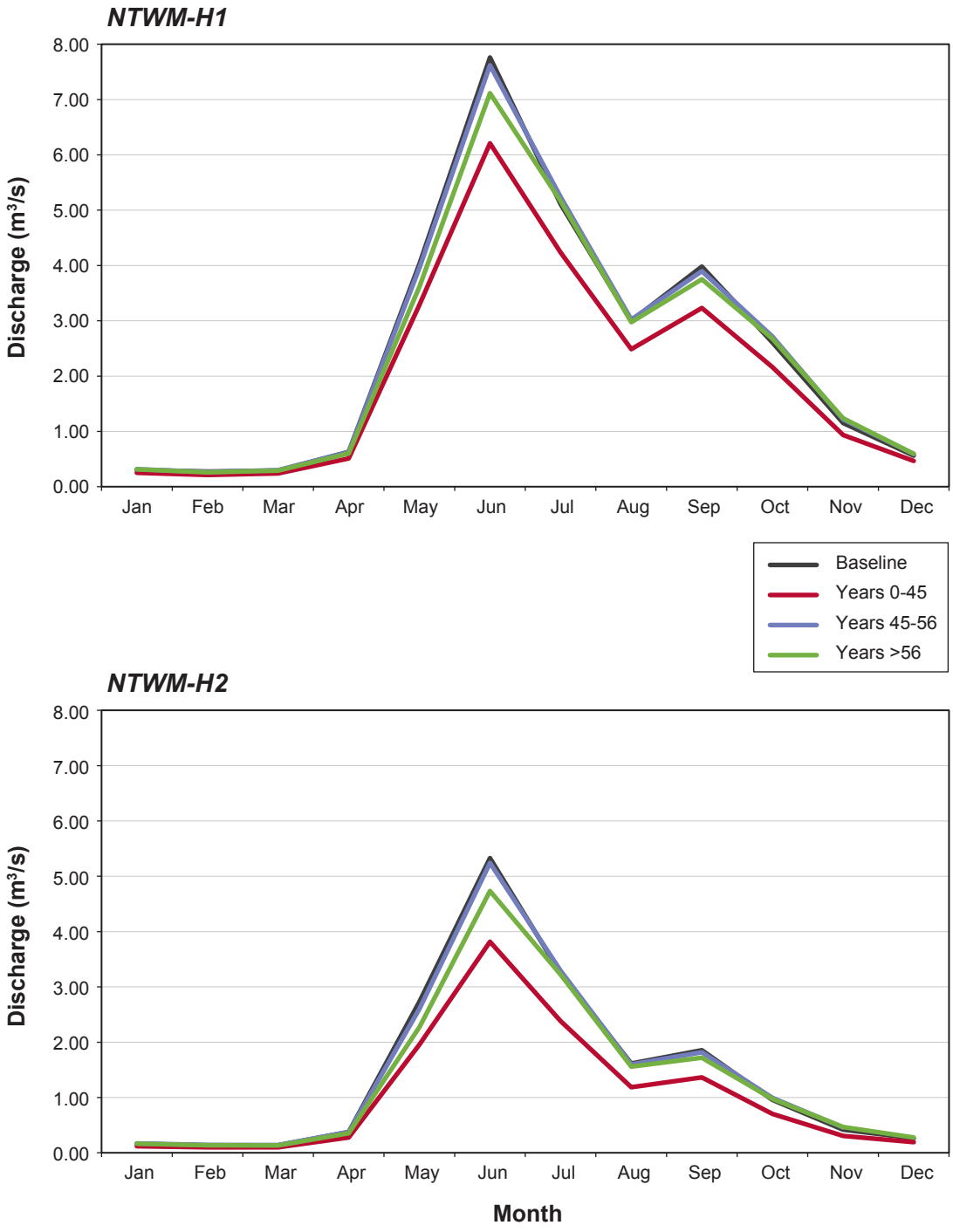
To evaluate effects on Dolly Varden summer parr rearing habitat, August was selected as a critical time period because of low flow conditions. The resulting predicted changes in North Treaty Creek discharge would result in fish habitat loss and alteration. To quantify the changes in fish habitat area, WUA calculations were used from the TMF development stage “worst case scenario” (i.e., greatest fish habitat impact period) for August. For North Treaty Creek the worst case scenario was determined to be Years 51 to 56, for which discharge reductions of 75% for Reach 1 and 30% for Reach 0 were predicted for August.

Table 4.2-14. Estimated Dolly Varden Habitat Effects on Weighted Usable Area in North Treaty Creek (Reach 0)

		Mesohabitat Unit		WUA		
Month	TMF Phase	Type	Length (m)	Baseline (m^2)	Developed (m^2)	Change (%)
August	0 - 24	Riffles	35	68.3	64.4	-5.7
		Cascades	1,631	1,117.2	988.7	-11.5
		Pools	106	319.6	309.7	-3.1
October	0 - 24	Riffles	35	122.2	119.6	-2.1
		Cascades	1,631	4,289.5	4,255.2	-0.8
		Pools	106	381.9	375.0	-1.8
August	25 - 30 and 45 - 50	Riffles	35	68.3	50.2	-26.5
		Cascades	1,631	1,117.2	544.1	-51.3
		Pools	106	280.9	193.0	-31.3
October	25 - 30 and 45 - 50	Riffles	35	122.2	103.6	-15.2
		Cascades	1,631	4,289.5	4,199.4	-2.1
		Pools	106	381.9	361.7	-5.3
August	30 - 45	Riffles	35	68.3	74.7	9.4
		Cascades	1,631	1,117.2	1,633.3	46.2
		Pools	106	319.6	346.1	8.3
October	30 - 45	Riffles	35	122.2	129.2	5.7
		Cascades	1,631	4,289.5	4,053.6	-5.5
		Pools	106	381.9	409.0	7.1
August	51 - 56	Riffles	35	68.3	32.2	-52.9
		Cascades	1,631	1,117.2	255.8	-77.1
		Pools	106	319.6	143.2	-55.2
October	51 - 56	Riffles	35	122.2	89.3	-26.9
		Cascades	1,631	4,289.5	3,954.9	-7.8
		Pools	106	381.9	341.0	-10.7
August	> 56	Riffles	35	68.3	62.5	-8.5
		Cascades	1,631	1,117.2	915.0	-18.1
		Pools	106	319.6	298.8	-6.5
October	> 56	Riffles	35	122.2	122.3	0.1
		Cascades	1,631	4,289.5	4,353.8	1.5
		Pools	106	381.9	381.9	0.0

4.2.3.3 South Teigen Creek

The MAD in South Teigen Creek downstream of the falls to Teigen Creek confluence (Reach 1) is predicted to change significantly over the duration of TMF development. Similarly, the MAD in South Teigen Creek upstream of the falls to the TMF (Reach 2) is predicted to change significantly over the duration of TMF development. For Reach 1, MAD is predicted to decrease by 18% in Years 0 to 45 to 0.3% reductions in Year 45-56. For Reach 2, MAD is predicted to decrease by 27% in Years 0 to 45 to 1% reductions in Year 45-56 (Figure 4.2-4).



Average Monthly Discharges in South Teigen Creek (NTWM-H1 and NTWM-H2) for Baseline and Tailing Management Facility Developed Conditions

Figure 4.2-4

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To evaluate effects on Dolly Varden summer parr rearing habitat, August was selected as a critical time period because of low flow and greater water temperatures. During Years 0 to 45, riffle HUs will be affected the greatest by changes in discharge relative to that of cascades and pools HUs (Table 4.2-15). Pool HUs will be affected greater than cascade HUs. During Years 45-56, all HUs demonstrate relatively the same change (+/- 1%). Based upon baseline observations, Dolly Varden parr use pool and cascade habitats more frequently than riffles, which are typically occupied by Dolly Varden fry.

Table 4.2-15. Estimated Dolly Varden Habitat Impacts on Weighted Usable Area in South Teigen Creek

Month	TMF Phase (years)	Reach	Mesohabitat Unit		WUA		
			Type	Length (m)	Baseline (m^2)	Developed (m^2)	Change (%)
August	0 - 45	Reach 2	Riffles	142	681.1	537.3	-21.1
			Cascades	1,063	6,137.3	5,303.7	-13.6
			Pools	213	1,268.1	1,027.1	-19.0
		Reach 1	Riffles	214	1,026.4	809.7	-21.1*
			Cascades	1,820	11,696.5	10,278.5	-12.1
			Pools	107	637.0	516.0	-19.0*
October	0 - 45	Reach 2	Riffles	142	483.1	533.9	10.5
			Cascades	1,063	4,345.4	4,564.3	5.0
			Pools	213	997.5	953.7	-4.4
		Reach 1	Riffles	214	728.1	804.6	10.5*
			Cascades	1,820	9,311.4	8,903.8	-4.4
			Pools	107	501.1	479.1	-4.4*
August	45 - 56	Reach 2	Riffles	142	681.1	681.1	0.0
			Cascades	1,063	6,137.3	6,088.9	-0.8
			Pools	213	1,268.1	1,257.2	-0.9
		Reach 1	Riffles	214	1,026.4	1,026.4	0.0*
			Cascades	1,820	11,696.5	11,696.5	0.0
			Pools	107	637.0	631.6	-0.9*
October	45 - 56	Reach 2	Riffles	142	483.1	475.1	-1.6
			Cascades	1,063	4,345.4	4,287.1	-1.3
			Pools	213	997.5	992.4	-0.5
		Reach 1	Riffles	214	728.1	716.1	-1.6*
			Cascades	1,820	9,311.4	9,405.1	1.0
			Pools	107	501.1	498.5	-0.5*
August	> 56	Reach 2	Riffles	142	681.1	679.7	-0.2
			Cascades	1,063	6,137.3	6,055.2	-1.3
			Pools	213	1,268.1	1,255.2	-1.0
		Reach 1	Riffles	214	1,026.4	1,024.3	-0.2*
			Cascades	1,820	11,696.5	11,638.8	-0.5
			Pools	107	637.0	630.6	-1.0*
October	> 56	Reach 2	Riffles	142	483.1	475.1	-1.6
			Cascades	1,063	4,345.4	4,328.3	-0.4
			Pools	213	997.5	997.5	0.0
		Reach 1	Riffles	214	728.1	716.1	-1.6*
			Cascades	1,820	9,311.4	9,242.5	-0.7
			Pools	107	501.1	501.1	0.0*

** indicates estimated based on Reach 2 results*

The resulting predicted changes in South Teigen Creek discharge would result in fish habitat loss and alteration. To quantify the changes in fish habitat area, WUA calculations were used from the TMF development stage worst case scenario (i.e., greatest fish habitat impact period) for August. For South Teigen Creek, the worst case scenario was determined to be Years 0 to 45, which predicted discharge reductions of 17% for Reach 1 and 27% for Reach 2 during August.

4.3 HABITAT LOSS SUMMARY

For the TMF dams, seepage collection pond dams, and TMF waste pile, calculation of habitat budgets, on the basis of the HSI models, used the SHIM data (Rescan 2010). For water quantity loss downstream of the dams, data required for calculating habitat budgets included SHIM data, instream flow habitat data, and water quantity modelling data. For the access roads, transmission line, and Treaty Creek pipeline outlet, reconnaissance level and detailed fish habitat assessment procedure (FHAP) data was used for calculating habitat budgets. Where data were insufficient for a specific biological HSI habitat variable, average or moderate values were assumed. Where data were insufficient for a specific HSI water quality variable, excellent or high values were assumed. These HSI models took into consideration instream and riparian habitat values to develop the habitat budgets.

HSI values for affected watercourses were determined for Dolly Varden, chinook salmon, and coho salmon (Appendix 4.3-1). HUs for affected watercourses were calculated for each the most abundant species and their life history stage. HUs for impacted transmission line riparian habitat crossings were calculated. A summary of total area and HUs lost is shown in Tables 4.3-1 to 4.3-6.

A total area of 53,734 m^2 (5.37 ha) of fish habitat will be lost from construction and use of the proposed TMF dams, seepage collection pond dams, the TMF waste pile, pipeline outlet, road and transmission line crossings, and as a result of water quantity loss. This represents a total of 91,115 HUs.

Table 4.3-1. Dolly Varden Stream Habitat Loss Summary

Watershed	Project Infrastructure	Habitat Type	Waterbody Name	Area Loss (m^2)	Dolly Varden Habitat Loss								Total HU Loss
					Adult		Embryonic Stage		Fry Rearing		Parr Rearing		
					HSI	HU	HSI	HU	HSI	HU	HSI	HU	
South Teigen	TMF Dam	Stream	1002	46.0	0.1	5	1	46	0.1	5	0.1	5	60
South Teigen	TMF Dam	Stream	1003	78.7	0.1	8	0.1	8	0.1	8	0.1	8	31
South Teigen	TMF Dam	Stream	1004	985.1	0.1	99	1	985	0.1	99	0.1	99	1,281
South Teigen	TMF Waste Pile	Stream	1012	432.0	0.5	216	1	432	0.5	216	0.5	216	1,080
South Teigen	TMF Waste Pile	Stream	1013	28.0	0.1	3	1	28	0.1	3	0.1	3	36
South Teigen	TMF Waste Pile	Stream	1014	35.8	0.1	4	0.1	4	0.1	4	0.1	4	14
South Teigen	TMF Waste Pile	Stream	1015	67.5	0.1	7	0.1	7	0.1	7	0.1	7	27
South Teigen	TMF Waste Pile	Stream	1016	1,794.0	0.25	449	1	1,794	0.25	449	0.25	449	3,140
South Teigen	TMF Waste Pile	Stream	1017	245.0	0.1	25	0.1	25	0.1	25	0.1	25	98
South Teigen	TMF Waste Pile	Stream	1018	36.0	0.1	4	0.1	4	0.1	4	0.1	4	14
South Teigen	TMF Dam	Stream	1027	101.5	0.1	10	1	102	0.1	10	0.1	10	132
South Teigen	TMF Dam	Stream	1029	750.0	0.1	75	0.1	75	0.1	75	0.1	75	300
South Teigen	TMF Dam	Stream	1030	1,566.0	0.1	157	1	1,566	0.1	157	0.1	157	2,036
South Teigen	TMF Dam	Stream	1110	656.3	0.1	66	1	656	0.1	66	0.1	66	853
South Teigen	TMF Dam	Stream	1150	64.5	0.5	32	0.1	6	0.5	32	0.5	32	103
South Teigen	TMF Dam	Stream	1151	25.5	0.1	3	0.1	3	0.1	3	0.1	3	10
South Teigen	TMF Dam	Stream	1152	29.3	0.1	3	1	29	0.1	3	0.1	3	38
South Teigen	TMF Waste Pile	Stream	1088	40.0	0.1	4	0.1	4	0.1	4	0.1	4	16
South Teigen	TMF Dam	Stream	1090	14.0	0.1	1	1	14	0.1	1	0.1	1	18
South Teigen	TMF Dam	Stream	1091	32.8	0.1	3	1	33	0.1	3	0.1	3	43
South Teigen	TMF Waste Pile	Stream	1207	30.0	0.1	3	1	30	0.1	3	0.1	3	39
South Teigen	TMF Dam	Stream	1205	86.8	0.1	9	1	87	0.1	9	0.1	9	113
North Treaty	TMF Dam	Stream	1051	124.7	0.1	12	0.1	12	0.1	12	0.1	12	50
North Treaty	TMF Dam	Stream	1052	32.7	0.1	3	0.1	3	0.1	3	0.1	3	13
North Treaty	TMF Dam	Stream	1053	162.0	0.1	16	0.5	81	0.1	16	0.1	16	130
North Treaty	TMF Dam	Stream	1082	279.8	0.1	28	0.1	28	0.1	28	0.1	28	112
North Treaty	TMF Dam	Stream	1072	121.6	0.1	12	0.1	12	0.1	12	0.1	12	49
North Treaty	TMF Dam	Stream	1059	300.6	0.1	30	0.1	30	0.1	30	0.1	30	120
North Treaty	TMF Dam	Stream	1070	20.3	0.1	2	0.1	2	0.1	2	0.1	2	8
South Teigen	TMF Dam	Stream	South Teigen - Reach 8	1,600.0	0.1	160	1	1,600	0.1	160	0.1	160	2,080
South Teigen	TMF Dam	Stream	South Teigen - Reach 7	1,566.0	0.1	157	0.1	157	0.1	157	0.1	157	626
South Teigen	TMF Dam	Stream	South Teigen - Reach 6	2,277.0	0.1	228	0.1	228	0.1	228	0.1	228	911
South Teigen	TMF Dam/Waste Pile	Stream	South Teigen - Reach 5	9,202.1	0.5	4,601	0.25	2,301	0.5	4,601	0.5	4,601	16,104
South Teigen	TMF Dam	Stream	South Teigen - Reach 4	8,275.9	0.5	4,138	1	8,276	0.5	4,138	0.5	4,138	20,690
South Teigen	Seepage Dam	Stream	South Teigen - Reach 4	2,152.7	0.5	1,076	1	2,153	0.5	1,076	0.5	1,076	5,382

(continued)

Table 4.3-1. Dolly Varden Stream Habitat Loss Summary (completed)

Watershed	Project Infrastructure	Habitat Type	Waterbody Name	Area Loss (m^2)	Dolly Varden Habitat Loss								Total HU Loss
					Adult		Embryonic Stage		Fry Rearing		Parr Rearing		
					HSI	HU	HSI	HU	HSI	HU	HSI	HU	
North Treaty	TMF Dam	Stream	North Treaty - Reach 2	3,136.5	0.5	1,568	1	3,136	0.5	1,568	0.5	1,568	7,841
North Treaty	TMF Dam	Stream	North Treaty - Reach 1	1,958.0	0.5	979	1	1,958	0.5	979	0.5	979	4,895
North Treaty	Seepage Dam	Stream	North Treaty - Reach 1	746.6	0.5	373	1	747	0.5	373	0.5	373	1,867
Treaty	Pipeline Outlet	Stream	Treaty Creek - 1	100.0	0.1	10	0.25	25	0.1	10	0.1	10	55
Unuk River	Bridge	Stream	2063	30.0	0.5	15	0.5	15	0.5	15	0.5	15	60
Unuk River	Bridge	Stream	Unuk River - 1025	220.0	0.5	110	0.5	110	0.5	110	0.5	110	440
Unuk River	Culvert	Stream	5008	16.0	0.1	2	0.5	8	0.1	2	0.1	2	13
Treaty	Bridge	Stream	100	150.0	0.1	15	0.5	75	0.1	15	0.1	15	120
Treaty	Culvert	Stream	108	40.0	0.1	4	0.5	20	0.1	4	0.1	4	32
Treaty	Culvert	Stream	204	6.0	0.1	1	0.25	2	0.1	1	0.1	1	3
Treaty	Culvert	Stream	205	8.0	0.1	1	0.5	4	0.1	1	0.1	1	6
Treaty	Culvert	Stream	209	18.0	0.1	2	0.25	5	0.1	2	0.1	2	10
Treaty	Culvert	Stream	210	45.0	0.1	5	0.5	23	0.1	5	0.1	5	36
North Treaty	Bridge	Stream	North Treaty Creek - 4011	210.0	0.5	105	0.5	105	0.5	105	0.5	105	420
Total				**39,944.1**									**71,555**

NA = not applicable.

ROW = right-of-way.

FSZ = fisheries sensitive zone.

Table 4.3-2. Dolly Varden Wetland Habitat Loss Summary

Watershed	Project Infrastructure	Habitat Type	Waterbody Name	Area Loss (m^2)	Dolly Varden Habitat Loss								Total HU Loss
					Migration		Spawning		Rearing		Overwintering		
					HS	HU	HS	HU	HS	HU	HS	HU	
South Teigen	TMF Dam	Wetland	STW2	314.0	NA	NA	NA	NA	0.1	31	0.1	31	63
Total				**314.0**									**63**

NA = not applicable

Table 4.3-3. Coho Salmon Habitat Loss Summary

Watershed	Project Infrastructure	Habitat Type	Waterbody Name	Area Loss (m^2)	Coho Salmon Habitat Loss								Total HU Loss
					Adult Migration		Spawning/Incubation		Rearing		Overwintering		
					HSI	HU	HSI	HU	HSI	HU	HSI	HU	
Coulter Creek	Culvert	Stream	2060	57	1	57	0.1	6	0.1	6	0.5	29	97
Coulter Creek	Bridge	Stream	Coulter Creek - 2061	60	1	60	0.7	42	0.1	6	0.5	30	138
Total				117									235

NA = not applicable.
ROW = right-of-way.
FSZ = fisheries sensitive zone.

Table 4.3-4. Chinook Salmon Habitat Loss Summary

Watershed	Project Infrastructure	Habitat Type	Waterbody Name	Area Loss (m^2)	Chinook Salmon Habitat Loss						Total HU Loss
					Adult Migration		Spawning/Incubation		Rearing		
					HSI	HU	HSI	HU	HSI	HU	
Bell Irving River	Bridge	Stream	Bell Irving River - 4004	248	0.4	99	0.5	124	0.4	99	322
Total				**248**							**322**

Table 4.3-5. Transmission Line Riparian Habitat Loss Summary

Watershed	Project Infrastructure	Habitat Type	Waterbody Name	Area Loss (m^2)	HSI	HU
Treaty	Transmission Line	Stream	108	900	0.2	180
Treaty	Transmission Line	Stream	114	900	0.2	180
Treaty	Transmission Line	Stream	204	900	0.2	180
Treaty	Transmission Line	Stream	205	900	0.2	180
Treaty	Transmission Line	Stream	209	900	0.2	180
Treaty	Transmission Line	Stream	244	900	0.2	180
Treaty	Transmission Line	Stream	210	900	0.2	180
North Treaty	Transmission Line	Stream	North Treaty Creek - 4011	900	0.2	180
Bell Irving River	Transmission Line	Stream	Bell Irving River - 4005	900	0.2	180
Bell Irving River	Transmission Line	Stream	Glacier Creek - 4006	900	0.2	180
Total				**9,000**		**1,800**

Table 4.3-6. Water Quantity Habitat Loss Summary

					Dolly Varden Habitat Loss								
					Adult		Embryonic Stage		Fry Rearing		Parr Rearing		Total HU Loss
Watercourse	Month	TMF Phase	Reach	Area Loss (m^2)	HSI	HU	HSI	HU	HSI	HU	HSI	HU	
South Teigen	August	0 - 45	Reach 1	1,756.0	0.5	1,756	1	1,756	0.5	1,756	0.5	1,756	7,024
			Reach 2	1,218.0	0.5	1,218	1	1,218	0.5	1,218	0.5	1,218	4,872
North Treaty	August	51 - 56	Reach 0	1,074.0	0.5	1,074	1	1,074	0.5	1,074	0.5	1,074	4,296
			Reach 1	163.0	0.5	163	1	163	0.5	163	0.5	163	652
Total				**4,211.0**									**16,844**

5. Compensation Planning and Assessment

5.1 DESKTOP ANALYSIS

Fish habitat compensation planning is an iterative process. Compensation planning requires knowledge of Project-related fish habitat effects, fish presence and distribution within the study area, quality of habitat affected, population size, and demography of the affected species.

A desktop analysis was conducted prior to commencing fieldwork for compensation project identification and assessment. A background literature review was completed for watersheds within and outside of the fish and aquatic habitat study area boundaries. In addition, a background literature review was completed for species-specific habitat limiting factors based upon peer-reviewed papers. The watershed literature reviews focused identification of factors limiting productive capacity within individual watersheds; for example, identification of present species and life history stages, identification of known key habitats (e.g., overwintering and spawning areas), and identification of anthropogenic impacts within watersheds.

An extensive list of background literature pertaining to the fisheries study area is referenced in *Kerr-Sulphurets-Mitchell Project: 2009 Fisheries Baseline Study Report* (Rescan 2010), *Kerr-Sulphurets-Mitchell Project: 2008 Fisheries Baseline Study Report* (Rescan 2009), and *KSM Project: Environmental Assessment-Chapter 15* (Rescan 2012d). The following additional background literature was also considered relevant: Tripp (1988), Applied Ecosystem Management (2000), SKR Consultants (1998), BC MOE (1988), FINS Consulting Ltd. (FINS; 2004), and Beak Environmental Specialists (1979).

A list of conceptual compensation techniques was developed based upon professional experience, literature reviews, Project information, fish life-history requirements, and design complexity (Slaney and Zaldokas 1997). For each concept technique, target species and life history stage, target habitat, primary and secondary objectives, and physical construction technique were identified (Table 5.1-1). Although Dolly Varden is the primary species affected by the Project, salmon habitat compensation projects were preferred due to consultation with Aboriginal groups at KSM Fisheries Working Group meetings. In addition, Dolly Varden and salmon species overlap in habitat preferences. Target species include: bull trout, chinook salmon, coho salmon, sockeye salmon, and rainbow trout/steelhead. Descriptions of each compensation concept are discussed in further detail in Section 6.1.

Multiple watersheds within and surrounding the fish and aquatic habitat study area were examined for potential fish habitat compensation sites. These watersheds included Treaty, Teigen, Hodkin, West Teigen, South Teigen, Gilbert, Todedada, Snowbank, Unuk, Bowser, Oweegee, Taft, Glacier, Mere, Skowill, Ritchie, Hodder, Spruce, and Bell-Irving. Preliminary compensation sites were identified through map review and assessment of terrain features. These sites were identified by keeping in mind DFO's *No Net Loss* policy through their hierarchy of habitat compensation preferences (DFO 1998). Certain compensation sites were also identified through a review of Highway 37 stream crossing assessment reports (FINS 2004) and online fisheries databases (e.g., BC MOE HabitatWizard; 2011).

The four most important criteria for identification of compensation sites were:

- moderate or high potential to provide adequate water supply (i.e., higher order streams versus 1st or 2nd order streams);
- terrain slope less than 5%, especially along floodplains;

Table 5.1-1. Conceptual Compensation Techniques

Concept Number	Target Species	Target Life Stages	Target Habitat	Primary Objective	Secondary Objective	Physical Technique
1	CO,DV,RB/ST,BT	Fry, Parr, Adult	Off-channel rearing, Overwintering habitat	Enhance/create overwintering and rearing habitat in off-channel areas by modifying ponds, beaver dams, wetlands, small floodplain tributaries to create low velocity, deep ponds with channels and complex woody debris cover	Combine spawning sites within outlet channels to seed habitat	Excavate ponds, join existing ponds with channels, or berm flow to backwater areas to create/enhance deep winter refuge habitat along floodplain at low risk of damage from mainstem, dig around beaver dams to create fish access
2	CO,DV,RB/ST,BT,CH	Fry, Parr	Side-channel rearing	Enhance/create rearing habitat in side-channels exposed to mainstem flows	-	Extend existing side channels and construct new side-channels with regulated water intakes; add complex with woody debris, boulder clusters and scour structures to increase fry/parr shear zones, slow areas and abundant cover, particularly if clear tributary flows into side-channel
3	CO,DV	Adult	Tributary/side-channel spawning habitat	Improve existing spawning habitat with cover and flow management	-	Add woody debris and boulder cover to marginal spawning areas which are deficient in cover to increase complexity of habitat and reduce predation, possibly manage flows into side-channel areas for better spawning success
4	CH,CO,RB/ST,BT,SK	Fry, Parr	Mainstem overwintering and summer rearing habitat	Enhance/create overwintering and rearing pools with increased cover	Enhance/create holding pools for adults with possible spawning areas in tailouts	Create pools by backwatering with rock riffles (less than 15 m channel width) or using lateral wood structures to scour riffles/glides into pools; add wood debris and coarse substrate for cover
5	CH,RB/ST,BT	Fry, Parr	Mainstem summer rearing habitat	Enhance/create improved rearing habitat in glides/riffles with boulder clusters for cover	-	Add boulder clusters for cover in cover-deficient, moderate gradient areas
6	CO,DV,RB/ST,BT	Fry, Parr, Adult	All habitats with obstructed access (i.e., beaver dams)	Restore fish access to existing habitat through improvements	-	Restore fish access through beaver dams with various techniques
7	DV,RB,BT	Adult	Spawning habitat	Improve/create spawning habitat with gravel placements	Improve invertebrate production in gravels	Add gravel to inlet/outlet streams and/or gravel rentention structures to improve abundance and quality of spawning area
8	DV,RB,BT,CO	Fry, Parr	Lake rearing and overwintering habitat	Improve littoral habitat around lake	Improve invertebrate production	Use helicopter to deposit woody debris into lake shore and anchor around margins of lake to improve cover
9	All species	Fry, Parr, Adult	Riparian rehabilitation	Improve riparian function adjacent to streams	-	Use forest management practices within the riaprian zone to promote release of coniferious trees and provide LWD recruitment

Dashes indicate not applicable

Species:

CO - coho salmon, CH - Chinook salmon, SK - sockeye salmon, DV - Dolly Varden, BT - bull trout, RB - rainbow trout, ST - steelhead

- proximity to known fish distribution and habitat quality (i.e., prioritization of areas in lower reaches along mainstems or floodplains versus headwaters with less fisheries resources or lower species composition); and
- biological benefit to target fish species.

Through this desktop analysis, a number of preliminary compensation sites were identified.

5.2 FIELD ASSESSMENT

5.2.1 Site Identification

Aerial reconnaissance and ground-truthing of the preliminary compensation sites occurred in 2009, 2010, and 2011. Sites were ground-truthed on multiple occasions to refine site objectives and identify opportunities, site-specific constraints, biological relevance, stability, permanence, target species, target habitat, and target life history stages. Assessment of site-specific constraints and opportunities included water supply magnitude and dependability, flood risk, water quality, sediment supply, gradient, soil stability, site constructability and access, construction costs, stability and durability of instream structures, obstructions and beaver dam risk, and time to full functionality of site.

A qualitative feasibility assessment, based upon professional experience, was conducted in 2009, 2010, and 2011 for each preliminary compensation site. This assessment was conducted by a water resources engineer to determine the technical feasibility of the sites. Through an iterative process of elimination and refinement, a list of technically feasible compensation sites was identified (Section 6.2).

Fish and fish habitat were assessed at each preliminary compensation site. Assessment methods are detailed in *KSM Project: 2010 Fisheries Baseline Study Report* (Rescan 2011a) and *KSM Project: 2011 Fish and Fish Habitat Compensation Baseline Report* (Rescan 2012a). A high-level summary of fish and fish habitat assessment methods is provided below for the Plan.

5.2.2 Fish Habitat

Stream habitat was assessed by one or more methods, depending upon the site-specific objectives. Stream habitat assessment methods included: reconnaissance level habitat assessment, detailed FHAP, SHIM, overwintering habitat assessment, and spawning surveys.

Streams were assessed using methods based on the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Protocol* (RISC 2001) and the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Site Card Field Guide* (RISC 1999a). This protocol involved characterizing fish habitat by measuring physical attributes (channel width, gradient, temperature, water quality, etc.), characterizing cover types and substrate (dominant/subdominant cover and substrate type, cover abundance, and location), and describing stream morphology.

FHAP assessments were conducted at representative sites for stream reaches. FHAP assessments involved differentiating the stream into separate HUs such as riffles, cascades, glides, and pools and then recording an array of habitat attributes for each unit (Johnston and Slaney 1996). These attributes included data on substrate composition, cover for fish, and fish habitat type.

SHIM was conducted at certain streams and off-channel wetlands. The SHIM method is intended as a standard for watercourse and fish habitat mapping in BC (Mason and Knight 2001). This method attempts to ensure the collection and mapping of reliable, high-quality, current, and spatially accurate information about fish habitats and watercourses. Streams and wetlands were located in the field and

their precise locations were mapped with a differential GPS unit. Moving in an upstream direction, streams were mapped, barriers were identified, and habitat assessments were conducted. Detailed fish habitat data were collected in the field as streams and wetlands were mapped. The spatial data were tied to fish habitat data collected in the field. Collected habitat data were a combination of the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001) and *Fish habitat assessment procedures* (Johnston and Slaney 1996) data.

Spawning assessments were conducted at certain sites depending upon the site-specific objectives. Target species for spawning assessments included Dolly Varden, bull trout, chinook salmon, coho salmon, sockeye, and rainbow trout/steelhead. Spawning assessment enumerated the abundance of spawners, timing, and location of spawning habitat.

Open water wetland habitat was qualitatively described and mapped either through SHIM or on aerial photography. The width and length of open water wetland habitats were measured, maximum water depth was recorded, and amount of cover and dominant cover type were recorded. Connectivity between wetlands and streams were documented. Professional expertise was used to rank habitat suitability for each fish life history stage (i.e., spawning, rearing, overwintering) and overall habitat quality.

For lake habitats, shoreline and littoral zone substrates were mapped and categorized with a hand-held GPS and an inflatable boat. Shoreline and littoral zone substrate segments were categorized by dominant and subdominant substrates present. Shoreline type was described and categorized by one of the following types: beach, low-rocky, cliff/bluff, wetland, and vegetated (mixed, shrub, coniferous, deciduous). Extensive submergent and emergent vegetation beds were described and mapped with a hand held GPS. Cover and fish habitat were described for the lake. Inlets and outlets were located, photographed, and described.

Wetland and stream overwintering habitat sites were located in the field, based upon the previous field seasons site assessment data. For each wetland and stream habitat site, snow and ice thickness was measured (to the nearest 1 cm) with a tape measure and/or measuring ruler. Water depth was measured (to the nearest 1 cm) with a measuring ruler. Dissolved oxygen (mg/L) was measured with a YSI Meter.

5.2.3 Fish Community

Streams were sampled using backpack electrofishers and minnow traps following RISC Fish Collection Methods and Standards (RISC 1997), Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures (RISC 2001) and the Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Fish Collection Field Guide (RISC 1999b). Electrofishing site length and effort varied depending upon the site-specific objectives. Mark-recapture and single pass electrofishing techniques were used depending upon site objectives. Biological data (fork length, weight, age structures) were collected in a standardized manner, including the identification fish life history stages (i.e., fry [0+], parr [1+], parr [2+], and adult).

The fish community in wetlands were sampled using baited minnow traps set in open water habitats for a period of approximately 24 hours. Caught fish were processed in a standardized manner.

Lakes were sampled with Resources Information Standards Committee (RISC) standard sinking gillnets and baited minnow traps. Gillnets were set randomly throughout the lake for a period of one hour to minimize fish mortality. If an unacceptable level of fish mortality was achieved, then the duration of net sets was shortened. If no fish were caught with one-hour net sets, then the duration of the net sets was lengthened. Minnow traps were randomly set in the littoral zone (less than 2 m) along the lake shoreline overnight. Caught fish were processed in a standardized manner.

6. Proposed Compensation Projects

6.1 COMPENSATION CONCEPTS

The proposed compensation projects will combine several concepts applied in different physical settings (i.e., off-channel, mainstem, lake). The concepts are listed below and are described in the following sections:

- Concept 1 - Off-channel overwintering habitat enhancement;
- Concept 2 - Side channel rearing habitat enhancement;
- Concepts 3 and 7 - Spawning habitat enhancement and creation;
- Concepts 4 and 5 - Using wood, boulders and pools to enhance rearing and overwintering habitat;
- Concept 6 - Improve fish access;
- Concept 8 - Enhance littoral habitat in lakes; and
- Concept 9 - Riparian function enhancement.

6.1.1 Concept 1: Off-channel Overwintering Habitat Enhancement

6.1.1.1 Rationale and Objectives

Off-channel habitat is present within and outside of the fish and aquatic habitat study area, particularly along the floodplains of Treaty and Teigen creeks, and the Bell-Irving, Bowser, and Unuk rivers (Rescan 2010, 2011b. Off-channel habitat includes beaver ponds, side channels, wall-base channels, small tributaries, and relic overflow channels along floodplains (Plates 6.1-1 and 6.1-2). These features typically have low seasonal flows, well-developed riparian communities, beaver dams, and a low to moderate risk of flooding from mainstem creeks. These characteristics result in productive rearing, overwintering, and a minor amount of spawning areas for salmonids (Lister and Finnigan 1997; Solazzi et al. 2000; Rescan 2007, 2011a, 2012a).

Off-channel habitat in the fish and aquatic habitat study area is utilized for summer rearing and overwintering by the target species: Dolly Varden and juvenile coho salmon (Plate 6.1-1; Rescan 2010, 2011). Saldi-Caromile et al. (2004) reported that few records exist of Dolly Varden and bull trout use of side channel and off-channel habitat, although fish sampling in the fish and aquatic habitat study area and other northwest BC localities indicates extensive use of these habitat types (Rescan 2007, 2009, 2010, 2011a, 2012a, 2012b).

The enhancement and creation of off-channel rearing and overwintering habitat is a key component of the proposed compensation projects, for several reasons (Table 5.1-1). Overwintering habitat is commonly a limiting factor and a population bottleneck for juvenile salmonids, particularly for coho salmon (Sandercock 1991; Cunjak 1995; Solazzi et al. 2000; Lister and Finnigan 1997). By targeting limiting habitat in certain concepts (e.g., off-channel overwintering habitat), substantial gains in production of coho salmon and Dolly Varden are anticipated (Ward 1997).

Off-channel pond and channel construction is a technique that has been successfully used in BC for the past 25 years, particularly when projects are well-designed and maintained regularly. Watershed restoration practitioners have built many successful projects over the past two decades (P. Slaney, pers. comm.; Slaney and Martin 1997). Off-channel sites are exposed to much lower stream flows and are less at risk of flood damage than mainstem sites resulting in higher likelihood of success.



Plate 6.1-1. Off-channel beaver ponds containing all life stages of Dolly Varden in the Treaty Creek Watershed.



Plate 6.1-2. Off-channel beaver ponds containing all life stages of Dolly Varden in the lower Teigen Creek Watershed.

Construction of off-channel projects is typically less costly per unit area compared to mainstem techniques like riffle construction (Lister and Finnigan 1997). This is because of the cost efficiency of excavating ponds or backwatering large areas with berms (Lister and Finnigan 1997; P. Slaney, pers. comm.). Another reason off-channel projects are attractive for development is that more opportunities exist to create off-channel habitat on floodplains (low risk) rather than in more dynamic, higher risk mainstem settings. Roni et al. (2002) reviewed many habitat rehabilitation projects; off-channel and side-channel projects have moderate and high chances of success even though variability in success was high. Monitoring and adaptive management are two key elements required for long-term success of off-channel projects.

A key aspect of enhancing or creating overwintering habitat in streams, side channels, and off-channel areas is to provide a relatively high amount of cover (i.e., over 20%). As noted in HSI models, high cover ratings provide greater suitability and higher value to fish (Table 3.2-1). Design targets of 30% (ponds) to 50% (channels) cover were used for the proposed sites. This is important because the amount and composition of cover for coho salmon (i.e., LWD) is positively correlated with higher overwinter survival and density (Bustard and Narver 1975; McMahon 1983; Tschaplinski and Hartman 1983; McMahon and Hartman 1989).

The primary biological objective for this concept is to enhance and create rearing and overwintering habitat in channels, pools, and ponds for Dolly Varden and coho salmon. Rainbow trout will likely see a small benefit from the new habitat based on their low abundance in existing off-channel areas (Rescan 2011). Substantial overlap in technique and benefits will arise from this off-channel concept which focuses on pond creation and the side-channel concept which focuses on summer rearing habitat. A secondary benefit will be the provision of spawning habitat in tailouts and runs among the new channels; provision of spawning habitat is compensation Concept 3 and is discussed in the following sections.

The biological objectives will be accomplished by constructing ponds, berms, water intakes, and small channels along the floodplains of larger streams. New ponds will be excavated or existing ones deepened and enlarged. Berms will be built to create backwatered ponds connected by small channels. Inlet channels will intercept groundwater, and side channels will carry surface water from small tributaries and surface intakes.

Water supply is a critical limitation on off-channel areas, and perennial sources of water will be captured to ensure fish access into new, permanent habitat. Several proposed projects are a combination of off-channel and side-channel concepts and include surface water intakes along main streams as well as large pond complexes.

Dolly Varden and coho salmon are anticipated to make extensive use of new off-channel ponds and side channels for rearing and overwintering based upon several factors:

- documented extensive use of off-channel areas for rearing, overwintering, and spawning in the study area (Rescan 2010, 2011, 2012a) and other mining projects (e.g., Galore Creek Project; Rescan 2007);
- professional experience with designing, constructing, and monitoring off-channel projects (e.g., watershed restoration projects in northwest BC and Vancouver Island);
- past success of off-channel habitat creation across BC (Lister and Finnigan 1997; Slaney and Martin 1997); and
- off-channel and side-channel habitat features fit the habitat preferences of coho salmon and Dolly Varden.

The proposed off-channel and side-channel compensation sites within and outside of the fish and aquatic habitat study area will result in a substantial increase in production of coho salmon and Dolly Varden. Published estimates of production benefits from off-channel ponds vary depending on the species and size of ponds (Keeley and Slaney 1996; Lister and Finnigan 1997; Saldi-Caromile et al. 2004). For example, constructed off-channel ponds supported an average of 1.01 juvenile coho fry/m^2 (Keeley and Slaney 1996). Based upon 1995 survival rates and 1.01 fish/m^2, the estimated production resulted in an estimate of 68 adult coho per 1,000 m^2 (i.e., 0.1 ha; Keeley and Slaney 1996). Coho smolt production from 93 off-channel projects in Washington State ranged from 0.2 to 1.0 smolts/m^2 and averaged 0.44 smolts/m^2 (Saldi-Caromile et al. 2004). Pond size is another factor affecting overall pond production, with small ponds more productive per unit area than larger ponds (Keeley and Slaney 1996).

6.1.1.2 Design Description

General

Design issues and considerations detailed in Lister and Finnigan (1997) and Saldi-Caromile et al. (2004) were consulted during the planning and design process. The preferred habitat attributes for Dolly Varden and coho salmon in HSIs were also reviewed and incorporated into site designs (Section 3).

Key habitat variables, which can be controlled with new construction or enhancement of existing habitat include percent cover, substrate composition, gradient, percent pools, vegetation index (several years after construction), pool/riffle ratios, discharge (to some degree), and velocity (related to gradient). Several habitat variables used in HSI models are difficult to control or alter from the ambient conditions (e.g., dissolved oxygen, flow, temperature, pH, conductivity). For example, little modification of the dissolved oxygen content is possible in a typical flowing stream as it is generally fully saturated. In ponds, dissolved oxygen content and temperature vary depending on ice cover, depth, macrophyte decomposition, and water column mixing.

Key factors considered during the assessment and design process included:

- water quality (e.g., dissolved oxygen concentrations, turbidity);
- winter ice cover;
- soil conditions;
- existing habitat features and productivity;
- proposed pond and channel shapes and depth;
- flows and water sources;
- habitat preferences of target species;
- presence and access of the target species; and
- beaver issues.

The typical off-channel project includes the following features:

- water supply (i.e., groundwater seepage and/or surface channel);
- a series of narrow channels;
- flood protection measures (e.g., gravel dyke); and
- an outlet to a larger stream.

Development, design, and construction of off-channel and side channel sites share similar techniques and approaches. The off-channel design discussion below focuses on the pond components. Narrow channels will be constructed between ponds for fish access and to supply water to ponds. Typical channel details are discussed in Section 6.1-2 and shown in Figures 6.1-1 to 6.1-4.

Ponds

Off-channel ponds for the compensation projects will range from 0.1 to 3.5 ha (Figures 6.1-1 and 6.1-2). The ponds will have a combination of features, depth, and cover to provide a complex physical environment that will maximize rearing and overwintering habitat quality for the target species. Pond features will include islands, LWD, shallow shoals, deep holes, salvaged vegetation, and variety of soil types. The complex shape and features in ponds are intended to maximize the littoral area for invertebrate and aquatic plant production as well as fish foraging, cover, and deep refuge value. Each pond will be fit to the local topography and, prior to construction, existing aquatic features and fish will be salvaged (e.g., sedge vegetation, LWD).

Two types of ponds will be constructed: excavated ponds and bermed ponds. The two pond types are differentiated by the amount of excavation and position of the water surface (Figures 6.1-1 to 6.1-3).

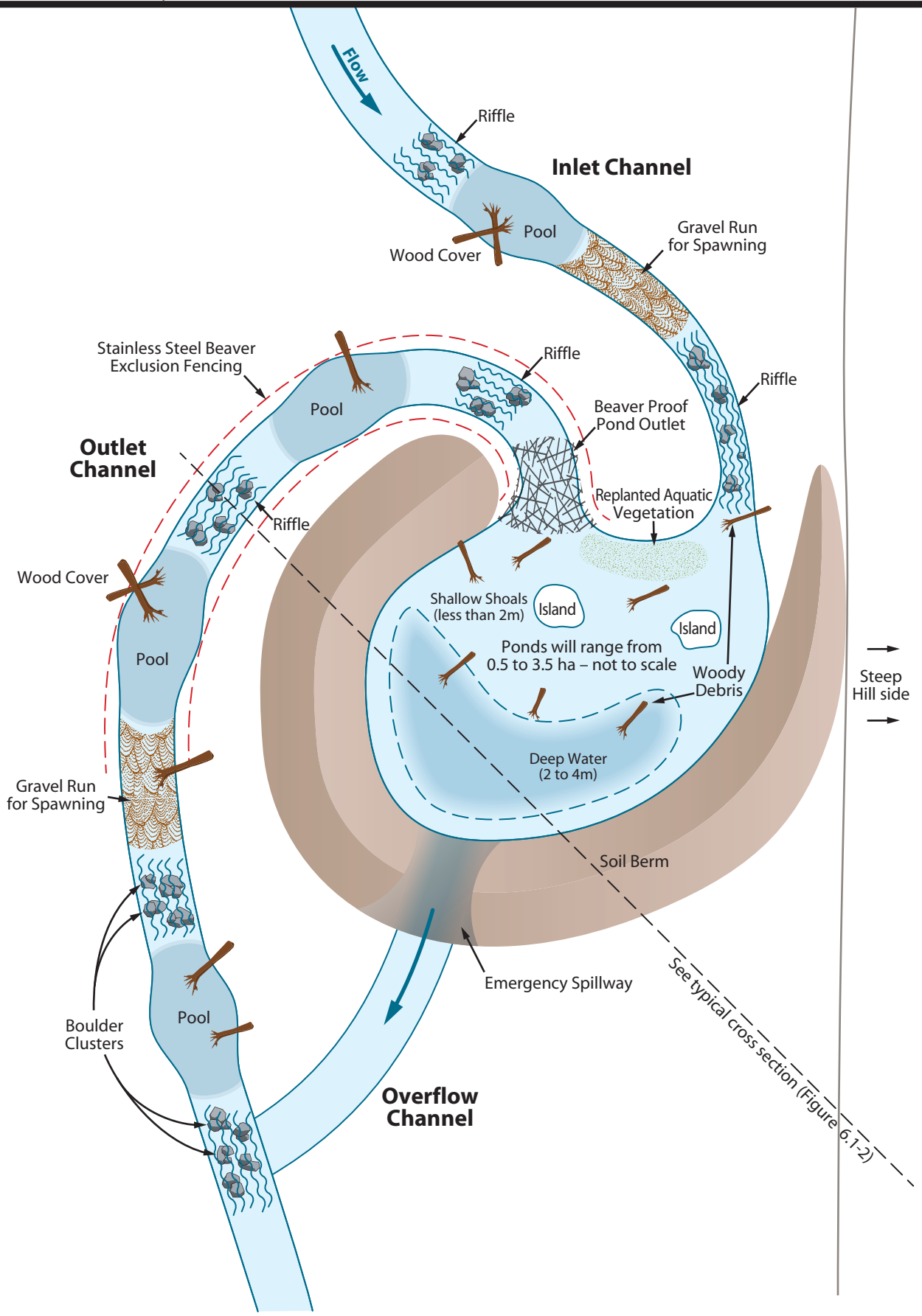
Key factors concerning excavated ponds are summarized below:

- pond area ranges from 0.1 to 0.5 ha (i.e., much smaller footprint than bermed ponds) and from 25 to 100 m in diameter;
- ponds will be excavated into the floodplain soils with water elevation below the surrounding land (Figure 6.1-3), with one inlet and outlet;
- pond depth is typically set several metres below the lowest groundwater elevation, hence monitoring of the sub-surface water table with piezometers and stand pipes is critical;
- spoil areas are situated immediately adjacent to ponds; while not integral to the pond design they will be revegetated or used as a flood protection dyke;
- higher cost per square metre of pond than bermed ponds due to spoil handling;
- supplied by surface and/or groundwater and will not subside if excavated into water table;
- can be built at many more locations than bermed ponds due to the small size and reliance on groundwater; and
- requires medium to large excavator.

In contrast, bermed ponds hold water up to several metres higher than the groundwater table and can be much larger. The beaver ponds found throughout the study area are examples of this concept using mud and stick dams. Bermed ponds will replace existing shallow beaver ponds.

Key factors concerning bermed ponds are summarized below (Figures 6.1-1 and 6.1-2):

- pond area ranges from 0.5 to 3.5 ha (i.e., up to seven times larger than dug ponds) with greater footprint for ponds, channels, and associated berms;
- large perimeter berms, up to 4-m high and 15-m width, hold water elevation above the surrounding land (Figure 6.1-2);
- pond depth is typically 2 to 3 m and dependent on berm height, not groundwater;
- much less spoil will be generated per square metre of pond than excavated ponds;
- large bermed ponds have substantial material handling requirements;

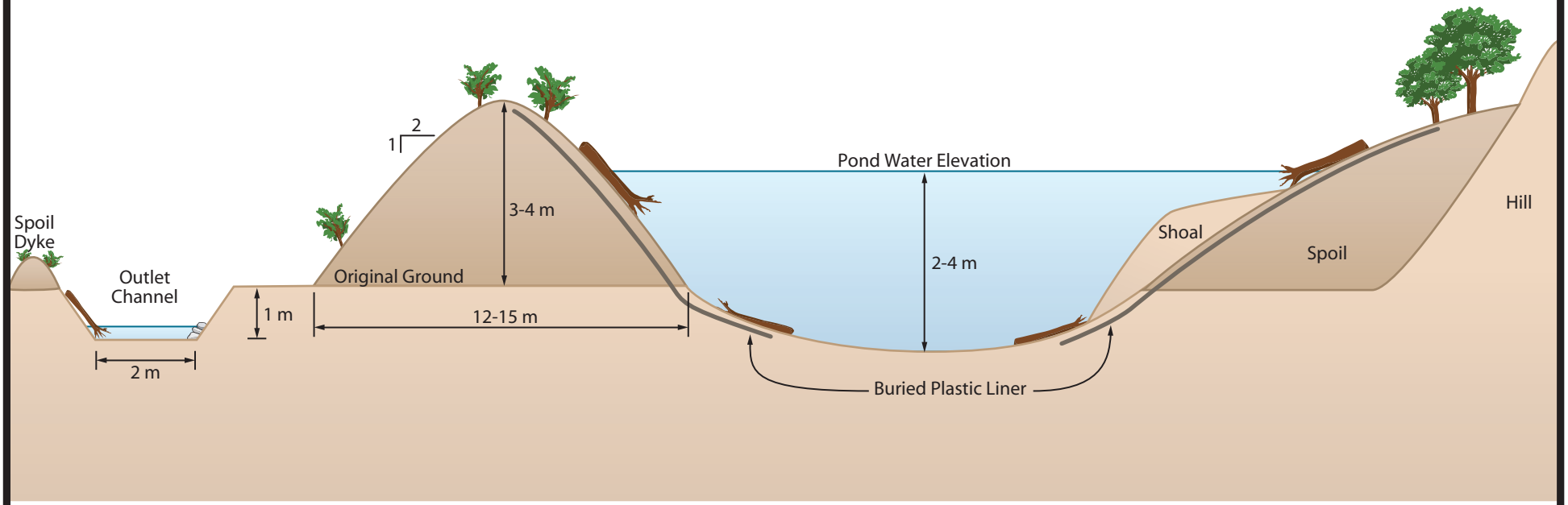


Typical Layout of a Bermed Pond and Channels

SEABRIDGE GOLD

FIGURE 6.1-1

Rescan™



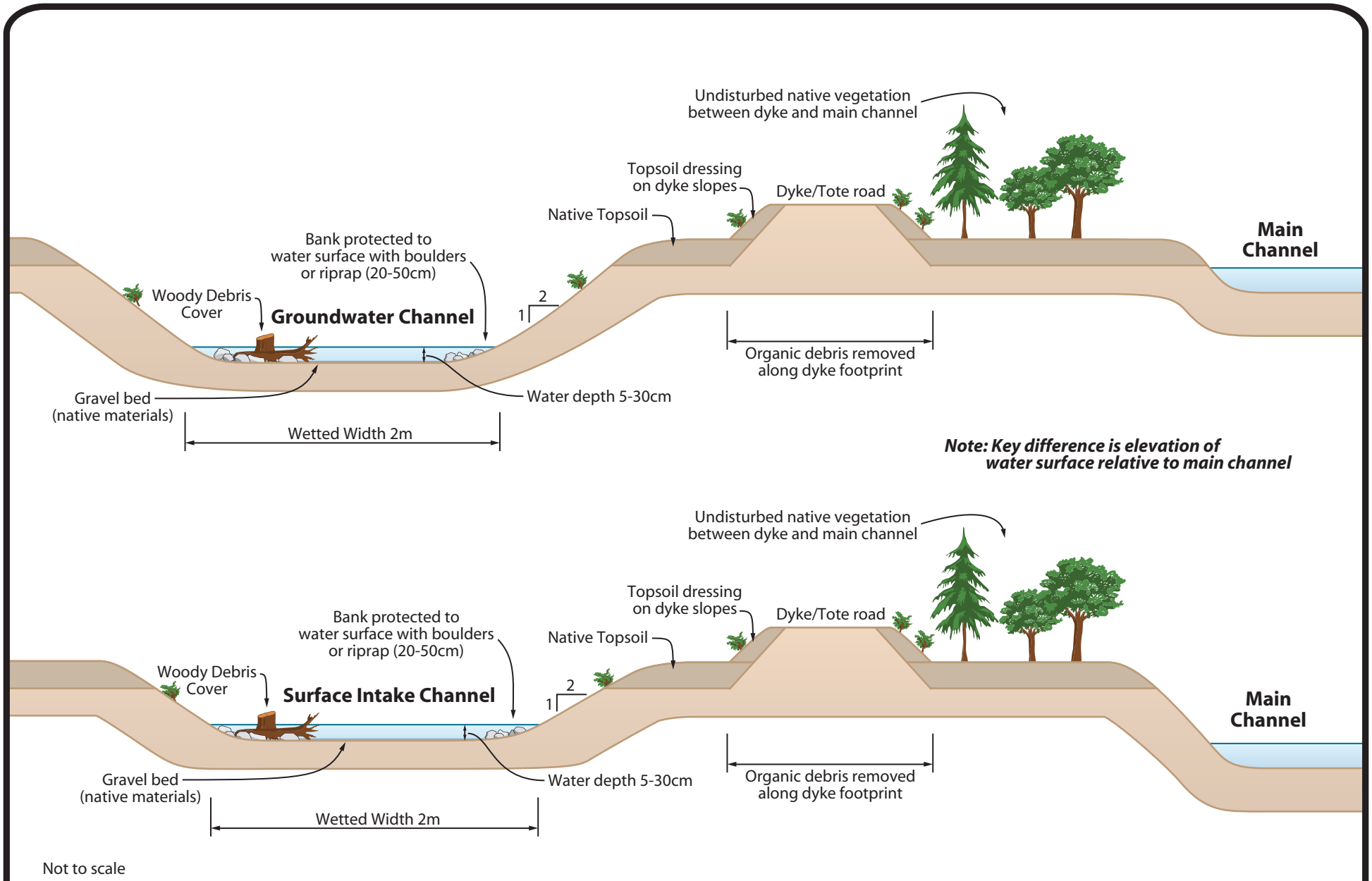
Not to scale

Typical Cross-section of a Bermed Pond and Outlet Channel

FIGURE 6.1-2

SEABRIDGE GOLD

Rescan™



Typical Cross-sections of an Excavated Groundwater Channel (top) and Excavated Surface Intake Channel (bottom)

FIGURE 6.1-3

SEABRIDGE GOLD

Rescan™

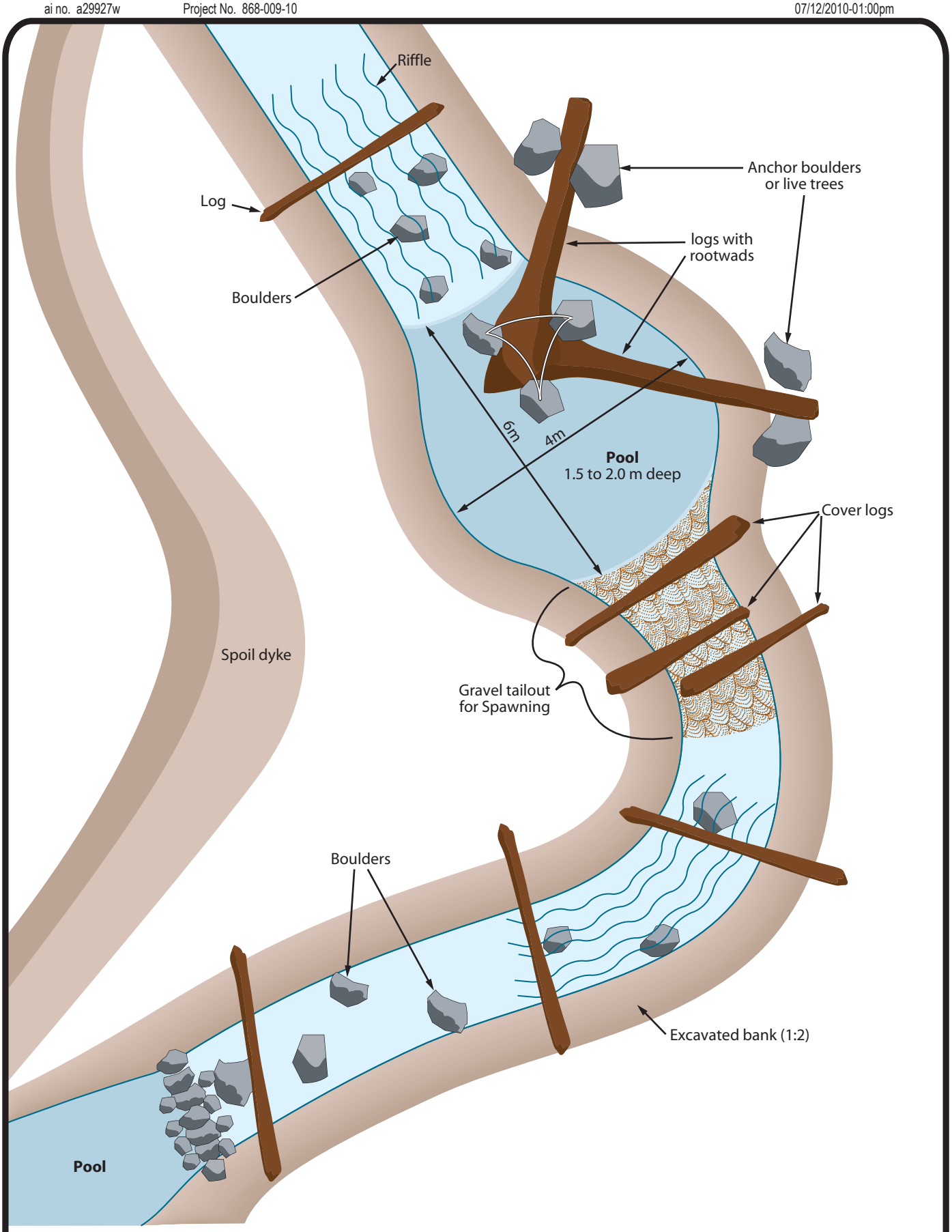


FIGURE 6.1-4

Typical Layout of an Excavated Channel with Pools

SEABRIDGE GOLD

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- spoil berms are integral to successful design and must be watertight (e.g., clay capping, geotextile fabric, or impermeable plastic liner);
- lower cost per square metre than excavated ponds;
- must have constant surface water input;
- two outlets required (i.e., main outlet for fish access and emergency overflow spillway [Figure 6.1-1] armoured with rock in case outlet becomes blocked by ice or beavers);
- must have beaver control features and fencing;
- can only be built at specific and less common locations; and
- requires more heavy equipment than dug ponds (i.e., medium-size excavator, bull dozer, and possibly dump truck for efficient construction of large ponds).

Regardless of the pond type, the attributes and target amounts of fish habitat features will be similar. The average water depth in ponds will range from 1.5 to 2.5 m with maximum depths between 3 and 4 m (Figures 6.1-1 and 6.1-2). Ice thickness in Treaty Creek off-channel areas in winter 2010 were up to 1.2 m (Rescan 2011c*)*. Ponds with inflow streams or groundwater seepage in winter had thinner ice and were ice-free longer in the study area (Rescan 2011, 2012a). Therefore, ponds will be constructed so that at least one half of the pond area will provide winter refuge habitat with at least 1 m of water below ice. A constant inflow of seepage or surface water to the ponds in winter is important for reducing ice thickness, maintaining fish access, and increasing dissolved oxygen levels.

A target for the amount of shoal area (i.e., gently sloping littoral area) at each pond will be between 25 and 50% of the pond (Figure 6.1-1). Abundant littoral areas with small islands will increase habitat quality due to aquatic vegetation colonization (e.g., sedges) and benthic insect production (Lister and Finnigan 1997). A target of 35% of each pond will be complexed with cover features. This is because high cover abundance is related to high juvenile fish density of off-channel areas (Johnson and Slaney 1996; Lister and Finnigan 1997). These features will include replanted aquatic vegetation and LWD salvaged during site preparation.

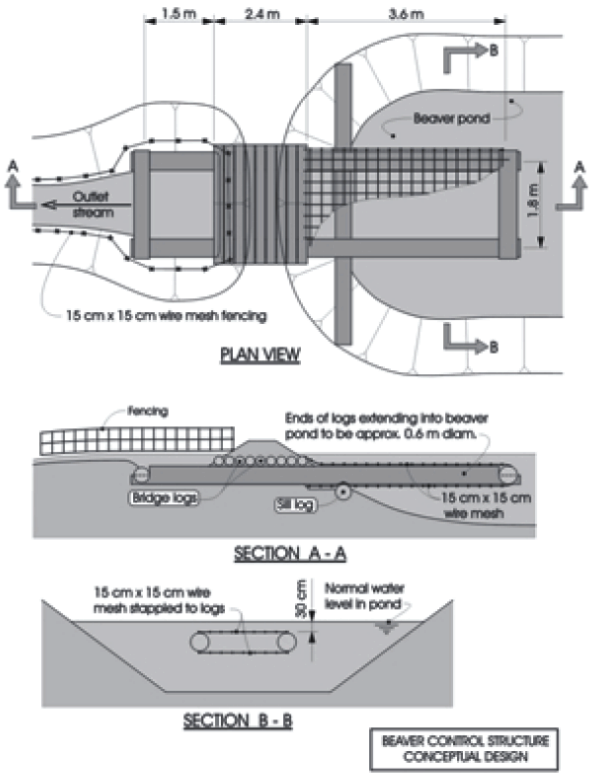
Ponds will help improve water quality by settling out fine particulate matter (i.e., suspended sediments). Silt deposited into ponds will contribute to aquatic and riparian soil formation and nutrient cycling. Siltation is not anticipated to result in excessive pond infill and degradation of fish habitat.

The inlet streams to each pond will have alternating riffle and pool sections. They will be complexed to provide maximum rearing and foraging habitat value (Figure 6.1-1 and 6.1-4). This is important since juvenile coho salmon growth is 50% faster at pond inlets than in pond outlets (Rosenfeld and Raeburn 2009). The greater growth is attributed to a higher rate of drifting invertebrate prey originating from riffle sections upstream, particularly the high abundance of terrestrial insects, compared to pond outlet locations (Rosenfeld and Raeburn 2009).

Beaver Management

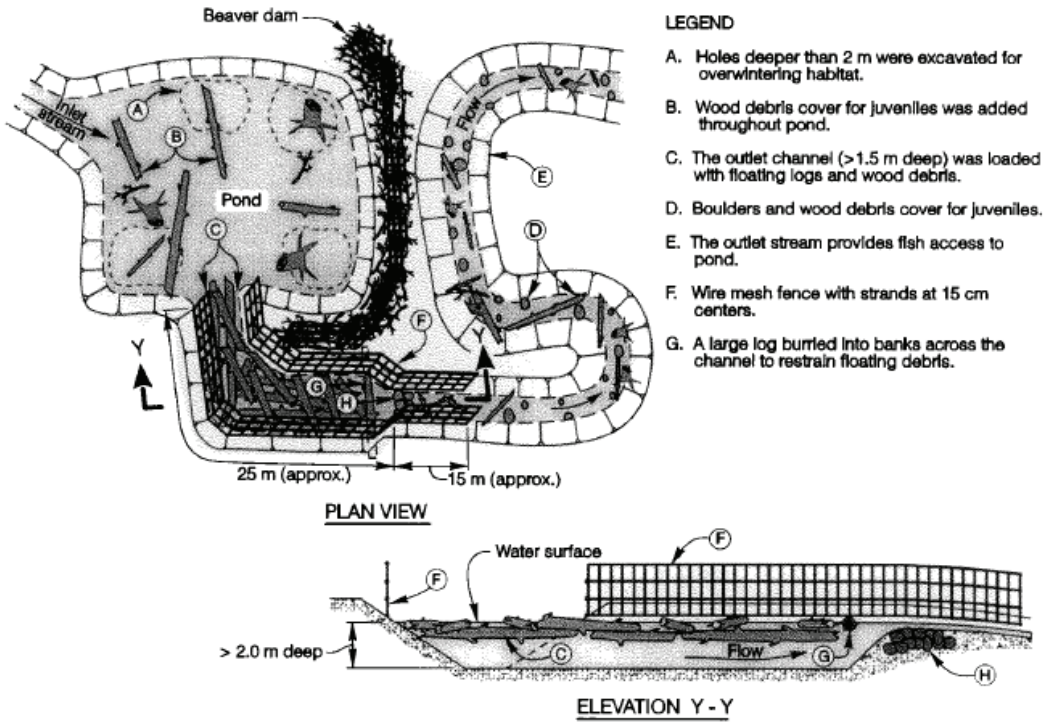
Several techniques will be incorporated into the off-channel sites to prevent beavers from damaging, blocking, or altering proposed sites. Beavers are endemic to the fish and aquatic habitat study area and provide fish habitat and wetland, amphibian, and wildlife benefits; therefore, planning for beaver activity is key (Figure 6.1-5). Beaver dams are a challenge in constructed off-channel projects because the constructed ponds are preferred beaver habitat. Secondly, beaver dams, and the lack of maintenance to remove beaver dams, are key reasons for the failure of constructed off-channel projects (Finnigan and Marshall 1997; L. Reese-Hanson, pers. comm.). Monitoring and minor maintenance of all off-channel projects will be required for long-term success.

a) A concept design for a beaver control structure



Source: Finnigan and Slaney 2002.

b) The Telkwa design concept. The outlet stream provides fish access into the beaver pond. Wire fence and floating logs restrict beaver access to the outlet stream.



Source: Finnigan and Marshall 1997.

SEABRIDGE GOLD

Beaver Management Techniques to Prevent Dam Construction at the Outlets of Off-channel Ponds

FIGURE 6.1-5

Rescan™

Beavers typically drag brush and branches overland from the adjacent riparian zone or swim upstream with materials to build dams. Fencing is commonly used to obstruct them, and it will be mandatory at the proposed compensation sites, particularly along excavated channels. Beaver fencing consists of wire mesh, ideally stainless steel; and steel fence posts installed immediately adjacent to the channels and at pond outlets (Figure 6.1-5).

Another technique to obstruct beavers includes beaver baffles, LWD structures, wire screens, and fences at pond outlets to obstruct beavers and reduce the sound of flowing water (Figure 6.1-5; Finnigan and Marshall 1997; Finnigan and Slaney 2002). The outlets of the proposed ponds will incorporate these features (i.e., beaver baffles, plywood levelling boxes, and structures of log debris and wire mesh [Figure 6.1-5]).

Vegetation

After construction of off-channel and side channel projects, riparian enhancement will be completed to establish vegetation along disturbed areas. In addition, riparian and wetland vegetation are expected to naturally colonize the margins of ponds rapidly and contribute to ecological function. The vegetation will help establish complex ecological processes (e.g., food production, invertebrate habitat, litterfall) and boost the fish habitat quality in off-channel and side channel sites.

Logistics

The construction of off-channel and side-channel projects typically involves extensive excavation and earth moving with a variety of equipment, including excavators, bulldozers, dump trucks, etc. Projects will typically be constructed during the summer months when streams and groundwater will be low and dry conditions will persist. Only a few proposed compensation sites have or will have road access nearby. The lack of road access to several sites will require establishing new road access or airlifting equipment.

6.1.2 Concept 2: Side Channel Rearing Habitat Enhancement

6.1.2.1 Rationale and Objectives

The creation and enhancement of rearing habitat in side channels is the second main concept of compensation projects (Table 5.1-1). Concept 2 deals with summer rearing habitat in side channels in contrast to the overwintering pond habitat of Concept 1.

Side channels contain productive habitat used for rearing, overwintering, and limited spawning by salmonids (Lister and Finnigan 1997; Rescan 2010, 2011, 2012a). Side channels also provide refuge during peak flood events and are often connected with off-channel beaver ponds and floodplain tributaries. Side channels are dynamic aquatic environments with similar habitat features, fish species, substrate, and gradients as the mainstem.

Side channels are common along the floodplains of Treaty and Teigen creeks and the Bell-Irving, Bowser, and Unuk rivers (Figure 1.3-1; Plates 6.1-3 and 6.1-4). Side channels typically carry seasonal high flows in summer and fall but often dry up or contain isolated pools in late summer and winter. Side channels are often dammed by beavers to form ponds and back flood extensive areas.

Both fish use and habitat quality in side channels are quite variable. Many side channels possess poor quality habitat with few pools and low cover since they are mostly riffles and runs (i.e., laminar fast flow; Rescan 2011, 2012a*)*. The riffle-run morphology is often due to the lack of LWD, boulders, or meander bends which deflect the flow to cause scour (Plates 6.1-5 and 6.1-6). The lack of cover in fast flowing, laminar channels of watersheds was found to support lower densities and lower species richness than complex side channels (Slaney and Martin 1997; Ward 1997).



Plate 6.1-3. Side channels along Treaty Creek with off-channel area on left.



Plate 6.1-4. Side channels along Bell-Irving River.



Plate 6.1-5. Coho salmon spawning in good quality gravel in East Todedada Creek. The substrate composition at spawning sites provided natural templates for planning spawning habitat enhancement.



Plate 6.1-6. Triangle wood structure that will be installed in side channels to create scour and sorting in the tailouts of new pools to enhance spawning habitat.

Fish sampling over the past three years in the fish and aquatic habitat study area found side channels were utilized for summer rearing by multiple species life stages (Rescan 2009, 2010, 2011, 2012a, 2012b). Deep, slow velocity side channels provide overwintering refuge areas and were commonly dammed by beavers. Fry and parr chinook salmon, coho salmon, Dolly Varden, sockeye salmon, rainbow trout/steelhead, bull trout, and mountain whitefish utilized side channels. Adults utilize side channels for spawning (i.e., coho salmon, chinook salmon, and Dolly Varden; Rescan 2010, 2011).

Unlike off-channel habitat, which is suspected to limit coho production in the study area, the lack of summer rearing habitat in channels has not been identified as a limiting factor. But small channels are critical components of most off-channel projects for fish access and water supply (Section 6.1-1). Consequently, developing good-quality rearing habitat in the various side channel and connecting channels will contribute to the overall success of off-channel projects. Two types of side channels are proposed for compensation work:

- enhancement of existing side channels adjacent to mainstems; and
- construction of rock armoured surface intakes to divert water into new channels (called protected side channels). Protected side channels will be excavated across the floodplain away from mainstems and lead into off-channel ponds.

Specifically, the objectives are:

- to improve rearing habitat quality in existing side channels as measured by increased percent cover, pool area, wood abundance, and residual pool depth;
- to increase the spawning habitat quality in existing side channels through scour and sorting from structures; and
- to construct good quality rearing and spawning habitat in protected side channels.

The habitat value in side channels can be improved by adding new habitat features like wood, pools, boulders and rock riffles as well as regulating the flow extremes (Slaney and Martin 1997). As noted for off-channel projects above, construction of side channels is also a very successful technique that has been used in watershed restoration for several decades (Lister and Finnigan 1997). Many of the same benefits of creating off-channel sites apply to side channel construction.

Juvenile chinook salmon, rainbow trout, and bull trout are not expected to utilize constructed overwintering ponds to the same extent as Dolly Varden or coho salmon. However, the proposed side channels connecting off-channel ponds will incorporate pools, riffles, and complex features which are preferred summer rearing habitat for all five species. In other words, side channels meet their habitat requirements, and will be more stable, accessible, and of higher quality than at present. Anticipated benefits of side channels are based upon the benefits which are apparent at the micro-site level (e.g., the improvement or creation of individual habitat features like boulders, logs, and pools). Collectively, the creation of channels with high cover, abundant deep pools, and good flows will result in more rearing, overwintering, and spawning habitat for fish. The new and enhanced channels will increase the productive capacity in the fish and aquatic habitat study area.

6.1.2.2 Design Description

General

Two types of side channel sites will be completed as part of the proposed compensation projects;

- enhancement of active side channels situated along mainstem creeks; and
- excavation of protected intake side channels to supply off-channel ponds.

Some features of proposed side channel sites were described in Section 6.1.1 since the projects share common elements (e.g., ponds, connecting channels). They share common habitat variables but differ in the flow regime and extent of excavation.

Mainstem Side Channels

This type of compensation is enhancement of active side channels where the discharge of the mainstem flow regulates side channel water levels. Discharge, water levels, bed load movement, and debris loads are much more variable in mainstem side channels than typical off-channel sites (Plates 6.1-2 and 6.1-4). Protected side channels will only be a few metres wide, whereas mainstem side channels are up to 20 m in width. Consequently, the habitat features added to mainstem side channels will be more robust, larger in size, and have a larger area of effect than the features used in protected side channels.

LWD and boulder structures will be installed to create cover, pools, and complexity. Triangle log structures, wood jams, boulder clusters and opposing triangle weirs will be added to mainstem side channels to create scour pools, provide cover, and improve rearing habitat. The specific details about these structures are discussed in Section 6.1.4. Compared to the protected side channels, relatively little excavation will be required to install structures every 50 to 100 m along the mainstem side channel.

Protected Side Channels

This type of compensation is construction of "protected intake" side channels between large off-channel ponds (Section 6.1-1). An armoured surface water intake will be constructed to withdraw water from the mainstem into a side channel and off-channel ponds (Figure 6.1-3). Protected side channels will have more reliable and a smaller range of flow since the intakes can be controlled by the shape and access. Protected side channels often intercept groundwater and will have lower flood risk than mainstem side channels (Finnigan and Marshall 1997; Roni et al. 2002).

Detailed monitoring of mainstem flows will establish the hydrograph and periods when excess flow is available for diversion. Because water is withdrawn from the mainstem to the floodplain, the potential for hydrological effects will be analyzed for the mainstem reach downstream. Potential effects are anticipated to be negligible on the mainstem since the withdrawn water volume will be small. The withdrawn water will be returned to the mainstem.

Regardless of whether a proposed site carries surface water, groundwater, or a hillslope tributary, constructed channels will possess common features and functions. Inlet and outlet channels from ponds will provide migration routes, summer rearing, overwintering, and spawning habitat as well as oxygenated water into ponds (Figures 6.1-1 and 6.1-3).

Typical channel attributes include:

- trapezoidal shape with 1.5 to 2.0 m wetted width with side slopes of 1:2 (rise : run; Figure 6.1-4);
- 0.5 to 3.0% gradient with gravel and cobble substrate;
- 5 to 30 cm water depth (excluding pool depth) and 1 to 3 m excavation into adjacent soils;
- replanted riparian vegetation and treatments to accelerate recovery of the riparian community functions;
- a protective dyke and tote road between the channel and mainstem river (Figures 6.1-3 and 6.1 4);
- cobble and small boulders lining the toe of the bank to prevent bank erosion;
- high cover amounts of 30 to 50% including LWD, logs, boulders, and pools to provide complex habitat;
- high pool to riffle ratio e.g., target of 40% or 1 pool every 25 m;

- abundant riffle areas for invertebrate production and aeration; and
- beaver control features and fencing.

Fish habitat features within the channel will be maximized to produce high-quality rearing habitat. The channels will be complexed with salvaged materials (i.e., cobble, boulders, LWD, root wads, branches; Figure 6.1-4). At least one-third of the channel and ideally about half of the channel will have overhead or instream cover. This is important because habitat quality for stream rearing salmonids is directly related to the abundance of cover (Tables 3.2-1 and 3.2-5; Johnstone and Slaney 1996; Ward 1997). Logs and root wads will be partially buried in the bank or cabled to boulders to prevent washout and displacement (Figure 6.1-4).

Pools will be excavated at regular spacing (e.g., every 25 m) along the connecting channels (Figure 6.1-4). The abundance of pools is directly related to the quality of rearing habitat (Johnstone and Slaney 1996). In the typical 2-m wide channel, pool area will account for approximately 40%. Pool area within channels will account for a minimum of one-third and up to one-half of the wetted channel area to create high quality salmonid rearing habitat as indicated in the HSI tables (Tables 3.2-1 and 3.2-5). Wood and boulder cover features are discussed in greater detail in Concept 5. The pools will also provide sufficient depth and cover for overwintering habitat (i.e., minimum residual depth of 1.0 m).

Spawning habitat typically develops in pool tailouts and runs containing sandy gravel and around scour features (Figure 6.1-4). Adequate velocity, cover, and depth of water are key attributes that will be factored into channel designs (Whyte et al. 1997). The channels will contain woody and boulder structures that will scour pools. It is anticipated that frequent and viable spawning habitat will also develop in the constructed channels. Should gravel placement be necessary for off-channel or side channel projects, then the placed material will follow established recommendations (e.g., 80% of 10 to 50 mm gravel, 20% of 100 mm gravel, and small portion of 2 to 5 mm coarse sand; Whyte et al. 1997).

Logistics

The construction will require extensive excavation and earth moving with a variety of equipment, including excavators, back-hoes, bulldozers, and dump trucks. Projects are typically constructed during the summer months when stream and groundwater tables are low and dry conditions exist. Access for heavy equipment into proposed compensation projects will be a key planning factor. New road access will be required or construction equipment will have to be airlifted.

6.1.3 Concept 3: Spawning Habitat Enhancement and Creation

6.1.3.1 Rationale and Objectives

The mainstem channels of Teigen, Treaty, Todedada, East Todedada, Snowbank and Oweegee creeks supply the majority of spawning habitat for large-body salmonids (rainbow trout/steelhead, chinook, coho, sockeye, bull trout). Side channels, flood channels, beaver pond outlets and small tributary streams along the floodplain are used extensively by small-body Dolly Varden for spawning and to a lesser degree by coho (Rescan 2010, 2011, 2012a, 2012b). Spawning habitat in off-channel settings typically consists of low to moderate gradient channels with sandy gravel substrate, overhanging cover, and riffle-run morphology with occasional pools (Rescan 2010, 2011, 2012a, 2012b). Within the study area, spawning habitat quality, access, cover, and flows in off-channel and side channel areas ranges from good to poor. Spawning habitat is generally not a limiting factor within the study area although access to, and flows at, potential spawning habitat impairs their use by fish.

Dolly Varden are small-bodied fish (i.e., up to 30 cm typically for stream resident fish) and require much less space and flow for successful reproduction than coho salmon. Dolly Varden were observed spawning in silt and sand substrate in northwest BC in channels as narrow as 25 cm with mainly sand

substrate (Rescan 2010). In comparison, coho salmon were typically observed spawning in deeper and wider channels with stronger flow and gravel and cobble substrate (Rescan 2011*)*. The quality of spawning habitat is dictated by the size, permeability, and compaction of the substrate; proximity to cover; and the velocity, depth, and dissolved oxygen content of the stream.

Concept 3 is the enhancement and creation of spawning habitat in a variety of settings (off-channel areas, side channels to large and small systems) in conjunction with other techniques (LWD and cover addition, enhanced flows). Creation and improvement of spawning habitat will help ensure a supply of juvenile fish adjacent to off-channel and side channel rearing and overwintering sites.

The key determinants for the success of spawning habitat at a compensation project are the permanence and nature of the water supply. Spawning habitat can be maintained naturally within constructed off-channel sites that include surface water intakes from mainstems to ensure flows persist and adult fish can gain access.

6.1.3.2 Design Description

Site-specific designs for spawning habitat have not been developed; rather, the habitat preferences and SIs were reviewed to identify key components to include in the design of typical off-channel and side channel projects. The specific locations for spawning habitat enhancement/creation will be identified during field assessments.

The detailed analysis will incorporate the following key elements to address spawning habitat requirements:

- channel attributes – slope (i.e., 0.5 to 3%) and width (up to 2 m);
- habitat elements - meander bends, wood, and pools for adult holding cover;
- soil conditions - gravel and cobble soils are best for natural recruitment; and
- hydrologic design targets will be set for depth, flow, and velocity for adult access and spawning, as well as for overwintering egg incubation.

Key criteria to consider when designing for average or better spawning and incubation habitat for coho salmon include (Whyte et al. 1997; Table 3.2-1):

- 5.0 mg/L or greater dissolved oxygen (adult);
- 40% or greater gravel/cobble substrate;
- less than 20% fines;
- substrate from 13 to 102 mm;
- water supply;
- minimum depth of 0.18 m;
- water velocity from 0.30 to 0.91 m/s;
- mean redd area of 2.8 m^2; and
- area of spawning per pair of 11.7 m^2 (i.e., one to two pairs per typical pool).

Habitat criteria to consider when designing for average (i.e., moderate) or better Dolly Varden spawning and incubation habitat includes (Washington Department of Fish and Wildlife 2004; Table 3.2-5):

- 6.0 mg/L or greater dissolved oxygen (embryo requirements);

- less than 20% fines;
- water depth of 0.1 to 0.79 m;
- water velocity from 0 to 0.58 m/s;
- water supply;
- less than 9% gradient;
- 10% or greater cover;
- moderate (75 to 149) or better riparian vegetation index; and
- presence of pools.

If gravel needs to be imported to construct spawning habitat, appropriate guidelines will be followed. The general substrate guideline for most species of salmonids is approximately 80% of 10 to 50 mm gravel, 20% of 100 mm gravel, and a small amount of coarse sand (2 to 5 mm; Adams and Whyte 1990). Gravel should be round for spawning, since angular rock will injure spawning fish (Saldi-Caromile et al. 2004). Control features such as weirs, boulders, and LWD clusters within proposed channels will retain and sort gravels (Figures 6.1-3 and 6.1-4).

6.1.4 Concepts 4 and 5: Using Wood, Boulders and Pools to Enhance Rearing and Overwintering Habitat

6.1.4.1 Rationale and Objectives

Concepts 1, 2, and 3 rely upon two approaches to achieve habitat quality objectives. The first approach is excavation and complexing of new channels, which will carry low discharge flows and not be subjected to floods. The other approach is to add rocks and logs to create new cover and scour pool features through the river's energy. Both approaches utilize Concepts 4 and 5 to maintain good-quality habitat for salmonids. Concept 4 is the creation of pools from addition of wood, boulders, and rock riffles. Concept 5 is the improvement or creation of complex cover with boulder clusters in riffle settings and runs instead of pools.

Pool and cover structures (e.g., wood triangles, log/boulder jams, single logs, opposing v-weirs, and rock riffles) will be added to existing side channels to improve rearing habitat (Slaney, Finnigan, and Millar 1997). Wood structures create pools, provide refuge and cover, store and trap sediment, dissipate energy, and stabilize channels (Slaney and Martin 1997; Cederholm, Dominguez, and Bumstead 1997).

Juvenile salmonids will utilize the cover and complex shear zones provided by LWD and boulders in a pool to defend feeding territories. In general, the greater the abundance of cover and pools in a channel, the greater the density of summer rearing and overwintering fish of all life stages (Allan and Lowe 1997; Ward 1997; Slaney and Martin 1997). Fish territory size and preferred depths increase with fish size, hence the deeper and larger a pool becomes, the higher the likelihood it will be used by multiple ages, sizes, and species of fish (Keeley and Slaney 1996). Complex cover within a pool aids juvenile fish in finding refuge from predatory adult fish, each other, and peak flows. Adult fish rely upon cover and pools when holding and the tailout sections are commonly used for spawning habitat.

These are fundamental techniques for the proposed compensation projects and they replicate natural templates in settings throughout the fish and aquatic habitat study area. Pools, LWD, and boulders are widespread and critical features of fish habitat in the study area (Rescan 2011; Plates 6.1-1 to 6.1-4). Depending on the setting (mainstem, off-channel, side channel, lake), various arrangements of boulders and wood will be used to create specific scour or cover attributes. The proven success and

adaptability of wood and boulder structures to a wide variety of channels, flow regimes, species, and settings is a fundamental reason for their widespread use.

The biological objectives of Concept 4 and 5 are:

- to improve rearing and overwintering habitat quality by increasing the percent cover, pool area, wood abundance, and residual pool depth in existing channels using wood structures and rock riffles (Concept 4);
- to create new rearing and overwintering habitat in constructed channels using wood structures and rock riffles to scour deep pools, create complex flow patterns, and provide abundant cover (Concept 4); and
- to enhance and create abundant, high quality rearing habitat in riffles using boulder clusters for cover (Concept 5).

6.1.4.2 Design Description

General

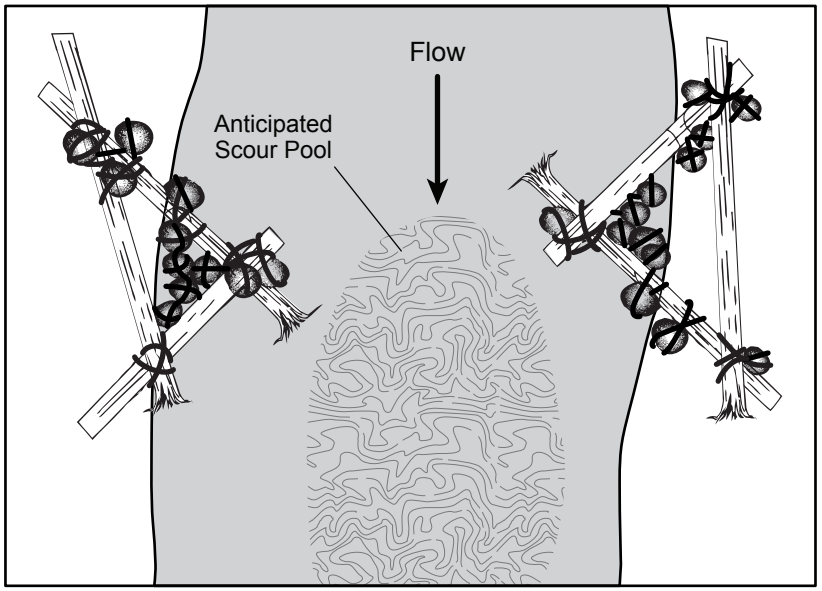
In addition to professional experience gained from designing and implementing similar projects, key design and planning criteria were reviewed including Fontaine and Merritt (1988), Slaney and Zaldokas (1997), D'Aoust and Millar (2000), and Saldi-Caromile et al. (2004). The designs will have detailed engineering, survey, geotechnical, and hydrological analysis undertaken during the final design. Key factors considered during the assessment and preliminary design process included:

- habitat preferences of target species;
- channel morphology (gradient, width, stability, bank integrity, and disturbances);
- soil, riparian, substrate, and ground conditions;
- hydrological issues (bankfull and low flow discharge, flood regime, hydrograph);
- design templates and potential channel effects (both up and downstream);
- structure spacing and position in channel;
- ballasting requirements;
- presence and access of the target species and existing habitat features;
- constructability and equipment/crew access; and
- source of materials.

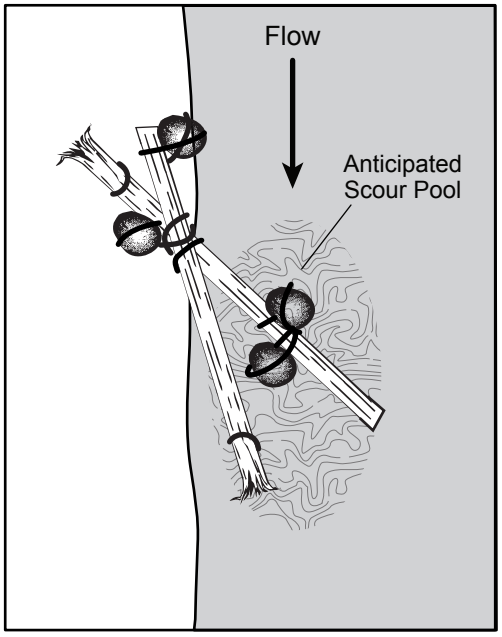
Three types of wood and boulder structures (triangle, opposing triangle, and single logs) and two types of rock structures (Newbury riffles and boulder clusters) will be constructed. Representative typical and schematic arrangements are shown in Figures 6.1-6 to 6.1-9. Each structure type is discussed briefly below.

Log Triangles

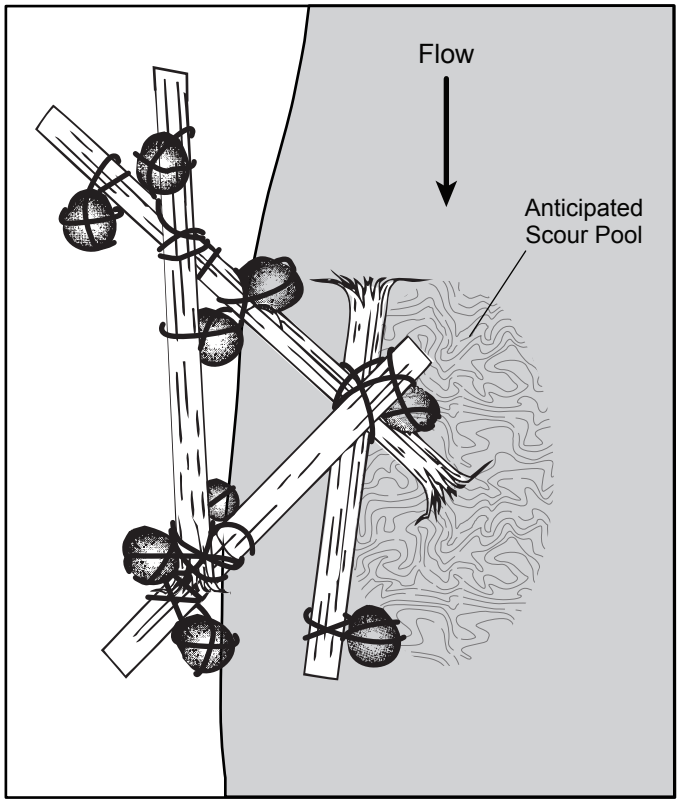
The wood structures will consist of two main types: log triangles, also called triangle log jams, and single logs (Figure 6.1-6). A third type of structure involves opposing log triangles. Structures will generally be situated on the outside of bends or in shallow wide glides. Structures will deflect the stream into the bed and banks to scour pools typically at the apex. They will replicate natural wood jams and sweepers and will protrude up to one half of the channel width. The critical outcome of these structures will be the scour pools, sorting of the substrate, as well as cover for rearing and overwintering.



Opposing Log Triangle



Double Log



Single Triangle on Outside Bend

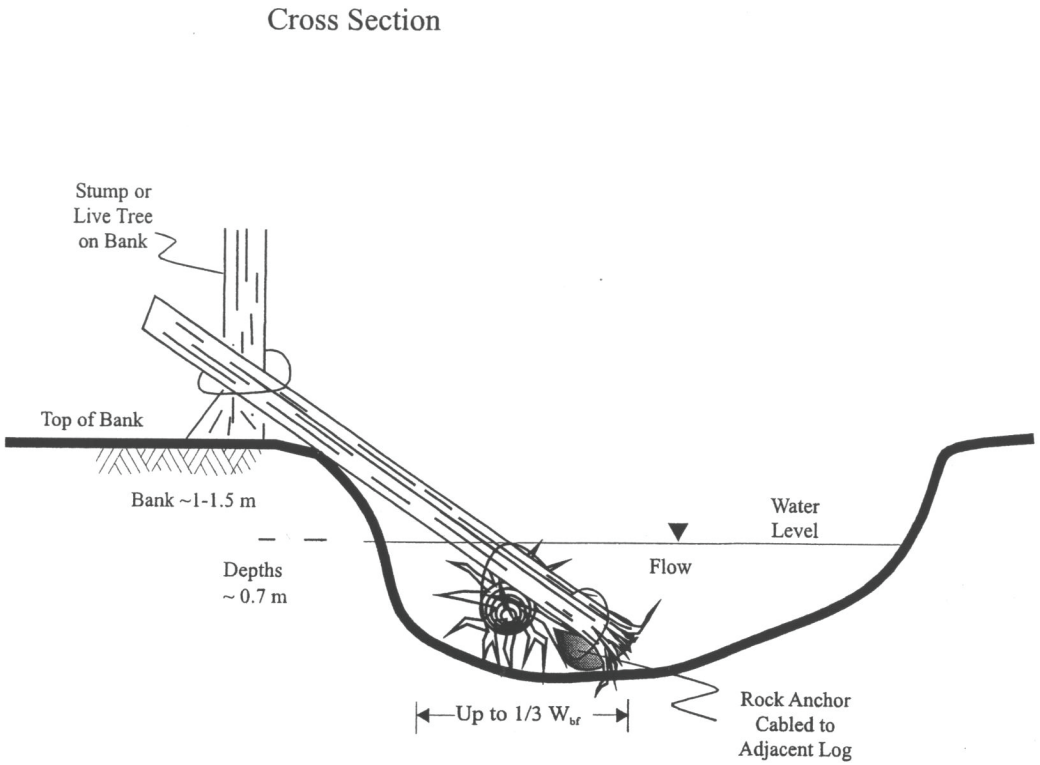
Source: Stanley and Zaldokas, 1997.

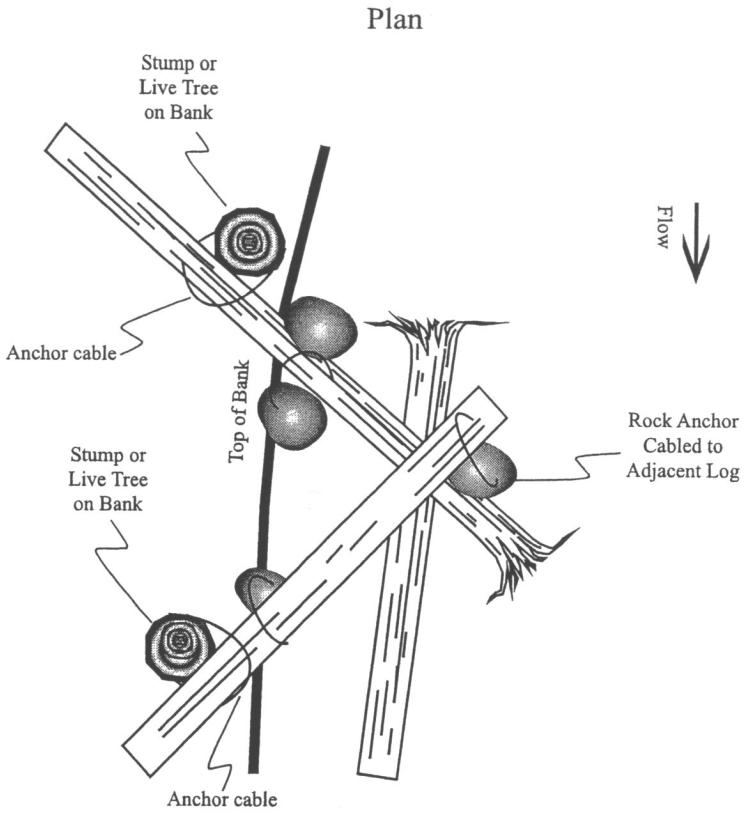
FIGURE 6.1-6

SEABRIDGE GOLD

Three Wood and Boulder Structure Templates

Rescan™





Construction Notes:

1) Use LWD pieces 8 to 15 m long x 0.5 m diameter.
2) Number and size of rock anchors depends on predicted maximum flow, maximum flow velocity and number and size of LWD used.
3) Leave cable anchors slack so that rock anchors scour into streambed.
4) If using deadman anchors instead of stumps or live trees on the bank care should be given to the positioning of the anchors to not allow the LWD to shift downstream.
5) Logs with rootwads attached to be used where available.
6) Limit LWD projection width to 1/3 of channel width or based on site conditions.

ANCHOR DIMENSIONS

Rock Required (assuming logs with rootwads):
10 - 0.8 m diameter boulders

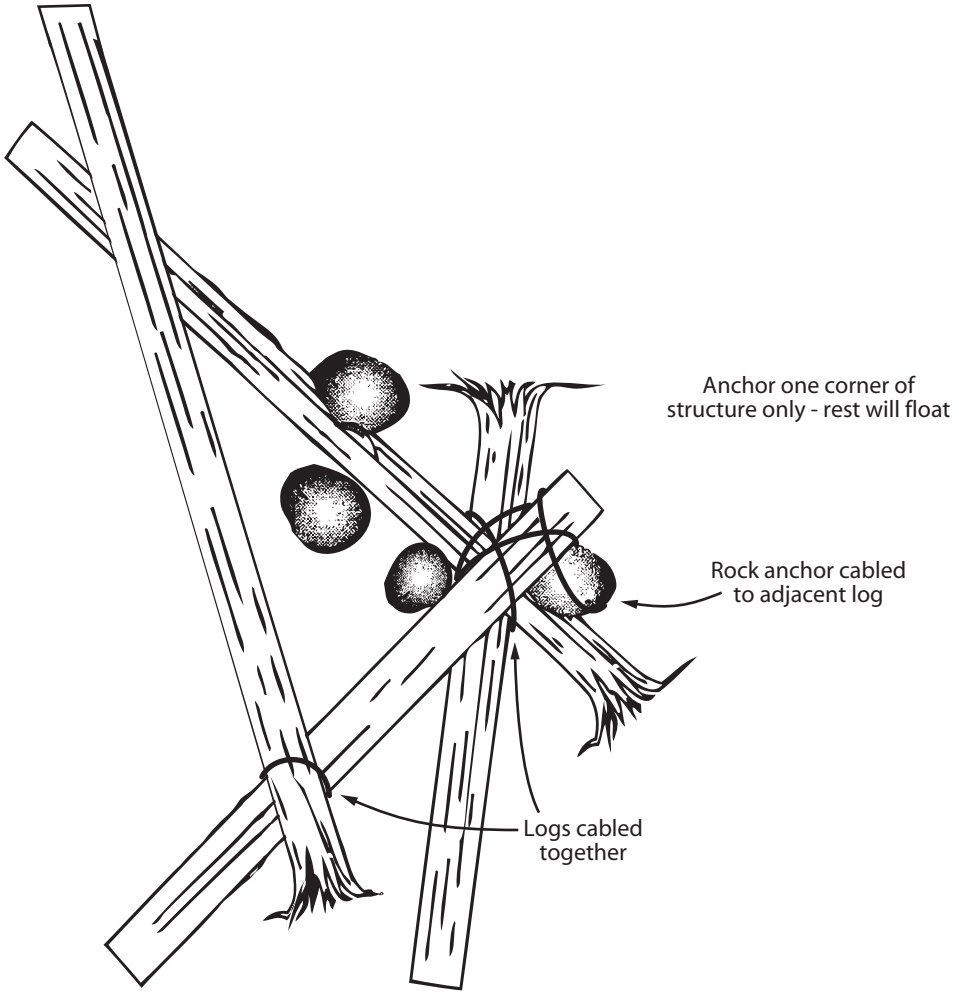
Source: Gaboury and Murray (2003)

FIGURE 6.1-7

SEABRIDGE GOLD

Typical Triangular LWD Structure

Rescan™



Construction Notes:

1) Use LWD pieces 8 to 15 m long x 0.5 m diameter.
2) Number and size of rock anchors depends on predicted maximum flow, maximum flow velocity and number and size of LWD used.
3) Leave cable anchors slack so that rock anchors scour into streambed.
4) Logs with rootwads attached to be used where available.
5) Single logs or log structures to be situated in deepest section of pond.
6) Use trees with branches and root wads attached.

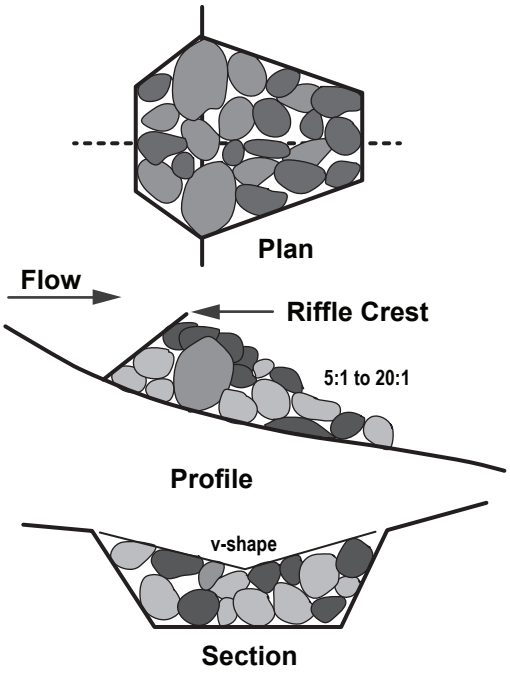
Typical Log Structure for Ponds

FIGURE 6.1-8

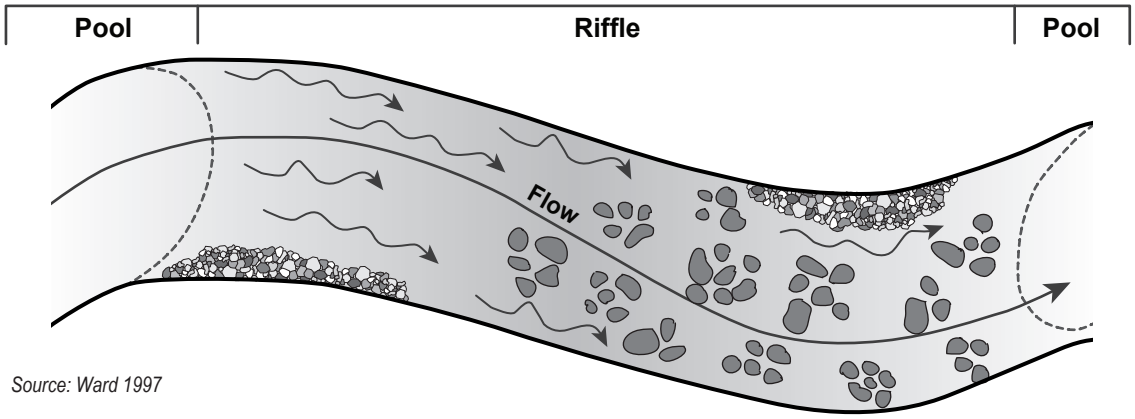
SEABRIDGE GOLD

Rescan™

1. PLAN: Build riffle crest across the stream with large diameter boulders; back up with next largest stone downstream.
2. PROFILE: Construct downstream face of riffle at a shallow re-entry slope that mimics local natural riffles (5:1 to 20:1).
3. SECTION: V-shape the crest and face downwards to the centre of the riffle (0.3 to 0.6 m).
4. SURFACE: Place large rocks randomly on the downstream face 20 to 30 cm apart to dissipate energy and create low flow fish passage channels.
5. BANKS: Rip-rap both banks with embedded boulders and cobbles to the floodplain level.



Source: Newbury, Gaboury and Bates, 1997.



Source: Ward 1997

FIGURE 6.1-9

SEABRIDGE GOLD

Newbury Rock Riffle and Boulder Cluster Layout

Rescan™

Three to four logs, 0.5 m in diameter by 8 to 15 m in length, will be cabled together to form a triangle structure (Figure 6.1-6; Plates 6.1-7 and 6.1-8). Large boulders (0.5 to 0.8 m in diameter, 250 to 600 kg) will be cabled to each corner of the structure and be placed on the bank top. Rock ballasting will depend on the sizes of logs available, species, buoyancy and design velocities. For example, typical three-log triangles of 0.5 m-diameter wood by 6 m in length will require approximately 2,200 kg of ballast in total (6 boulders of 350 kg; Slaney, Finnigan, and Millar 1997). Boulders will be cabled to each other with wire rope that will be epoxied approximately 30 cm into each boulder (Figure 6.1-6 and 6.1-7). This system is a reliable and recommended system for building durable wood and boulder structures (D'Aoust and Millar 2000; Fontaine and Merritt 1988).



Plate 6.1-7. Triangle log structure.



Plate 6.1-8. Spider-hoe constructing triangle log and boulder structure along Cheakamus River. (Used with permission – NuCreek Developments Inc.)

The log triangles will be spaced approximately every 25 to 75 m apart, depending on the channel width. Triangles will influence approximately 100 m^2 of habitat at each site while single logs will influence up to 50 m^2. Single logs will typically be installed in shallow glides and pools to provide cover in tailouts.

Opposing Log Triangles

Two log triangle structures will be built opposite each other (Figure 6.1-6, Plate 6.1-9). They will be spaced approximately one-quarter to one-third of the channel width apart. These structures will force the flow into the middle of the channel and back water upstream. This configuration will result in a plunging effect as the water is pinched into a narrow opening between the structures and will scour a large pool. Opposing structures will be used in several systems to replace low beaver dams which currently create upstream glides with low fish habitat value. Single trees or root wads will be added to the downstream pools to increase the cover value. Approximately 150 m^2 of habitat will be improved at each site.



Plate 6.1-9. Opposing triangle and boulder structures with large scour pool in mid-channel.

Floating Log Triangles in Beaver Ponds and Lakes

Poor-quality overwintering and rearing habitat have been identified in beaver ponds within the fish and aquatic habitat study area, which could be improved by adding triangle structures for cover. For example, the beaver ponds along East Todedada Creek had almost no instream cover except for overhanging shrubs.

The typical log triangle will be constructed but only anchored at one end with four to six large boulders (Figure 6.1-8). Structures will be anchored on only one end so the remainder can float with fluctuating water levels and provide maximum overhead cover. The structures will have little scour function since they will be exposed to much slower water velocities in the ponds.

Newbury Rock Riffles

Newbury rock riffles are another technique that is suitable for creating pools and enhancing rearing and overwintering habitat in continuous cascade systems (Newbury, Gaboury, and Bates 1997). Newbury riffles are commonly used in channelized stream sections to backwater upstream cascade sections into alternating pool and riffle sequences (Figure 6.1-9; Plate 6.1-10). Newbury rock riffles are also proposed to be used to backwater a perched culvert to improve fish passage.



Plate 6.1-10. Spider-hoe installing a Newbury rock riffle along Mahatta River. (Used with permission – NuCreek Developments Inc.)

Boulder Clusters

Concept 5 is the use of clusters of 0.5-m diameter boulders in small streams and side channels to improve rearing cover in riffles (Figure 6.1-9). Groups of five to seven boulders will be spaced up to 1.0 m apart in the lower half of riffles and tailouts of pools (Ward 1997). These clusters will influence up to 10 m^2 of habitat and are typically added throughout a reach (e.g., every 50 to 100 m).

Construction Considerations

An excavator or a spider-hoe will be the only heavy equipment needed to correct log triangles and boulder clusters in channels (Plates 6.1-9 and 6.1-10). Heavy-lift helicopters will be needed to airlift equipment into remote sites as well as to mobilize boulders and logs to stream sites. At sites with road access, dump trucks and tracked excavators will mobilize materials and undertake construction from stream banks.

A spider-hoe is an invaluable piece of equipment for constructing instream structures since it can walk in streams with minimal disruption, unlike a tracked excavator (Plates 6.1-9 and 6.1-10). Experienced crews, appropriate machinery and materials, and good equipment operators are needed to complete these complex projects effectively.

6.1.5 Concept 6: Fish Access

6.1.5.1 Rationale and Objectives

Beavers are present throughout the fish and aquatic habitat study area in ponds, side channels, and off-channel tributaries along floodplains (Plates 6.1-1 to 6.1-4). Beavers maintain large areas of wetlands, some of which contain fish. The height of beaver dams, lack of flow, and dispersed flows around dams typically exclude juvenile fish from using large areas of aquatic habitat in the study area (Rescan 2010, 2011a). In certain cases, lack of suitable outflow prevents coho smolts, which had immigrated into beaver

ponds as fry, from emigrating from ponds. Fish are often located within beaver ponds upstream of the dams, which indicates that only partial or seasonal obstruction of fish access occurred. Adult access into off-channel areas are also blocked by dams at several sites (see Table 6.2-1).

The objective for this concept is to restore fish access into areas obstructed by beavers through a variety of techniques (e.g., channels, juvenile passage structures; see Table 6.2-1).

6.1.5.2 Design Description

Certain compensation projects have been identified in areas currently used by beavers that have excellent potential to be large compensation sites if fish access could be restored (see Table 6.2-1 and 6.2-2).

The main technique for restoring permanent fish access is to construct channels with heavy equipment around beaver dams and reinforce existing beaver dams or remove them entirely, and install beaver proof fencing. This technique can only work under very specific conditions.

The key outcome of this concept is the recognition that the highest likelihood for overall success in providing fish access is at sites where a combination of concepts can be used, e.g., where a surface water intake will provide sufficient flows to off-channel ponds and a new outlet channel can be justified to restore fish access.

6.1.6 Concept 8: Enhance Littoral Habitat in Lakes

6.1.6.1 Rationale and Objectives

Climatic, chemical, biotic,. and geologic factors strongly influence productivity in lakes. Another key factor is the habitat complexity of the littoral zone, which is linked to the lake productivity through fish communities, nutrients, and energy flow (Schindler and Scheuerell 2002). Complex littoral systems provide cover and substrate and mediate the energy flow among communities. In addition, juvenile salmonids utilize the shallow margins of lakes, particularly at night and when emigrating from nursery streams.

The productivity of fish-bearing lakes within the fish and aquatic habitat study area ranges from productive waterbodies at low elevation to nearly barren lakes at high elevation (Rescan 2009). For example, Todedada Lake contains abundant rainbow trout and complex littoral habitat (Tripp 1987; Plate 6.1-11; see Figure 6.2-1). It is a small, clear, low elevation lake in the Todedada Creek Watershed with abundant LWD around the perimeter. In contrast, Hodkin Lake, is located on a high plateau in the upper Teigen Creek Watershed and had a low abundance of Dolly Varden when sampled in July 2010 (Plate 6.1-12; Rescan 2011*)*.

The objective for this concept is to increase the diversity, complexity, and abundance of woody cover in the margins of lakes (see Table 6.2-3).

6.1.6.2 Design Description

This concept involves the introduction of LWD, to be anchored to boulders and bedrock along the margins of four lakes. An increase of 10% shoreline cover will be targeted i.e., one large triangle every 100 m of shoreline, assuming each large triangle affects about 150 m^2 of habitat up to 15 m from shore. Approximately 10% of the shoreline of each lake will be treated with a focus on the shallower basins and outlet and inlet streams.

Whole trees, trunks, and root wads (8 to 15 m in length, minimum 0.5 m diameter) will be flown via helicopter from a nearby source and deposited along the margins of the lakes. The helicopter will drop logs and rocks in triangle arrangements. Logs will be anchored with cables to boulders and bedrock as floating log triangles, such that at least 75% of the structures are within the lake at low water (Figure 6.1-8).



Plate 6.1-11. Complex littoral zone around productive Todedada Lake.



Plate 6.1-12. Hodkin Lake with isolated population of Dolly Varden and sparse littoral zone.

Construction considerations are straightforward for this concept since, aside from a helicopter to move wood, no heavy machinery is required onsite for moving logs. Crews would anchor and cable the structures to prevent dislodgement by wind, waves, and ice shifting. The identification of sources of rock and logs would be the primary planning activity for this concept.

6.1.7 Concept 9: Riparian Function Enhancement

6.1.7.1 Rationale and Objectives

The riparian zone is the interface between upland vegetation and soils and flowing water containing aquatic habitat (Plates 6.1-1 to 6.1-4). Riparian vegetation within this zone provides essential ecological services including shade, energy contribution (litterfall), bank stability, filtration of overland run-off, biochemical functions in the soil, and contributions of LWD. Riparian vegetation is an important component of rearing and overwintering habitat in streams and ponds. Terrestrial insects drop from overhanging vegetation into streams and ponds, while organic matter such as leaves provide a food source for aquatic invertebrates which are in turn consumed by fish (Adams and Whyte 1990).

A wide variety of riparian vegetation communities exists along creek channels in the fish and aquatic habitat study area. Vegetation types range from sedge and shrub dominated communities in Todedada Creek to deciduous shrubs and trees in the cottonwood-dominated floodplains of the Bell-Irving River. Mature coniferous forests exist along many channels and hillslopes and provide one of the most obvious examples of riparian zone function: the contribution of trees and root wads to the channel. When planning habitat compensation projects, the use of plant species native to the area is often recommended (DFO 2006). Native plant material can be grown in nurseries, collected from undisturbed areas (within reason), or salvaged from areas that will be subject to development.

Construction activities at certain fish habitat compensation projects will involve the removal of large amounts of vegetation. Rehabilitation projects will be planned to coincide with construction activities to take advantage of native plant materials that can be salvaged instead of being destroyed.

The biological objective for this concept is to rehabilitate disturbed riparian areas as efficiently as possible and accelerate the recovery of self-sustaining vegetation communities with a wide variety of techniques. Additional approaches to riparian enhancement include the treatment of naturally impaired or human-impacted vegetation and sites (e.g., logged riparian areas in cutblocks), should there be few opportunities for rehabilitating disturbed communities.

6.1.7.2 Revegetation Approach and Techniques

The development of a revegetation plan by a qualified botanist will identify methods to salvage vegetation, areas and species, timing, storage needs, and planting techniques. The revegetation plan will be driven by the scheduling of both mine site and compensation site construction to maximize the efficiency of salvage and transplant operations and minimize soil and vegetation exposure.

Two revegetation techniques commonly used in restoration activities include the use of dormant cuttings and transplants (Babakaiff, Hay, and Fromuth 1997).

Dormant cuttings are used in a variety of ways in restoration projects, and include live staking, brush layering, live siltation, brush mats, and bundles (fascines). Dormant cuttings can be harvested from living, woody plants during the winter/early spring (or during the fall if planting will occur in the fall), or can be purchased from nurseries. Cuttings are collected from plant species that root easily, such as willow, poplar, and cottonwood.

Live staking is often used in conjunction with other revegetation techniques, and is an inexpensive method of revegetating a site. It does, however, have a lower survival rate when compared to other revegetation techniques. Brush mats constructed of dormant branches provide both erosion control and vegetative cover to an area. They require large amounts of plant material, which will be considered prior to their inclusion in a revegetation design.

Transplanting involves the relocation of a plant, or plants, containing roots and shoots, from one area to another. Transplants can vary in size, from large vegetation mats, to smaller plugs, sprigs, and single-plant transplants. All types of transplants require careful handling to ensure success. Transplanting can be mechanized, depending on the size of material (e.g., vegetation mats). Transplanting is a suitable revegetation method used for species that do not root well from cuttings.

Vegetation mats can also be propagated in a greenhouse or outdoors. The benefit of vegetation mats is that they provide an instant plant cover and also help protect the site from soil erosion.

If the introduction of herbaceous vegetation to the area is a desired goal, then the use of a vegetation mat composed of native grasses or sedges will be considered. Similarly, grass and sedge species can be fashioned into a roll, held together with biodegradable fabric and twine (Babakaiff, Hay, and Fromuth 1997). When placed along the bank, the roll provides structural protection as well as an overhanging vegetative cover. Plugs and sprigs are smaller than vegetative mats and often contain only one plant species. They can be collected from a donor location or grown in a nursery or greenhouse environment.

6.2 COMPENSATION PROJECTS SUMMARY

6.2.1 Project Identification

Desktop analysis and field assessments were completed for the preliminary compensation projects (Table 6.2-1). For each site, habitat limitations and physical techniques to achieve the objectives are summarized and biological objectives are identified. The preliminary projects are located in three watershed physical settings: lake, off-channel/side channel, and mainstem. There are 4 lake littoral zone enhancement projects, 12 mainstem creation/enhancement projects, and 20 off-channel/side channel creation projects.

The locations of the preliminary projects are presented in Figures 6.2-1 and 6.2-2. The preliminary projects are located within 15 different watersheds: Teigen, Hodkin, Unuk, Gilbert, South Teigen, Snowbank, Treaty, East Todedada, Todedada, Glacier, Taft, Oweegee, Mere, Bowser, and Bell-Irving.

A summary of fish species and life history stages present at each preliminary project is presented in Table 6.2-2. Dolly Varden and coho salmon were the most common species present at the majority of compensation sites. The abundance and distribution of fish at specific preliminary compensation sites varied depending upon habitat limitations. Target habitat and species priorities were assigned to each preliminary compensation site based upon field assessment data and compensation concept techniques (Table 6.2-3). Target species-specific life history stages were identified for each preliminary compensation site.

Table 6.2-4 summarizes the existing physical environment conditions for each compensation site. Primary and secondary water sources (e.g., surface or ground water) are identified, including their magnitude and dependability. Potential concerns from flood risk, water and sediment quality, and obstructions were identified.

6.2.2 Project Screening

Each preliminary compensation project was screened according to a set of high level criteria (Table 6.2-5): DFO hierarchy for compensation, regional fisheries management objectives, inclusion of traditional knowledge, technical and economic feasibility, stability and permanence, and biological relevance.

DFO hierarchy for compensation was classified for each compensation site:

1. Replacing lost habitat with the same habitat in the same ecological unit.
2. Increasing the productive capacity of existing habitat with unlike habitat in the same ecological unit.
3. (a) Replacing lost habitat with like-for-like habitat in another ecological unit.
   (b) Replacing lost habitat with like-for-unlike habitat in another ecological unit.
4. Using artificial production (i.e., building hatcheries or fertilizing lakes).

The BC MOE has not developed regional fish and fish habitat objectives specifically relevant to the study area watersheds. The BC MOE has developed provincial fisheries management objectives for species other than migratory Pacific salmon (BC MOE 2010b) that were applied for the screening. These objectives broadly include:

- maintain healthy fish habitat;
- maintain or enhance indigenous fish populations;
- sustain water quality and use;
- effective management and stewardship of fish and wildlife species, ecosystems, and protected areas;
- shared stewardship with Aboriginal Groups to protect the environment; and
- increase and diversify angling opportunities for recreation and employment.

Similarly, DFO has not developed specific regional objectives for the study area watersheds. However, DFO is responsible for the management of migratory Pacific salmon; therefore, this was taken into consideration during the screening. In general, DFO habitat managers strive (pursuant to the *No Net Loss* guiding principle) to maintain the current productive capacity of fish habitat. This supports Canada's fishery resources, such that the habitat is able to produce fish suitable for human consumption (DFO 1998). In order to satisfy the *No Net Loss* guiding principle, the habitat manager's first priority is to avoid or reduce the project's potential for habitat loss through appropriate mitigation measures.

All preliminary compensation projects fulfilled DFO's and/or BC MOE's regional fisheries management objectives. The majority of projects included traditional knowledge and traditional land use information made available during fisheries working group meetings, and traditional knowledge and traditional land use reports prepared for the Project. Baseline studies were developed in consultation with aboriginal groups at working group meetings. Certain compensation sites lack traditional knowledge and traditional land use information because the compensation sites are outside of the study area boundaries. Future working groups meetings will incorporate traditional knowledge where possible. All projects are economically feasible, stable, and permanent. The majority of projects have the potential for multispecies benefit.

Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Teigen	-	Teigen Lake	1	Littoral zone lacks LWD rearing habitat and cover	Improve littoral zone rearing habitat cover by providing LWD	Simple, repeatable design concept. Add anchored LWD to increase overhead cover for fish rearing and refuge	8	-			X
Teigen	Hodkin	Hodkin Lake	1	Littoral zone lacks LWD rearing habitat and cover	Improve littoral zone rearing habitat cover by providing LWD	Simple, repeatable design concept. Add anchored LWD to increase overhead cover for fish rearing and refuge	8	-			X
Unuk	-	Unuk Lake	1	Littoral zone lacks LWD rearing habitat and cover	Improve littoral zone rearing habitat cover by providing LWD	Simple, repeatable design concept. Add anchored LWD to increase overhead cover for fish rearing and refuge	8	-			X
Treaty	Gilbert	Gilbert Lake	1	Littoral zone lacks LWD rearing habitat and cover	Improve littoral zone rearing habitat cover by providing LWD	Simple, repeatable design concept. Add anchored LWD to increase overhead cover for fish rearing and refuge	8	-			X
Teigen	Hodkin	Hodkin Lake Creek 1	2	Inlet creek lacks suitable spawning substrate. Low densities of mature Dolly Varden present in Hodkin Lake. Hodkin Lake productivity limited by abundance and quality suitable spawning substrate	Improve poor quality spawning habitat and increase spawning habitat by providing suitable spawning substrate and channel complexity in lower reach of creek	Add suitable spawning gravels and gravel retention structures to increase amount of good quality spawning habitat	7	-		X	
Teigen	Hodkin	Hodkin Lake Creek 2	3	Inlet creek lacks suitable spawning substrate. Low densities of mature Dolly Varden present in Hodkin Lake. Hodkin Lake productivity limited by abundance and quality suitable spawning substrate	Improve poor quality spawning habitat and increase spawning habitat by providing suitable spawning substrate and channel complexity in lower reach of creek	Add suitable spawning gravels and gravel retention structures to increase amount of good quality spawning habitat	7	-		X	
Teigen	-	Teigen Creek	3	Upper reaches of Teigen Creek dominated by cascade-pool morphology with coarse bed substrates, high velocity, and limited pool habitat. Low densities of Chinook salmon fry and low abundance of Chinook salmon spawning habitat present in upper reaches compared to mid and lower reaches. Upper reaches lacks suitable velocity refuge and rearing habitat cover, abundance and quality of suitable spawning habitat, and abundant and quality pool overwintering habitat.	Improve existing poor and fair quality summer rearing habitat velocities and overwintering habitat in upper reaches by creating pool and cover habitat. Improve poor quality spawning habitat at tailouts of pools	Repeatable design concept in appropirate hydralic conditions. Build rock riffles to backwater cascade habitat sequences to provide suitable rearing velocities, improve overwintering habitat, and create spawning habitat at pool tailouts. Add overhead cover and instream boulder clusters to improve rearing and overwintering habitat complexity.	4	5		X	
Teigen	South Teigen	South Teigen Creek	1	Lower reach of South Teigen Creek dominated by cascade habitat with coarse bed substrates, high velocity, and limited pool habitat. Creek lacks channel complexity. Lower reach lacks suitable velocity refuge and rearing habitat, suitable spawning habitat, and quality pool overwintering habitat.	Improve existing poor quality summer rearing habitat velocities and overwintering habitat in lower reach by creating pool and cover habitat. Improve poor quality spawning habitat	Repeatable design concept in appropirate hydralic conditions. Build rock riffles to backwater cascade habitat sequences and sort bed substrates to provide suitable rearing velocities, improve overwintering habitat, and create spawning habitat by retaining gravels. Add overhead cover, LWD and instream boulder clusters to improve rearing and overwintering habitat complexity.	4	5		X	
Teigen	Snowbank	Snowbank Creek	1	Reach downstream of open-water wetland and Redflat Creek is dominated by riffle-run habitat with gravel-cobble substrates, low abundance of funcitional LWD, and limited pool frequency. Creek lacks channel complexity to provide a diveristy of rearing, spawning and overwintering habitat.	Increase the abundance of functional LWD within the channel which will improve the diversity of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting	Add anchored LWD complexes to enhance rearing habitat, create pools and spawning habitat	4	5		X	
Teigen	-	Teigen Creek	1	Majority of off-channel within the Teigen Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Poor quality off-channel habitat is limiting the productive capacity for summer rearing and overwintering habitat. Availability of good spawning habitat to seed off-channel and side-channel habitat is limited.	Improve and create overwintering and rearing habitat in off-channel areas by modifying existing beaver ponds. Create series of deep ponds with LWD cover and connecting channels to ponds and side-channel habitats. Provide fish access to ponds.	Complex design. Intercept exisiting hillside stream for water supply to construct impermeable berms to backwater a series of deep ponds. Add anchored LWD complexes to ponds. Add SWD and overhanging cover, as required. Connect ponds to each other and side-channel/mainstem through excavation of channel. Create channel complexity through the addition of LWD structures, gravel placement and gravel retention structures. Incorporate channels to allow fish access around/through ponds.	1	3,6,9	X		
Teigen	-	Teigen Creek	2	Functional side-channel habitat within the Teigen Creek floodplain is limited in abundance. Poor quality and/or inaccessible side-channel habitat is limiting the productive capacity for summer rearing and overwintering habitat. Availability of good spawning habitat to seed side-channel habitat is limited.	Improve existing side-channel rearing and overwintering habitat in off-channel areas by adding LWD complexes. Extend existing side-channel to increase the amount of rearing and over-wintering habitat. Addition of functional LWD within the channel tol improve the diversity of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting	Complex design. Construct water intake control structure at entry of side-channel. Excavate extension of side-channel. Create chanel complexity by adding anchored LWD complexes. Provide low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades.	2	3	X		

(continued)

Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Teigen	-	Teigen Creek	4	Majority off-channel habitat within the Teigen Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Off-channel habitat is accessible to fish limiting the productive capacity for summer rearing and overwintering. Fair quality off-channel habitat lacks LWD structure and complexity.	Improve fish passage past beaver dams to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Install beaver dam bypass channel to allow fish movement. Improve fish cover by adding cabled LWD complexes to ponds. Re-enforce beaver dams by berming dam materials.	1	9,6	X		
Treaty	-	Treaty Creek	1	Majority of off-channel habitat within the Treaty Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Poor quality rearing and overwintering habitat is present at the site. Relic beaver ponds lack complexity, water depth and fish accessibility. Availability of good spawning habitat to seed off-channel habitat is lacking.	Create overwintering and rearing habitat. Create series of deep ponds with LWD cover and connecting channels to ponds. Create spawning habitat and complexity within channel. Provide fish access to ponds.	Complex design. Divert portion of surface water from North Treaty Creek for water source. Contruct water intake control structure on North Treaty Creek. Construct berms to back up water and create a series of ponds. Excavate channels to connect ponds to each other, North Treaty Creek, and Treaty Creek. Create low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades.	1	6,9	X		
Treaty	-	Treaty Creek	2	Majority off-channel habitat within the Treaty Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Poor quality stream and small relic beaver dams present within the floodplain is limited in productive capacity for summer rearing and overwintering habitat. Relic beaver ponds lack complexity, water depth and fish accessibility. Availability of good spawning habitat to seed off-channel habitat is lacking.	Create overwintering and rearing habitat. Create series of deep ponds with LWD cover and connecting channels to ponds. Create spawning habitat and complexity within channel. Provide fish access to ponds.	Complex design. Intercept exisiting lake-source stream for water supply to construct impermeable berms to backwater a series of deep ponds. Add cabled LWD complexes to ponds. Add SWD and overhanging cover, as required. Connect ponds to each other and Treaty Creek through excavation of channel. Create channel complexity through the addition of LWD structures, gravel placement and gravel retention structures. Incorporate channels to allow fish access around/through ponds.	1	6,9	X		
Treaty	-	Treaty Creek	3	Majority off-channel habitat within the Treaty Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Good quality beaver pond present within the floodplain with lake-source stream for water supply. Beaver ponds limited in productive capacity for summer rearing and overwintering habitat because of fish in-accessibility to Treaty Creek.	Improve fish passage past beaver dams to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Install beaver dam bypass channels to allow fish movement. Improve fish cover by adding cabled LWD complexes to ponds. Re-enforce beaver dams by berming dam materials.	1	9,6	X		
Treaty	Gilbert	Gilbert Creek	1	Fish inaccessibility upstream of large beaver dam. Good quality rearing, overwintering and spawning habitat downstream of beaver dam. Fair quality rearing habitat, poor quality overwintering and spawning habitat upsteam of beaver dam. Lack of pool habitat, embedded gravel substrates, and low frequency of functional LWD frequency. Gilbert Creek prone to flood risk from glacial tributary.	Improve fish passage past beaver dam to enable adult migration to upstream reaches and seed under-utlized rearing habitat. Addition of functional LWD within the channel to improve the diversity of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting.	Breach dams, beaver fencing, riparian management. Create channel complexity through the addition of anchored LWD complexes. Construct berm between Gilbert Creek and glacial tributary to protect high value creek.	3,4,9	6		X	
Treaty	Gilbert	Gilbert Creek	2	Fish inaccessibility upstream of large beaver dam. Abundant, high value littoral zone rearing habitat within Gilbert Lake. Lack of suitable and sufficient spawning habitat to seed lake littoral zone with Coho salmon parr.	Create groundwater spawning and fry rearing channel to seed under-utilized lake littoral parr rearing habitat. Addition of functional LWD to add channel complexity.	Excavate groundwater channel from West Todedada Creek fan towards Gilbert Lake mouth. Create channel complexity through addition of anchored LWD complexes, gravel placement, and gravel retention structures.	7	2,9	X		
Treaty	Todedada	East Todedada Creek	1	Upper reach of East Todedada Creek lacks cover for rearing fry and parr, no functional LWD, composed of a high proportion of riffle-run habitats with low pool frequency for overwintering. Good spawning habitat is localized. Majority of gravels are embedded and and spawning habitat is underutilized throughout the upper reach.	Improve mainstem rearing, overwintering and spawning habitat. Addition of functional LWD within the mainstem to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting.	Create channel complexity through the addition of anchored LWD complexes at suitable locations. Add anchored LWD to existing barren pools to enhance overwintering and rearing habitat.	4	5		X	

(continued)

Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Treaty	Todedada	East Todedada Creek	2	Off-channel wetland habitat lacks overwintering habitat cover. Existing beaver dams restrict adult fish passage, smolt emigration, and fish movement.	Improve overwintering habitat cover with LWD.	Improve fish cover by adding cabled LWD complexes to wetlands.	1	-	X		
Treaty	Todedada	East Todedada Creek	3	Lower reach of East Todedada Creek lacks depth and velocity characteristics for summer rearing fish. Slough, backwater glide habitat created by small check beaver dams. LWD and cover for rearing fish absent.	Improve velocity and depth profile for summer rearing fish in select locations by increasing channel complexity. Add LWD complexes within glide habitat to add cover for summer rearing fish.	Remove a selection of small beaver check dams and replacing with anchored LWD and boulders covering a proportion of the stream cross-sectional area. Create deeper backwater areas to generate elevational drop and ideal velocity and depth profile. Add anchored LWD to glide habitat.	4	-		X	
Treaty	Todedada	Todedada Creek	1	Middle to upper reaches of Todedada Creek lack good rearing habitat, no functional LWD, composed of a high proportion of riffle-run habitats, high velocity flows during summer rearing, low pool frequency with no cover. Abundant spawning gravels are present, however spawning habitat is underutilized.	Improve mainstem rearing, overwintering and spawning habitat. Addition of functional LWD within the mainstem to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting. Add boulder clusters for cover in proper hydraulic sites.	Create channel complexity through the addition of anchored LWD complexes at suitable locations. Add anchored LWD to existing barren pools to enhance overwintering and rearing habitat. Add boulder clusters of proper size and location.	4	5		X	
Treaty	Todedada	Todedada Creek	2	Middle reach of Todedada Creek lack good spawning habitat, no functional LWD, composed of a high proportion of riffle-run habitats, high velocity flows during summer rearing, low pool frequency with no cover. Tribuatry of Todedada Creek provides good overwintering habitat that is underutilized.	Create new off-channel spawning and rearing habitat in a blind groundwater channel along West Todedada Creek fan. Add LWD and spawning substrate. Create pools, riffles and alcove ponds. Direct channel towards existing overwintering habitat along valley floor.	Excavate groundwater channel along fan and complex with LWD, gravel, and gravel retention structures.	1	2,9	X		
Bell-Irving	Glacier	Glacier Creek	1	Lower reach of Glacier Creek, downstream of culvert, is dominated by cascade habitats, lacks suitable rearing habitat for juvenile fish, with poor quality spawning and overwintering habitat. High channel gradient and high velocity unsuitable for fry and parr rearing, and adult spawning.	Create low gradient side channel to provide rearing and overwintering habitat, with spawning habitat benefits. Add LWD and boulders to create a channel complexity and cover.	Complex design. Construct water intake control structure at entry of side-channel. Excavate side-channel. Create chanel complexity by adding anchored LWD complexes and boulders. Provide low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades.	2	9	X		
Bell-Irving	Taft	Taft Creek	1	Lower reach of Taft Creek, downstream of brudge, is dominated by cascade habitats, lacks suitable rearing habitat for juvenile fish, with poor quality spawning habitat. High channel gradient and high velocity mainstem unsuitable for fry and parr rearing, and adult spawning.	Create low gradient side channel with alcove ponds to provide rearing, spawning habitat, with overwintering habitat benefits. Add LWD and boulders to create a channel complexity and cover.	Complex design. Construct water intake control structure at entry of side-channel. Excavate side-channel. Create chanel complexity by adding anchored LWD complexes and boulders. Provide low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades. Excavate alcove ponds.	2	9	X		
Bell-Irving	Taft	Taft Creek	2	Off-channel habitat within lower reach of Taft Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Good quality off-channel habitat is inaccessible to fish limiting the productive capacity for summer rearing and overwintering.	Improve fish passage past beaver dam to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Complex design. Construct water intake control structure at entry of off-channel. Excavate side-channel. Create chanel complexity by adding anchored LWD complexes and boulders. Provide low gradient channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover along with small riffles/cascades. Improve fish cover by adding cabled LWD complexes to ponds.	1	9,6	X		
Bell-Irving	-	Bell-Irving River	1	Functional off-channel pond habitat adjacent to the Bell-Irving River is in limited supply. Groundwater source off-channel pond at site has shallow water depth and beaver dam restricts fish passage.	Improve poor quality overwintering habitat by increasing water depth. Allow for juvenile fish passage. Add LWD complexes to pond to create summer rearing and overwintering cover. Increase productive capacity of groundwater pond	Create berm to backup water and increase depth of pond. Install beaver dam bypass channel to allow fish movement. Improve fish cover by adding cabled LWD complexes to pond.	1	6	X		
Bell-Irving	Oweegee	Oweegee Creek	1	Lower reach of Oweegee Creek lacks good rearing habitat and spawning habitat, low frequency of functional LWD, composed of a high proportion of riffle-run habitats, and low pool frequency.	Improve mainstem rearing, overwintering and spawning habitat. Addition of functional LWD within the mainstem to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting. Add boulder clusters for cover in proper hydraulic sites.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	4	-		X	

(continued)

Table 6.2-1. Habitat Constraints and Objectives for Compensation Sites (completed)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Habitat Constraint / Limitation	Compensation Project		Primary Concept Number	Secondary Concept Number(s)	Physical Setting		
					Biological Objectives	Physical Techniques			Off-Channel / Side-Channel	Mainstem	Lake
Bell-Irving	Oweegee	Oweegee Creek	2	Side-channel fed by Oweegee Creek baseflow with seasonal influence from Bell-Irving River mainstem. Channel provides low abundance of spawning habitat, provides poor rearing habitat in low velocity glide habitat with no cover, and provides low abundance of overwintering habitat.	Increase the abundance and quality of spawning habitat. Addition of functional LWD within the side-channel to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting.	Construct water control structure at entry of side-channel with Bell-Irving River. Create chanel complexity by adding anchored LWD complexes, boulders and constricting channel width. Create channel with complex hydraulics (e.g. shear zones, eddies, refuges) using boulder and wood cover.	3	2,1	X		
Bell-Irving	Mere	Mere Creek	1	Mere Creek lacks pools for overwintering and abundant gravel for spawning.	Improve poor quality overwintering habitat and poor quality spawning habitat.	Create pools by backwatering with rock riffles or using lateral wood structures to scour riffles/glides into pools; add wood debris and coarse substrate for cover. Add gravel and/or gravel rentention structures to improve abundance and quality of spawning area.	4	7		X	
Bowser	-	Bowser River	1	Off-channel habitat within Bowser River Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Good quality off-channel habitat is inaccessible to fish limiting the productive capacity for summer rearing and overwintering.	Improve fish passage past beaver dam to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Install beaver dam bypass channel to allow fish movement. Improve fish cover by adding cabled LWD complexes to ponds. Re-enforce beaver dams by berming dam materials.	1	6,9	X		
Bowser	-	Bowser River	2	Off-channel habitat within Bowser River Creek floodplain is inaccessible to fish, limited in supply, and has a low productive capacity. Good quality off-channel habitat is inaccessible to fish limiting the productive capacity for summer rearing and overwintering.	Improve fish passage past beaver dam to enable dispersal of fry and parr into existing but under-utilized habitat. Add LWD complexes to beaver ponds to create summer rearing and overwintering cover. Increase productive capacity of beaver ponds.	Install beaver dam bypass channel to allow fish movement. Improve fish cover by adding cabled LWD complexes to ponds. Re-enforce beaver dams by berming dam materials.	1	6,9	X		
Bowser	-	Bowser River	3	Lower reach of Unnamed Creek, downstream of beaver pond complex, lacks good summer rearing habitat and spawning habitat, low frequency of functional LWD, composed of a high proportion of riffle-run habitats, and low pool frequency.	Improve mainstem rearing and spawning habitat. Addition of functional LWD within the mainstem to improve the diversity and cover of rearing habitat, cause bed scour for pool and overwintering habitat creation, and improve spawning habitat through bed scour and gravel sorting.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	4	-		X	
Bell-Irving	-	Bell-Irving River	1	Bell-Irving River side channels provide seasonal rearing habitat during moderate/high flows, but are generally not active during the fall through spring. The side channels lack deep overwintering pools in association with LWD.	Enhance or create deep scour pools and associated LWD structures to provide overwintering pools and improved rearing habitat complexity at high flows.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	2	-	X		
Bell-Irving	-	Bell-Irving River	2	Bell-Irving River side channels provide seasonal rearing habitat during moderate/high flows, but are generally not active during the fall through spring. The side channels lack deep overwintering pools in association with LWD. Clear tributary discharges into side channel provide realiable water source.	Enhance or create deep scour pools and associated LWD structures to provide overwintering pools and improved rearing habitat complexity at high flows.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	2	-	X		
Bell-Irving	-	Bell-Irving River	3	Bell-Irving River side channels provide seasonal rearing habitat during moderate/high flows, but are generally not active during the fall through spring. The side channels lack deep overwintering pools in association with LWD. Overwintering channel lacks functional LWD.	Enhance or create deep scour pools and associated LWD structures to provide overwintering pools and improved rearing habitat complexity at high flows.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	2	-	X		
Bell-Irving	-	Bell-Irving River	4	Bell-Irving River side-channels provide seasonal rearing during moderate and high flows but generally cease flowing in the fall through spring. The side-channels generally lack deep overwintering pools in association with woody debris. Lower 250 m of channel provides overwintering habitat, but lacks LWD cover.	Enhance or create deep scour pools and associated LWD structures to provide overwintering pools and improved rearing habitat complexity at high flows.	Create channel complexity through the addition of anchored LWD complexes at suitable locations.	2	-	X		

Dashes indicate not applicable

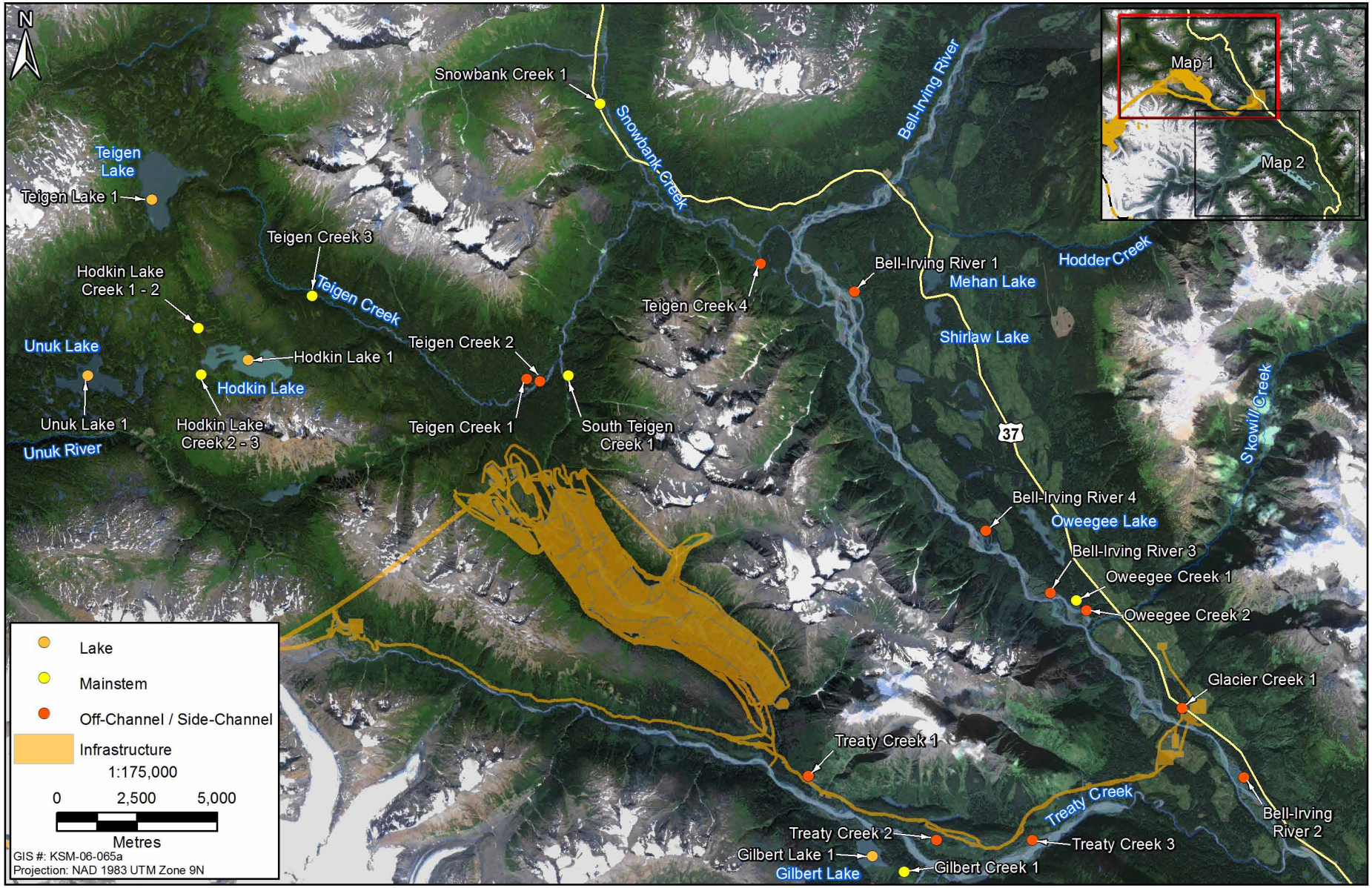


Figure 6.2-1

SEABRIDGE GOLD
KSM PROJECT

Location of Compensation Projects - Map 1

Figure 6.2-1

Rescan
Engineers & Scientists



Figure 6.2-2

SEABRIDGE GOLD
KSM PROJECT

Location of Compensation Projects - Map 2

Figure 6.2-2

Rescan
Engineers & Scientists

Table 6.2-2. Species and Life History Stages Present at Compensation Sites

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Species and Life Stage Present																				
					Dolly Varden			Bull Trout			Rainbow Trout / Steelhead			Coho Salmon				Chinook Salmon			Sockeye Salmon			Mountain Whitefish		
					Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr(1+)	Parr(2+)	Adult	Fry	Parr(1+)	Adult	Fry	Parr	Adult	Fry	Parr	Adult
Treaty	-	Treaty Creek	1	Off-channel pond creation			X						X												
Treaty	-	Treaty Creek	3	Off-channel pond fish passage enhancement	X	X	X																		
Treaty	-	Treaty Creek	2	Off-channel pond creation	X	X	X																		
Teigen	-	Teigen Creek	4	Off-channel pond fish passage enhancement										X	X	X		X							
Teigen	-	Teigen Creek	1	Off-channel pond creation and fish passage enhancement	X	X	X					X		X	X	X									
Treaty	Todedada	East Todedada Creek	2	Off-channel pond fish passage enhancement		X	X							X	X	X									
Bell-Irving	Glacier	Glacier Creek	1	Side channel habitat creation	0	X	X						X	X			X								
Bell-Irving	Taft	Taft Creek	1	Off-channel pond complex	X	X	X	X	X	X	X	X	X	X	0		X	X		X				X	X	X
Bell-Irving	Taft	Taft Creek	2	Off-channel pond complex and fish passage enhancement			X							X	X										
Bell-Irving	-	Bell-Irving River	1	Off-channel pond creation and fish passage enhancement			X								X	X									
Bowser	-	Bowser River	1	Off-channel pond fish passage enhancement																					
Bowser	-	Bowser River	2	Off-channel pond fish passage enhancement			X							X											
Teigen	-	Teigen Lake	1	Littoral zone LWD enhancement	0	0	X	0	0	X	0	0	X					0		X				0	0	X
Teigen	Hodkin	Hodkin Lake	1	Littoral zone LWD enhancement	X	X	X																		
Unuk	-	Unuk Lake	1	Littoral zone LWD enhancement	X	X	X																		
Treaty	Gilbert	Gilbert Lake	1	Littoral zone LWD enhancement	0	0	X	0	0	X	0	0	X											0	0	X
Teigen	Hodkin	Hodkin Lake Creek 1	2	Stream spawning habitat creation	X	X	X																		

(continued)

Table 6.2-2. Species and Life History Stages Present at Compensation Sites (completed)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Species and Life Stage Present																				
					Dolly Varden			Bull Trout			Rainbow Trout / Steelhead			Coho Salmon				Chinook Salmon			Sockeye Salmon			Mountain Whitefish		
					Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr(1+)	Parr(2+)	Adult	Fry	Parr(1+)	Adult	Fry	Parr	Adult	Fry	Parr	Adult
Teigen	Hodkin	Hodkin Lake Creek 2	3	Stream spawning habitat creation	X	X	X																		
Bowser	-	Bowser River	3	Mainstem LWD and pool enhancement	X	X	X				X	X	0	X			x								
Teigen	-	Teigen Creek	3	Mainstem pool habitat creation	X	X	X	X	X	X	X	X	X	X	X	0	X	X	0	X	0		X	X	X	X
Teigen	South Teigen	South Teigen Creek	1	Mainstem pool habitat creation	X	X	X	X	X	X		X												0	X	X
Teigen	Snowbank	Snowbank Creek	1	Mainstem pool habitat creation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	0	X				0	X	X
Teigen	-	Teigen Creek	2	Side channel habitat enhancement and creation	X	X	X				0	X		X	0		X	X		X						
Treaty	Gilbert	Gilbert Creek	1	Mainstem pool habitat creation and fish passage enhancement	Z	Z	Z				X	X	x	Y	Y		Y	Y		Y				Z	Z	Z
Treaty	Todedada	East Todedada Creek	1	Mainstem LWD and pool enhancement	X	X	X							X	0		X									
Treaty	Todedada	East Todedada Creek	3	Mainstem LWD and pool enhancement	X	X	X							X	0		X				Y		Y			
Treaty	Todedada	Todedada Creek	1	Mainstem LWD, boulder and pool enhancement	X	X	X		X	0			0	X	0	0	X	0	X	0	0		X	0	0	X
Bell-Irving	Oweegee	Oweegee Creek	1	Mainstem LWD and pool enhancement	X	X	X	0	0	X	X	X	0	X	X	0	X	0		X	0		X	0	X	X
Bell-Irving	Oweegee	Oweegee Creek	2	Side channel LWD and pool enhancement						X	X	0	0	X	0	0	X	X		X	0		X	0	0	0
Bell-Irving	Mere	Mere Creek	1	Mainstem pool habitat creation	X	X	X				X	0	0	X	X		X									
Bell-Irving	-	Bell-Irving River	1	Side channel LWD and pool enhancement										X	X			X						X	X	
Bell-Irving	-	Bell-Irving River	2	Side channel LWD and pool enhancement								X		X	X			X	X							
Bell-Irving	-	Bell-Irving River	3	Side channel LWD and pool enhancement										X				X						X	X	
Bell-Irving	-	Bell-Irving River	4	Side channel LWD and pool enhancement								X						X						X		

Dashes indicate not applicable

X' indicates species and life history stage confirmed present through fieldwork or FDIS data

O' indicates species life history stage assumed to be present given site-specific habitat

Y' indicates species only present downstream of 1st beaver dam

Z' indicates species only present downstream of 1st beaver dam and within lake

Table 6.2-3. Target Habitat, Species, and Life History Stage Priorities for Compensation Sites

					Target Habitat Priorities				Target Species Priorities					
Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Spawning	Rearing	Overwintering	Migration	Dolly Varden	Bull Trout	Rainbow Trout / Steelhead	Coho Salmon	Chinook Salmon	Sockeye Salmon
Teigen	-	Teigen Lake	1	Littoral zone LWD enhancement		1			2	1	3			
Teigen	Hodkin	Hodkin Lake	1	Littoral zone LWD enhancement		1			1					
Unuk	-	Unuk Lake	1	Littoral zone LWD enhancement		1			1					
Treaty	Gilbert	Gilbert Lake	1	Littoral zone LWD enhancement		1			2	3	4	1		
Teigen	Hodkin	Hodkin Lake Creek 1	2	Stream spawning habitat creation	1	2			1					
Teigen	Hodkin	Hodkin Lake Creek 2	3	Stream spawning habitat creation	1	2			1					
Teigen	-	Teigen Creek	3	Mainstem pool habitat creation	3	2	1			3	2		1	
Teigen	South Teigen	South Teigen Creek	1	Mainstem pool habitat creation	3	2	1		1	2				
Teigen	Snowbank	Snowbank Creek	1	Mainstem pool habitat creation	3	2	1		5	3	2	4	1	
Teigen	-	Teigen Creek	1	Off-channel pond creation and fish passage enhancement	4	2	1	3	2		3	1		
Teigen	-	Teigen Creek	2	Side channel habitat enhancement and creation	4	2	1	3	2	3	4	1	5	
Teigen	-	Teigen Creek	4	Off-channel pond fish passage enhancement		3	1	2	2			1		
Treaty	-	Treaty Creek	1	Off-channel pond creation	4	2	1	3	1		3	2		
Treaty	-	Treaty Creek	2	Off-channel pond creation	4	2	1	3	2		3	1		
Treaty	-	Treaty Creek	3	Off-channel pond fish passage enhancement		2	1	3	2		3	1		
Treaty	Gilbert	Gilbert Creek	1	Mainstem pool habitat creation and fish passage enhancement	4	3	2	1	4	3	2	1	5	
Treaty	Gilbert	Gilbert Creek	2	Groundwater spawning channel creation	1	2				3	2	1		
Treaty	Todedada	East Todedada Creek	1	Mainstem LWD and pool enhancement	3	2	1		2			1		
Treaty	Todedada	East Todedada Creek	2	Off-channel pond enhancement		3	2		2			1		
Treaty	Todedada	East Todedada Creek	3	Mainstem LWD and pool enhancement	3	1	2		2			1		3
Treaty	Todedada	Todedada Creek	1	Mainstem LWD, boulder and pool enhancement	3	2	1		3	4		2	1	
Treaty	Todedada	Todedada Creek	2	Groundwater spawning channel creation	1	2	3		2	3		1	4	

(continued)

Table 6.2-3. Target Habitat, Species, and Life History Stage Priorities for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Target Habitat Priorities				Target Species Priorities					
					Spawning	Rearing	Overwintering	Migration	Dolly Varden	Bull Trout	Rainbow Trout / Steelhead	Coho Salmon	Chinook Salmon	Sockeye Salmon
Bell-Irving	Glacier	Glacier Creek	1	Side channel habitat creation	3	1	2		1		2	3		
Bell-Irving	Taft	Taft Creek	1	Side channel and alcove pond habitat creation	4	2	1	3	2	4		1	3	
Bell-Irving	Taft	Taft Creek	2	Off-channel pond fish passage enhancement	4	2	1	3	2			1		
Bell-Irving	-	Bell-Irving River	1	Off-channel pond creation and fish passage enhancement		3	2	1	2			1		
Bell-Irving	Oweegee	Oweegee Creek	1	Mainstem LWD and pool enhancement	3	2	1			3	1	2		
Bell-Irving	Oweegee	Oweegee Creek	2	Side channel LWD and pool enhancement	1	2	3			5	4	3	1	2
Bell-Irving	Mere	Mere Creek	1	Mainstem pool habitat creation	3	2	1		2		3	1		
Bowser	-	Bowser River	1	Off-channel pond fish passage enhancement		3	2	1	2		3	1		
Bowser	-	Bowser River	2	Off-channel pond fish passage enhancement		3	2	1	2		3	1		
Bowser	-	Bowser River	3	Mainstem LWD and pool enhancement	3	2	1		3		2	1		
Bell-Irving	-	Bell-Irving River	1	Side channel LWD and pool enhancement		2	1					1	2	
Bell-Irving	-	Bell-Irving River	2	Side channel LWD and pool enhancement		2	1					1	2	
Bell-Irving	-	Bell-Irving River	3	Side channel LWD and pool enhancement		2	1					1	2	
Bell-Irving	-	Bell-Irving River	4	Side channel LWD and pool enhancement		2	1					1	2	

(continued)

Table 6.2-3. Target Habitat, Species, and Life History Stage Priorities for Compensation Sites (continued)

	Target Species and Life Stage																	
	Dolly Varden			Bull Trout			Rainbow Trout / Steelhead			Coho Salmon			Chinook Salmon			Sockeye Salmon		
Watershed	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult
Teigen	X	X		X	X		X	X										
Teigen	X	X																
Unuk	X	X																
Treaty	X	X		X	X		X	X		X	X							
Teigen	X		X															
Teigen	X		X															
Teigen				X	X	X	X	X	X				X	X	X			
Teigen	X	X	X	X	X	X												
Teigen	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Teigen	X	X	X				X	X		X	X	X						
Teigen	X	X	X	X	X	X	X	X		X	X	X	X		X			
Teigen	X	X	X							X	X							
Treaty	X	X	X				X	X		X	X	X						
Treaty	X	X	X				X	X		X	X	X						
Treaty	X	X	X				X	X		X	X							
Treaty	X	X	X	X	X	X	X	X	X	X	X	X	X		X			
Treaty				X		X	X		X	X		X						
Treaty	X	X	X							X	X	X						
Treaty	X	X	X							X	X	X						
Treaty	X	X	X							X	X	X				X		X
Treaty	X	X	X	X	X	X				X	X	X	X		X			
Treaty	X	X	X	X	X	X				X		X	X		X			

(continued)

Table 6.2-3. Target Habitat, Species, and Life History Stage Priorities for Compensation Sites (completed)

	Target Species and Life Stage																	
	Dolly Varden			Bull Trout			Rainbow Trout / Steelhead			Coho Salmon			Chinook Salmon			Sockeye Salmon		
Watershed	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult	Fry	Parr	Adult
Bell-Irving	X	X	X				X	X	X	X	X	X						
Bell-Irving				X	X	X	X	X	X	X	X	X	X		X			
Bell-Irving	X	X	X							X	X							
Bell-Irving	X	X	X							X	X							
Bell-Irving				X	X	X	X	X	X	X	X	X						
Bell-Irving					X	X	X	X		X	X		X		X	X		X
Bell-Irving	X	X	X				X	X		X	X	X						
Bowser	X	X	X					X	X	X	X							
Bowser	X	X	X					X	X	X	X							
Bowser	X	X	X				X	X	X	X	X	X						
Bell-Irving										X	X		X	X				
Bell-Irving										X	X		X	X				
Bell-Irving										X	X		X	X				
Bell-Irving										X	X		X	X				

Dashes indicate not applicable

Table 6.2-4. Existing Physical Environment Conditions for Compensation Sites

					Physical Environment								
Watershed	Sub-Watershed	Waterbody	Watershed Site Number	Compensation Project Type	Primary Watersource	Secondary Watersource	Water Supply Magnitude	Surface Water Supply Dependability	Flood Risk	Water Quality Concerns	Sediment Supply Concerns	Gradient	Obstructions
Teigen	-	Teigen Lake	1	Littoral zone LWD enhancement	SW	-	-	-	-	N	N	-	-
Teigen	Hodkin	Hodkin Lake	1	Littoral zone LWD enhancement	SW	-	-	-	-	N	N	-	-
Unuk	-	Unuk Lake	1	Littoral zone LWD enhancement	SW	-	-	-	-	N	N	-	-
Treaty	Gilbert	Gilbert Lake	1	Littoral zone LWD enhancement	SW	-	-	-	-	N	N	-	-
Teigen	Hodkin	Hodkin Lake Creek 1	2	Stream spawning habitat creation	SW	GW Minor	L	L Low winter flows	L	N	L Low energy stream and low gravel recruitment	L	N
Teigen	Hodkin	Hodkin Lake Creek 2	3	Stream spawning habitat creation	SW	GW Minor	L	L Low winter flows	L	N	L Low energy stream and low gravel recruitment	L	N
Teigen	-	Teigen Creek	3	Mainstem pool habitat creation	SW	-	H	H Lake headwater	M Teigen Creek mainstem	N	N	L/M	N
Teigen	South Teigen	South Teigen Creek	1	Mainstem pool habitat creation	SW	-	M	H	M South Teigen Creek mainstem	N	N	M	N
Teigen	Snowbank	Snowbank Creek	1	Mainstem pool habitat creation	SW	-	H	H Large headwater wetland	M Snowbank Creek mainstem	Y High turbidity	Y High sediment load from Redflat Creek	L/M	N
Teigen	-	Teigen Creek	1	Off-channel pond creation and fish passage enhancement	SW	GW	L	L Low winter flows, Groundwater supply dependable	L	N	N	L	Y Beaver dams

(continued)

Dashes indicate not applicable

Primary and Secondary Watersource: SW = surface water, GW = groundwater

Water Supply Magnitude: L = Low

Surface Water Supply Dependability: L = Low, M = Moderate, H = High

Flood Risk: L = Low, M = Moderate, H = High

Water Quality Concerns: Y = Yes, N = No, P = Probable

Sediment Supply Concerns: N = None, L = Low, M = Moderate, H = High

Gradient: L = Low (0 - 2%), M = Moderate (3 - 5%), H = High (> 6%)

Obstructions: Y = Yes, N = No

DO = dissolved oxygen

Table 6.2-4. Existing Physical Environment Conditions for Compensation Sites (continued)

					Physical Environment								
Watershed	Sub-Watershed	Waterbody	Watershed Site Number	Compensation Project Type	Primary Watersource	Secondary Watersource	Water Supply Magnitude	Surface Water Supply Dependability	Flood Risk	Water Quality Concerns	Sediment Supply Concerns	Gradient	Obstructions
Teigen	-	Teigen Creek	2	Side channel habitat enhancement and creation	SW	GW	M	M Supply determined by mobility of Teigen Creek bed at inlet	M Direct connection to Teigen Creek mainstem	N	N	L	Y Beaver dams
Teigen	-	Teigen Creek	4	Off-channel pond fish passage enhancement	SW	GW	L	H	M Potential for Teigen Creek influence upstream of site	P Possible low winter DO	N	L	Y Beaver dams
Treaty	-	Treaty Creek	1	Off-channel pond creation	GW	SW Minor	L	L Groundwater supply dependable	L	P Possible low winter DO	N	L	Y Beaver dams
Treaty	-	Treaty Creek	2	Off-channel pond creation	SW	GW	L	H Lake headwater	L	P Possible low winter DO	N	L	Y Beaver dams
Treaty	-	Treaty Creek	3	Off-channel pond fish passage enhancement	SW	GW	L	H Lake and wetland headwater	L	P Possible low winter DO	N	L	Y Beaver dams
Treaty	Gilbert	Gilbert Creek	1	Mainstem pool habitat creation and fish passage enhancement	SW	GW	L	H Lake headwater, High groundwater table	M Flood risk from West Todedada Creek	N	N	L	Y Beaver dams
Treaty	Gilbert	Gilbert Creek	2	Groundwater spawning channel creation	GW	-	L	H	N	N	N	L	N
Treaty	Todedada	East Todedada Creek	1	Mainstem LWD and pool enhancement	SW	GW	L	H Large groundwater source	M Flood risk from Todedada Creek	N	N	L	N
Treaty	Todedada	East Todedada Creek	2	Off-channel pond enhancement	SW	GW	L	H Large groundwater source	N	N	N	L	Y Beaver dams
Treaty	Todedada	East Todedada Creek	3	Mainstem LWD and pool enhancement	SW	GW	L	H Large groundwater source	N	N	N	L	Y Beaver dams

(continued)

Dashes indicate not applicable

Primary and Secondary Watersource: SW = surface water, GW = groundwater

Water Supply Magnitude: L = Low

Surface Water Supply Dependability: L = Low, M = Moderate, H = High

Flood Risk: L = Low, M = Moderate, H = High

Water Quality Concerns: Y = Yes, N = No, P = Probable

Sediment Supply Concerns: N = None, L = Low, M = Moderate, H = High

Gradient: L = Low (0 - 2%), M = Moderate (3 - 5%), H = High (> 6%)

Obstructions: Y = Yes, N = No

DO = dissolved oxygen

Table 6.2-4. Existing Physical Environment Conditions for Compensation Sites (continued)

					Physical Environment								
Watershed	Sub-Watershed	Waterbody	Watershed Site Number	Compensation Project Type	Primary Watersource	Secondary Watersource	Water Supply Magnitude	Surface Water Supply Dependability	Flood Risk	Water Quality Concerns	Sediment Supply Concerns	Gradient	Obstructions
Treaty	Todedada	Todedada Creek	1	Mainstem LWD, boulder and pool enhancement	SW	GW	H	H Large groundwater source	M Todedada Creek mainstem	Y Turbidity	Y High glacial sediment load	L	N
Treaty	Todedada	Todedada Creek	2	Groundwater spawning channel creation	GW	-	L	H	N	N	N	L	N
Bell-Irving	Glacier	Glacier Creek	1	Side channel habitat creation	SW	-	M	M Possible low winter flows	L	N	N	L/M	N
Bell-Irving	Taft	Taft Creek	1	Side channel and alove pond habitat creation	SW	GW Minor	H	H	L	Y Turbidity	Y High glacial sediment load	L	N
Bell-Irving	Taft	Taft Creek	2	Off-channel pond fish passage enhancement	GW	SW Minor	L	L Groundwater supply dependable	L	P Possible low winter DO	N	L	Y Beaver dams
Bell-Irving	-	Bell-Irving River	1	Off-channel pond creation and fish passage enhancement	GW	-	L	L Groundwater supply dependable	L	P Possible low winter DO	N	L	Y Beaver dams
Bell-Irving	Oweegee	Oweegee Creek	1	Mainstem LWD and pool enhancement	SW	GW Minor	L	H Lake headwater	L	N	N	L/M	N
Bell-Irving	Oweegee	Oweegee Creek	2	Side channel LWD and pool enhancement	SW	GW Minor	L-H Depends on influence of Bell-Irving River	H Lake headwater	H	N	Y Glacial sediment load from Bell-Irving River	L	N
Bell-Irving	Mere	Mere Creek	1	Mainstem pool habitat creation	SW	-	L	L Possible low winter flows	L	N	N	L	N

(continued)

Dashes indicate not applicable

Primary and Secondary Watersource: SW = surface water, GW = groundwater

Water Supply Magnitude: L = Low

Surface Water Supply Dependability: L = Low, M = Moderate, H = High

Flood Risk: L = Low, M = Moderate, H = High

Water Quality Concerns: Y = Yes, N = No, P = Probable

Sediment Supply Concerns: N = None, L = Low, M = Moderate, H = High

Gradient: L = Low (0 - 2%), M = Moderate (3 - 5%), H = High (> 6%)

Obstructions: Y = Yes, N = No

DO = dissolved oxygen

Table 6.2-4. Existing Physical Environment Conditions for Compensation Sites (completed)

					Physical Environment								
Watershed	Sub-Watershed	Waterbody	Watershed Site Number	Compensation Project Type	Primary Watersource	Secondary Watersource	Water Supply Magnitude	Surface Water Supply Dependability	Flood Risk	Water Quality Concerns	Sediment Supply Concerns	Gradient	Obstructions
Bowser	-	Bowser River	1	Off-channel pond fish passage enhancement	GW	SW Minor	L	L Low winter flows, Groundwater supply dependable	L	P Possible low winter DO	N	L	Y Beaver dams
Bowser	-	Bowser River	2	Off-channel pond fish passage enhancement	SW	GW	L	H Large beaver pond complex within lake headed system	L	P Possible low winter DO	N	L	Y Beaver dams
Bowser	-	Bowser River	3	Mainstem LWD and pool enhancement	SW	GW	L	H Large beaver pond complex within lake headed system	L	N	N	L	N
Bell-Irving	-	Bell-Irving River	1	Side channel LWD and pool enhancement	SW	-	H	H	H	N	Y Glacial sediment load from Bell-Irving River	L	N
Bell-Irving	-	Bell-Irving River	2	Side channel LWD and pool enhancement	SW	-	H	H	H	N	Y Glacial sediment load from Bell-Irving River	L	N
Bell-Irving	-	Bell-Irving River	3	Side channel LWD and pool enhancement	SW	-	H	H	H	N	Y Glacial sediment load from Bell-Irving River	L	N
Bell-Irving	-	Bell-Irving River	4	Side channel LWD and pool enhancement	SW	-	H	H	H	N	Y Glacial sediment load from Bell-Irving River	L	N

Dashes indicate not applicable

Primary and Secondary Watersource: SW = surface water, GW = groundwater

Water Supply Magnitude: L = Low

Surface Water Supply Dependability: L = Low, M = Moderate, H = High

Flood Risk: L = Low, M = Moderate, H = High

Water Quality Concerns: Y = Yes, N = No, P = Probable

Sediment Supply Concerns: N = None, L = Low, M = Moderate, H = High

Gradient: L = Low (0 - 2%), M = Moderate (3 - 5%), H = High (> 6%)

Obstructions: Y = Yes, N = No

DO = dissolved oxygen

Table 6.2-5. Screening Criteria for Compensation Sites

Watershed	Sub-Watershed	Waterbody (s)	Site Number	Compensation Project Type	Screening Criteria						
					DFO Hierarchy for Compensation	Regional Fisheries Management Objectives	Inclusion of TK and TLU	Technically Feasible	Economically Feasible	Stable and Permanent	Biologically Relevant
Teigen	-	Teigen Lake	1	Littoral zone LWD enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses MOE objectives	Pending Site immediately outside of KSM fisheries study area boundary but within Teigen Creek Watershed, Discussed at working group meetings	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	Hodkin	Hodkin Lake	1	Littoral zone LWD enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit	Yes Dolly Varden specific benefit
Unuk	-	Unuk Lake	1	Littoral zone LWD enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden specific benefit
Treaty	Gilbert	Gilbert Lake	1	Littoral zone LWD enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	Hodkin	Hodkin Lake Creek 1	2	Stream spawning habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden specific benefit, Increased productive capacity of Hodkin Lake
Teigen	Hodkin	Hodkin Lake Creek 2	3	Stream spawning habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden specific benefit, Increased productive capacity of Hodkin Lake
Teigen	-	Teigen Creek	3	Mainstem pool habitat creation	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	South Teigen	South Teigen Creek	1	Mainstem pool habitat creation	1 Increase productive capacity of like-for-like habitat in same EU	Adresses MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	Snowbank	Snowbank Creek	1	Mainstem pool habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	-	Teigen Creek	1	Off-channel pond creation and fish passage enhancement	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Teigen	-	Teigen Creek	2	Side channel habitat enhancement and creation	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area, Discussed at working group meetings	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Teigen	-	Teigen Creek	4	Off-channel pond fish passage enhancement	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Treaty	-	Treaty Creek	1	Off-channel pond creation	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Treaty	-	Treaty Creek	2	Off-channel pond creation	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit

Dashes indicate not applicable

(continued)

EU = ecological unit

TK = traditional knowledge

TLU = traditional land use

DFO Hierarchy for Compensation = refer to Section 6.2.2 for definitions

Table 6.2-5. Screening Criteria for Compensation Sites (continued)

Watershed	Sub-Watershed	Waterbody (s)	Site Number	Compensation Project Type	Screening Criteria						
					DFO Hierarchy for Compensation	Regional Fisheries Management Objectives	Inclusion of TK and TLU	Technically Feasible	Economically Feasible	Stable and Permanent	Biologically Relevant
Treaty	-	Treaty Creek	3	Off-channel pond fish passage enhancement	1 Increase productive capacity of like-for-like habitat in the same EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Treaty	Gilbert	Gilbert Creek	1	Mainstem pool habitat creation and fish passage enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Requires active beaver management	Yes Increased productive capacity of Gilbert Lake, Dolly Varden and multispecies benefit
Treaty	Gilbert	Gilbert Creek	2	Groundwater spawning channel creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	East Todedada Creek	1	Mainstem LWD and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	East Todedada Creek	2	Off-channel pond enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	East Todedada Creek	3	Mainstem LWD and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	Todedada Creek	1	Mainstem LWD, boulder and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Treaty	Todedada	Todedada Creek	2	Groundwater spawning channel creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Bell-Irving	Glacier	Glacier Creek	1	Side channel habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Bell-Irving	Taft	Taft Creek	1	Side channel and alcove pond habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Pending Site outside of KSM fisheries study area	Yes	Yes	Yes Long term benefit	Yes Dolly Varden and multispecies benefit
Bell-Irving	Taft	Taft Creek	2	Off-channel pond fish passage enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Pending Site outside of KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Bell-Irving	-	Bell-Irving River	1	Off-channel pond creation and fish passage enhancement	3b Increase productive capacity of like-for-unlike habitat in a different EU	Adresses DFO and MOE objectives	Pending Site outside of KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Bell-Irving	Oweegee	Oweegee Creek	1	Mainstem LWD and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Bell-Irving	Oweegee	Oweegee Creek	2	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit

Dashes indicate not applicable

(continued)

EU = ecological unit

TK = traditional knowledge

TLU = traditional land use

DFO Hierarchy for Compensation = refer to Section 6.2.2 for definitions

Table 6.2-5. Screening Criteria for Compensation Sites (completed)

Watershed	Sub-Watershed	Waterbody (s)	Site Number	Compensation Project Type	Screening Criteria						
					DFO Hierarchy for Compensation	Regional Fisheries Management Objectives	Inclusion of TK and TLU	Technically Feasible	Economically Feasible	Stable and Permanent	Biologically Relevant
Bell-Irving	Mere	Mere Creek	1	Mainstem pool habitat creation	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Pending Site outside of KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Bowser	-	Bowser River	1	Off-channel pond fish passage enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Bowser	-	Bowser River	2	Off-channel pond fish passage enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Check beaver activity/influence periodically	Yes Dolly Varden and multispecies benefit
Bowser	-	Bowser River	3	Mainstem LWD and pool enhancement	3a Increase productive capacity of like-for-like habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Yes Long term benefit, Low energy stream	Yes Dolly Varden and multispecies benefit
Bell-Irving	-	Bell-Irving River	1	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit, Large river habitat targeted
Bell-Irving	-	Bell-Irving River	2	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit, Large river habitat targeted
Bell-Irving	-	Bell-Irving River	3	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit, Large river habitat targeted
Bell-Irving	-	Bell-Irving River	4	Side channel LWD and pool enhancement	3b Increase productive capacity of unlike habitat in a different EU	Adresses DFO and MOE objectives	Yes Site within KSM fisheries study area	Yes	Yes	Stable - Yes Permanent - Flood risk dependant	Yes Multispecies benefit, Large river habitat targeted

Dashes indicate not applicable
EU = ecological unit
TK = traditional knowledge
TLU = traditional land use
DFO Hierarchy for Compensation = refer to Section 6.2.2 for definitions

A holistic approach was implemented to prioritize the preliminary compensation sites, with the primary objective of achieving DFO's *No Net Loss* principle and a compensation ratio of approximately 2:1. First, projects that were higher on DFO's hierarchy for compensation were identified. DFO's first preference is projects that replace lost habitat with the same habitat in the same ecological unit. Eights projects lie within this category (Table 6.2-5):

- South Teigen Creek Site 1 - mainstem pool habitat creation;
- Teigen Creek Site 1 - off-channel pond creation and fish passage enhancement;
- Teigen Creek Site 2 - side channel habitat enhancement and creation;
- Teigen Creek Site 3 - mainstem pool habitat creation;
- Teigen Creek Site 4 - off-channel pond fish passage enhancement;
- Treaty Creek Site 1 - off-channel pond creation;
- Treaty Creek Site 2 - off-channel pond creation; and
- Treaty Creek Site 3 - off-channel pond fish passage enhancement.

The approach to select the primary projects for detailed analysis took into consideration the screening results, site-specific risks and opportunities, fish habitat area, and HUs gained from preliminary compensation sites, site access, design complexity, and construction costs.

Teigen and South Teigen creeks mainstem pool habitat creation projects are viable projects; however, the application of pool creation is limited to a select few locations and the overall biological benefit to fish populations within these watersheds would be minimal. Therefore, Teigen Creek Site 3 and South Teigen Site 1 were placed as lower priority.

The remaining projects are off-channel or side channel habitat creation/enhancement projects. Teigen Creek Sites 2 and 4 provide a moderate to high biological benefit to fish populations within these watersheds; however, the site-specific engineering risks due to flooding and erosion are high and would require considerable design complexity. Furthermore, there is no current or proposed site access to these sites. Therefore, Teigen Creek Sites 2 and 4 were placed as lower priority.

Treaty Creek Sites 2 and 3 provide a moderate to high biological benefit to fish populations within these watersheds; however, the site-specific engineering risks due to flooding and erosion from Treaty Creek are high and would require considerable design complexity. A protected surface water intake for these projects would be difficult given the geomorphology of Treaty Creek. Therefore, Treaty Creek Sites 2 and 3 were placed as lower priority.

Teigen Creek Site 1 and Treaty Creek Site 1 provide a high biological benefit to fish populations within these watersheds. The site-specific engineering risks due to flooding and erosion from the mainstems are low, given the placement of the projects within the watershed. A protected surface water intake for these projects is less complex than the other proposed off-channel projects. Furthermore, the proposed Treaty Creek Access Road will be immediately adjacent to Treaty Creek Site 1 and Teigen Creek Site 1 would require a spur access trail from the plant site. Therefore, Teigen Creek Site 1 and Treaty Creek Site 1 were selected for development of technically feasible compensation designs. However, additional projects are required for HU budgeting and to achieve a compensation ratio of 2:1 for both the MMER and HADD fish habitat compensation plans.

Following the same logic, projects that were next on DFO's hierarchy for compensation were identified. DFO's second preference is projects that increase the productive capacity of existing habitat with unlike habitat in the same ecological unit. However, none of the proposed projects achieved DFO's second preference. DFO's third preference (i.e., category 3a) is replacing lost habitat with like-for-like habitat in another ecological unit. Nineteen projects lie within this category (Table 6.2-5).

Mainstem pool habitat creation projects are viable projects; however, the application of this technique is limited to a select few locations and the overall biological benefit to fish populations and productive capacity within these watersheds. Also, some of these mainstem complexing sites are remote and difficult to access (e.g., Hodkin Creek and East Todedada Creek). Therefore, mainstem complexing projects were placed as lower priority.

The remaining projects are variations of off-channel creation with moderate to high biological benefit to fish populations within these watersheds. Of all these projects, Taft Creek Site 1 and Glacier Creek Site 1 were selected for development of technically feasible compensation designs. The site-specific engineering risks due to flooding and erosion from the mainstems are low given the placement of the projects within the watershed. A protected surface water intake for these projects is less complex than the other proposed off-channel projects. Furthermore, access to these projects currently exists along Highway 37.

Of the four priority projects identified above, the following compensation projects were selected based upon the holistic approach and represent technically feasible compensation sites for HU budgeting to achieve a compensation ratio of 2:1.

- Teigen Creek Site 1 – Off-channel pond complex habitat creation; and
- Glacier Creek Site 1 – Off-channel pond complex habitat creation.

6.3 TECHNICALLY FEASIBLE COMPENSATION PROJECT DESCRIPTIONS

6.3.1 Teigen Creek – Site 1

6.3.1.1 Site Description

Location

Site 1 is located on the north side of the Teigen Creek Valley, approximately 0.8 km upstream of the South Teigen Creek confluence (Figure 6.3-1). The centre of the proposed project is at Universal Transverse Mercator (UTM) 9U.439735E.6283407N. The nearest road to the site is Highway 37, approximately 7 km to the northeast. Once the proposed TMF is built, the nearest road will be approximately 3.5 km to the south.

The proposed project is 2.5-km long and approximately 400-m wide along the north valley wall (Plates 6.3-1 to 6.3-7). It includes a large portion of the north valley floodplain with the following features:

- mature coniferous forest;
- a series of wetlands and five beaver ponds totalling 0.4 ha in area (all are fish-bearing);
- seepages and hill slope drainage channels with a total channel area of 55 m^2; and
- shrub, sedge, and willow meadows.

Water flow through the site originates from the north hill slope run-off, from storage in beaver ponds, and from groundwater seepage (Rescan 2011c).

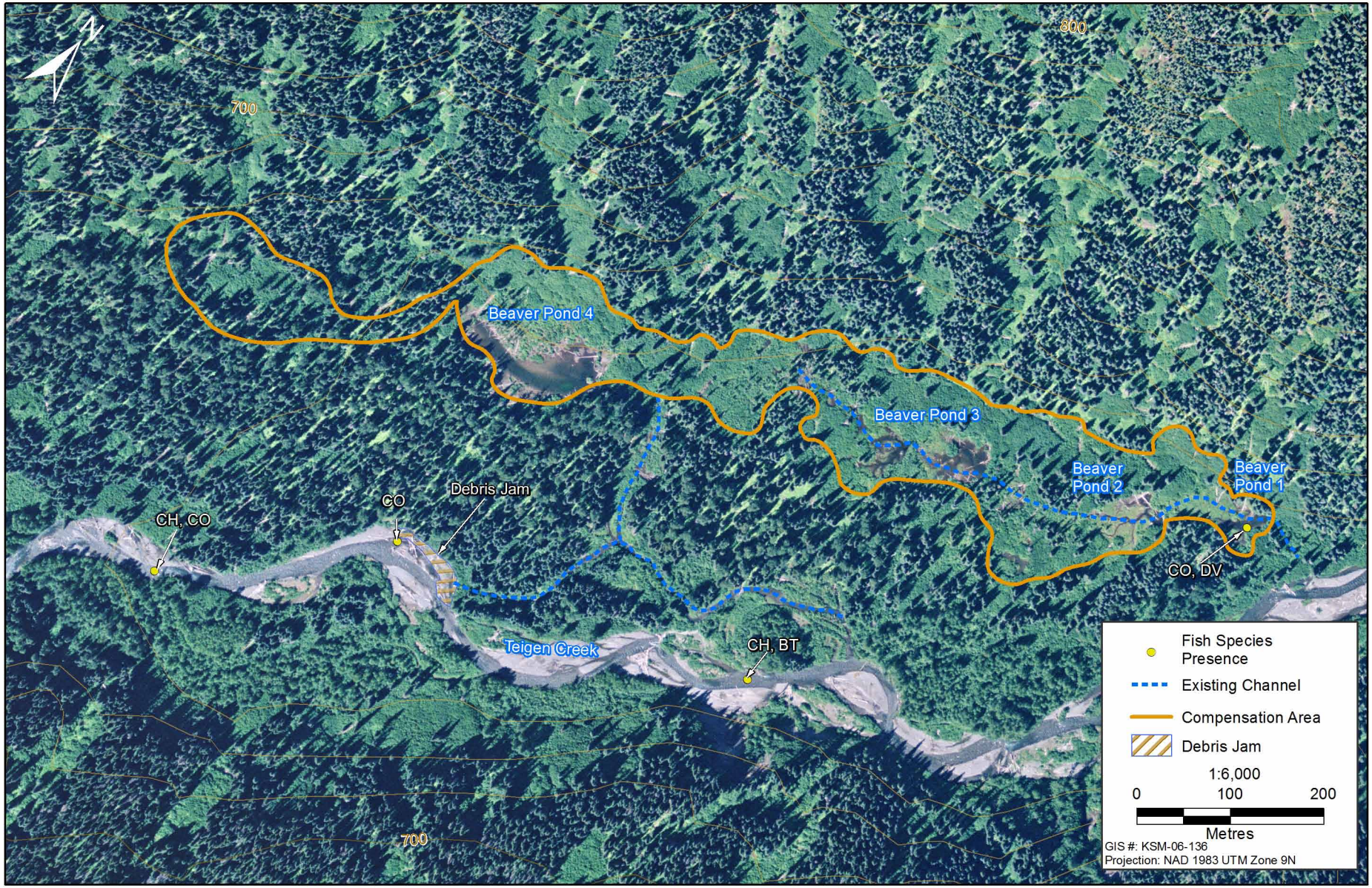


Figure 6.3-1

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Teigen Creek Site 1 – Existing Conditions

Figure 6.3-1

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Plate 6.3-1. Aerial view of existing Pond 1 within Teigen Creek floodplain.



Plate 6.3-2. Ground view of existing Pond 1. Pond is frozen to bottom during winter.



Plate 6.3-3. Aerial view of wetland ponds within the east section of site. Ground water channels are present in lower section of photo.

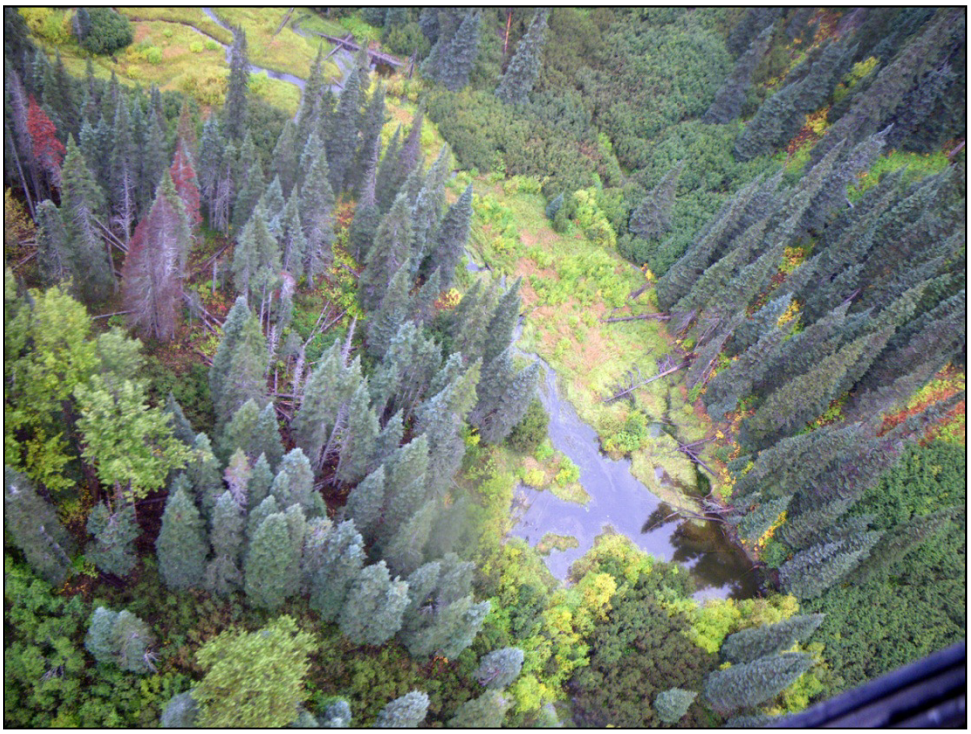


Plate 6.3-4. Aerial view of groundwater and surface water pond within eastern section of site. Pond is ice free during winter.



Plate 6.3-5. Ground view of groundwater and surface water pond within eastern section of site.



Plate 6.3-6. Aerial view of proposed intake location near bedrock-controlled pool.



Plate 6.3-7. Ground view of proposed intake location near bedrock-controlled pool.

Vegetation and Wildlife

The area is subject to prolonged, perhaps constant, flooding. Much of the site is maintained in an edaphic state as alder and willow. These sites are classified as both low bench flood plains (Fl01) and Sitka willow – Sitka sedge wetland swamps (Ws06). These two associations often occur in combination as they occupy similar landscape positions. However, the Fl01 flood association is slightly more hydrodynamic, with higher energy water regimes and a prolonged drying period. The Ws06 is associated with brief flooding and prolonged saturation of the rooting zone. The hydrodynamic regime is less mobile, but not stagnant. Much of the proposed site has been influenced by beaver activity. Marsh ecosystems are developed along the pond fringes.

An assessment of provincially and federally rare ecosystems/plants (Rescan 2012e) indicated that there are no rare plant species at the site; however, the following provincially rare blue-listed ecosystems are present (Figure 6.3-2):

- Fm03: Cottonwood – Subalpine Fir – Devil's Club (*Populus balsamifera - Abies lasiocarpa - Oplopanax horridus*)

  This middle-bench floodplain forest occurs on sandy or gravelly flats adjacent to streams and rivers with relatively prolonged flood durations. Cottonwood (*Populus balsamifera*) forms an open canopy with scattered subalpine fir and interior spruce. Devil's club is abundant in the understorey.

- Ws06: Sitka Willow / Sitka Sedge (*Salix sitchensis- Carex sitchensis*)

  This swamp wetland is typically associated with fluvial systems or networks of depressions that experience extended saturation and ephemeral early-season flooding. The shrub and herb layers are dominated by Sitka willow and Sitka sedge, respectively. Additional large sedges such as water sedge (*Carex aquatilis*) and *C. utriculata* may also be present.

- Fl02: Mountain Alder - Lady Fern (*Alnus incana - Athyrium filix*)

  This ecosystem is found in wet depressions in the bottoms of gullies and adjacent to creeks and lakes. Mountain alder dominates the canopy, and the understory is lush and dense with ferns. It represents an edaphic climax, as the conditions where it develops promotes the retention of the shrub community. Soils are usually cumulic, with inundation being evidenced by aggradations of sediments, especially fine sands.

In addition to beavers, other wildlife signs observed included moose tracks and damaged shrubs browsed by moose. An assessment for western toad (*Anaxyrus boreas)* breeding habitat was conducted in 2011 (Rescan 2011b). Western toad is rare species, and is designated as a "species of special concern" by the Committee on the Status of Endangered Wildlife in Canada and is present on Schedule 1 of the federal *Species at Risk Act* (2002). The species is also present on the red list published by the International Union for Conservation of Nature. During July breeding surveys, no western toads were observed at Teigen Creek Site 1. No breeding sites were confirmed; however, western toads may not breed every year and wetland areas where adults or juveniles were observed, or where suitable habitat was identified, may still support western toad breeding in some years. Therefore, western toad breeding habitat is assumed to be present at the site.

Archaeology

An archaeology assessment was conducted at this site in 2011. This area was assessed to have low archaeological potential. Subsurface testing was conducted in areas of low archaeological potential to confirm the assessment, and no archaeological materials were recovered.

6.3.1.2 Fish Community and Habitat

Teigen Creek supports chinook, sockeye and coho salmon, rainbow trout/steelhead, Dolly Varden, bull trout, and mountain whitefish (Rescan 2011a). Fish can access good-quality habitat in the mainstem up to Teigen Lake.

Summer fish and fish habitat rearing assessments were conducted in 2009 and 2011 (Rescan 2010, 2012a). A total of 136 hours of minnow trapping in the beaver pond complex in August 2009 captured coho salmon parr and adult Dolly Varden (Rescan 2010; Table 6.2-2; Figure 6.3-1). A total of 342 hours of minnow trapping in the beaver pond complex in August 2011 captured parr and adult Dolly Varden and coho salmon fry (Rescan 2012a). Catch per unit effort minnow trap data also demonstrated that Dolly Varden and coho salmon are more abundant in reference wetlands compared to wetlands within Teigen Creek Site 1 (Rescan 2012a). In 2009, electrofishing stream channels captured Dolly Varden parr and coho salmon fry.

Fish habitat quality was considered poor in August 2009 and 2011 in most of the shallow beaver ponds due to the lack of flow, limited access to the mainstem and between wetlands, shallow water, and organic substrate (Table 6.2-4). Only a few areas were considered fair- to good-quality rearing habitat. Cover in the form of logs, stumps, and brush was present at all wetlands, whereas instream sedges and overhanging vegetation provided abundant cover throughout the site.

Substrate in the existing channels between beaver ponds was mainly organic. Salmonid spawning habitat does not exist at Site 1. Gravel substrate suitable for Dolly Varden spawning was only observed at the inlet stream from the northern hillslope.

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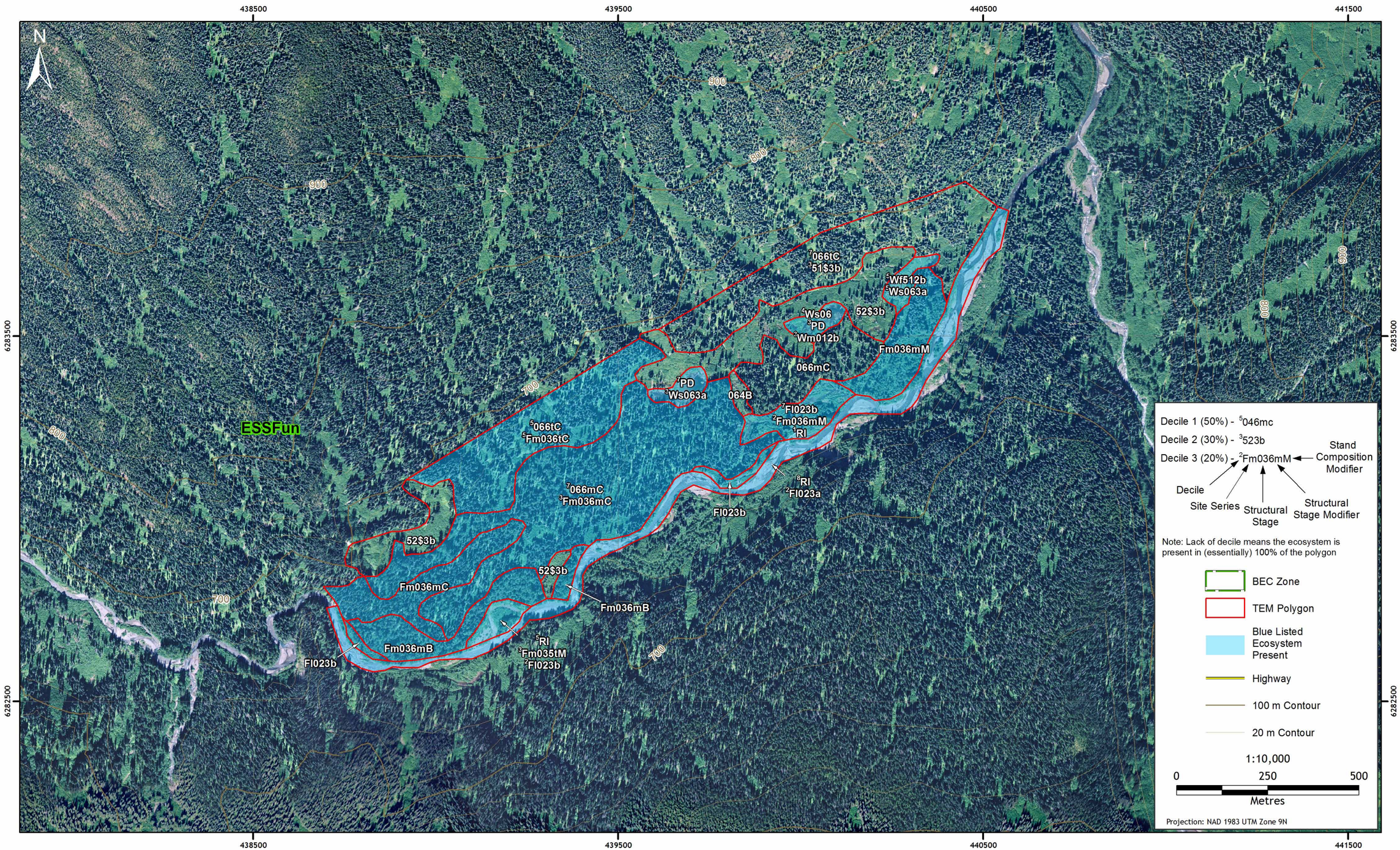


Figure 6.3-2

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Teigen Creek Site 1 - Terrestrial Ecosystems

Winter fish and fish habitat rearing assessments occurred in 2010 and 2011 (Rescan 2011a, 2012a). In the winter of 2010 and 2011, ponds were observed with up to 1.5 m of ice in the Teigen Creek Watershed. Shallow ponds were frozen to the bottom, or nearly frozen with 0.3 m of water depth. No fish were caught in these ponds and dissolved oxygen concentrations were low (2.5 mg/L). Overwintering habitat quality was strongly influenced by the presence of winter base flow, groundwater seepage, and ice thickness. Most of the existing beaver ponds in Site 1 provide poor quality overwintering habitat.

One pond in the eastern portion of the compensation site provide good quality overwintering habitat due to the presence of groundwater and no ice cover. Overwintering coho salmon parr were caught in this pond.

Habitat quality in Pond 1, the largest pond, is poor for overwintering due to the loss of water and ice freezing to the pond bed. Field assessments in July, August, September, October, and March (2009 to 2011) confirmed that water depth within the large pond decreases throughout the year. A range of historical water levels is evident within the large pond, such as high beaver dam height, beaver lodge height, and changes in riparian vegetation along the pond banks. Water loss within the large pond is likely due to a number of factors, including evaporation, absence of significant tributary water sources, absence of groundwater sources, and seepage through the soil and beaver dam throughout the year.

The inlet stream from the northern hillslope was assessed for winter base flow conditions in March 2010 at the downstream reach (Rescan 2011). The inlet stream had a low winter base flow with water depths of 3 cm and high snow cover. Water depth and flow was insufficient to conduct a depth and velocity profile with the Swoffer Velocity Meter. Flow and discharge could not be reliably measured by other techniques; however, velocity was estimated to be less than 0.05 m/s.

In summary, the existing habitat at Site 1 is only of poor quality with obstructed fish access such that the overall productivity is low (Table 6.2-4). Fish access through the beaver pond complex is obstructed by beaver dams and fish cannot access habitat upstream of dams. Contributing to the fish access problem is the lack of perennial flow, lack of water depth, mainly organic substrate and discontinuous channels between ponds (Table 6.2-4). Typically, coho salmon juveniles rear in off-channel areas similar to Site 1, but their absence is likely due to a combination of these limitations. These limitations were also observed at other compensation sites and off-channel areas throughout the watershed.

6.3.1.3 Objectives and Technique

The proposed compensation sites will provide a large amount of permanent, good-quality habitat for rearing and overwintering along with spawning habitat for coho salmon. Site 1 will support all life stages of two target species: Dolly Varden and coho salmon (Table 6.2-3). This site will address legislated fisheries management objectives for DFO and provincial fisheries agencies and provide multi-species benefits (Table 6.2-5).

The objectives for Site 1 are:

- construct a surface-water intake from Teigen Creek to supply reliable flow into a protected off-channel and through a series of ponds;
- create 14.55 ha of good quality overwintering and rearing habitat in ponds;
- construct 1889 m of channels to create 0.38 ha of habitat with complex features (pools, riffles, wood, boulders);

- enhance the functional aspects of wetland ecosystems (e.g., nutrient recycling, water quality improvement, and fish and wildlife habitat);
- provide spawning habitat for coho salmon and Dolly Varden using wood cover, gravel substrate, and deep pools within the constructed channels; and
- maintain fish access and prevent beaver dam construction with beaver-proof fencing and wood structures at pond outlets.

The 0.41 ha of existing poor quality, shallow fish habitat in Site 1 will be replaced with 14.93 ha of good quality habitat. This is greater than a 25 fold increase in habitat at the site.

6.3.1.4 Proposed Design

The preliminary site layout is provided in Figure 6.3-3 and 6.3-4 (a to g) and the components are described below. The off-channel concept is described in Section 6.1. The proposed project includes:

- 1,889 m of excavated stream channels;
- a water intake from a bedrock controlled pool in Teigen Creek leading into the off-channel complex;
- flow control structures;
- 14.55 ha of ponds; and,
- an outlet channel to Teigen Creek.

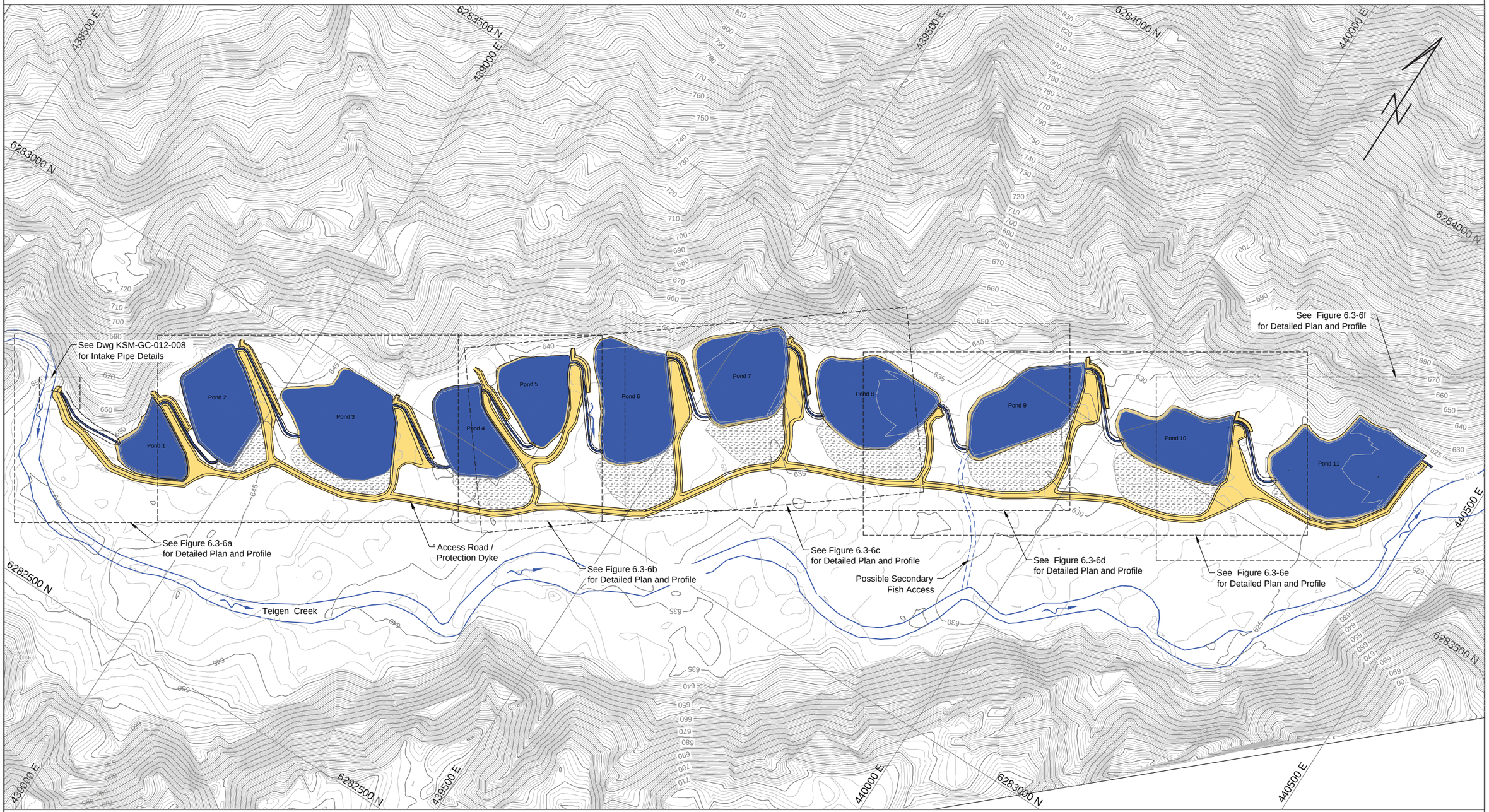
The channels will provide high-quality rearing habitat for juvenile coho and Dolly Varden during the ice-free period. The pools in the channels will supply overwintering habitat in addition to the large ponds. The typical pond and channel layout and cross-sections are shown in Figure 6.1-1 to 6.1-3. Final channel dimensions and layout will be shown on construction drawings.

The typical wetted width of the channel will be 2.0-m wide and the channel incision will be 1.5 to 3.0 m in depth. Water depth in channels will depend on slope and will range from 0.05 to 0.3-m deep (excluding pool depth). The channel will be complexed with salvaged materials (i.e., cobble, boulders, LWD, root wads) such that approximately 50% of the channel has overhead or instream cover. Logs and root wads will be partially buried in the bank or cabled to boulders for stability (additional details on anchoring of LWD is presented in Section 6.1). The typical channel arrangement and details are shown in Figures 6.1-3 and 6.3-4g.

Small pools will be excavated along the constructed channels every 20 to 30 m. Typical pools will be designed to have 1.0 m residual depth. They will be complexed with wood, branches, and boulders to provide cover. The gravel tailouts of pools will provide spawning habitat for the target species.

The channel will be sinuous with riffle/run/pool morphology and gradients from 0.5 to 2% (Figure 6.3-3 and 6.3-4). The channel will carry water from the Teigen Creek intake at 648 masl, through the upper pond, and down the outlet with Teigen Creek (621 masl). Excavated material will be deposited alongside the channel to form a tote road. The working corridor will be 15 to 20 m in width. Site preparation work prior to excavation will include tree felling and grubbing of root wads; trees and root wads will be incorporated as fish habitat features within the channel.

Materials excavated from the channel and ponds will be used to build a gravel dyke along the floodplain adjacent to Treaty Creek. The gravel dyke will help prevent flooding to the lower section of the off-channel complex.



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Figure 6.3-3

Teigen Creek Site 1 – Plan View



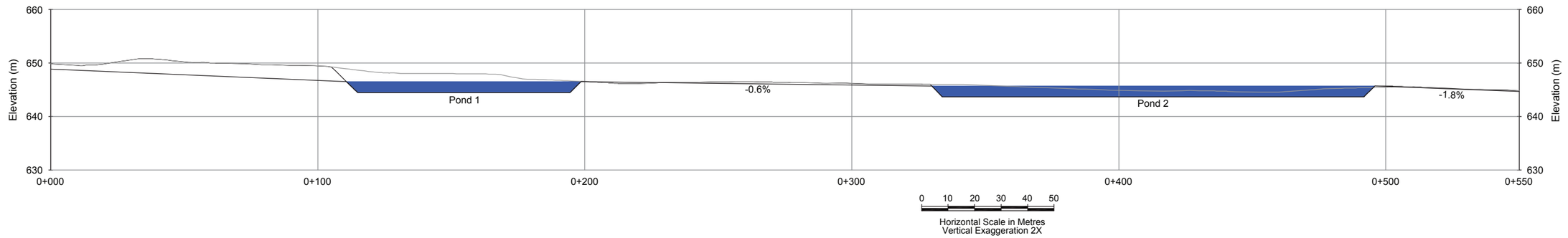
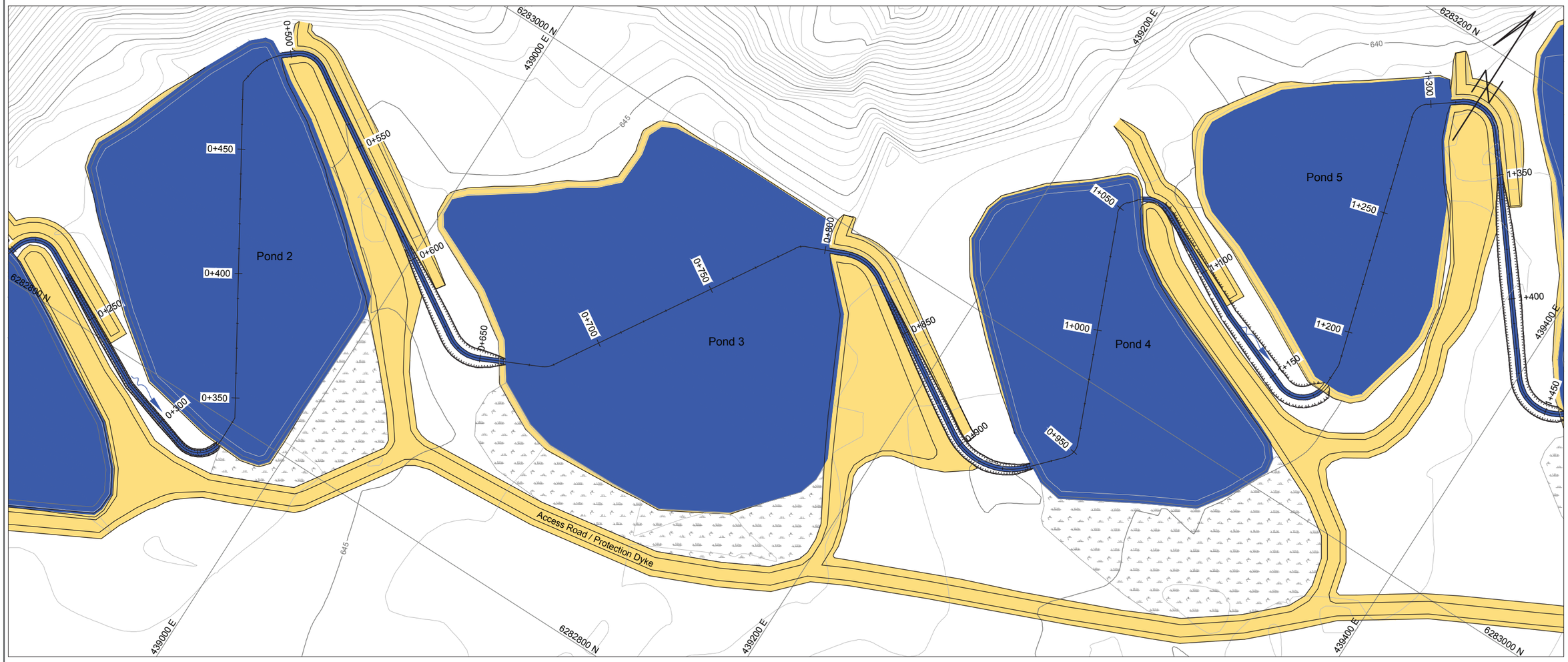


Figure 6.3-4a

Teigen Creek Site 1 - Plan and Profile View (Station 0+000 to 0+550)

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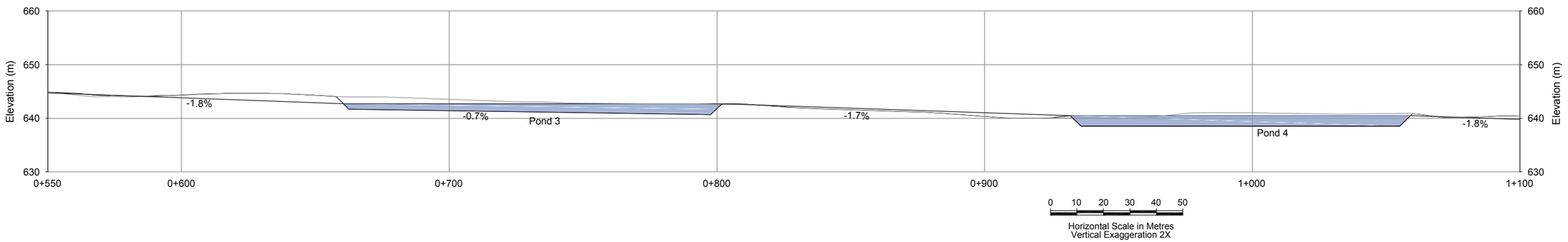


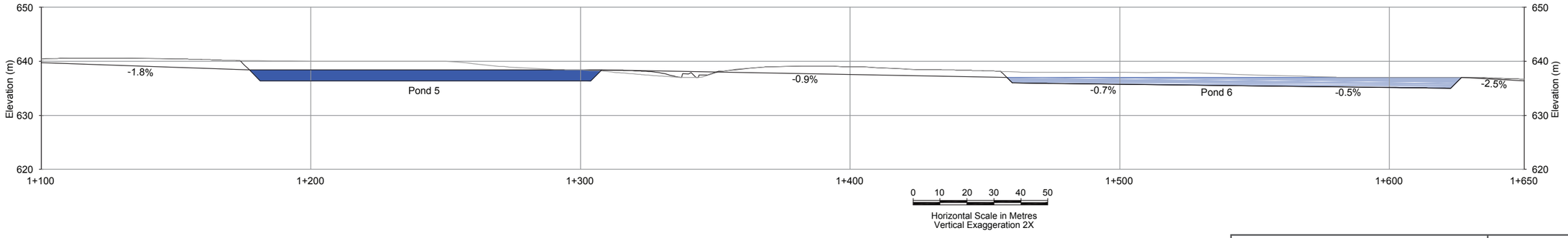
Figure 6.3-4b

Teigen Creek Site 1 – Plan and Profile View (Station 0+550 to 1+100)

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Figure 6.3-4c

Teigen Creek Site 1 - Plan and Profile View (Station 1+100 to 1+650)



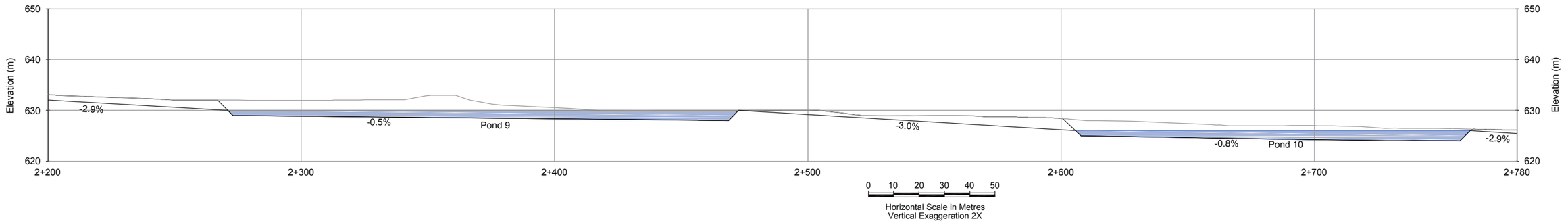
Figure 6.3-4d

Teigen Creek Site 1 - Plan and Profile View (Station 1+650 to 2+200)

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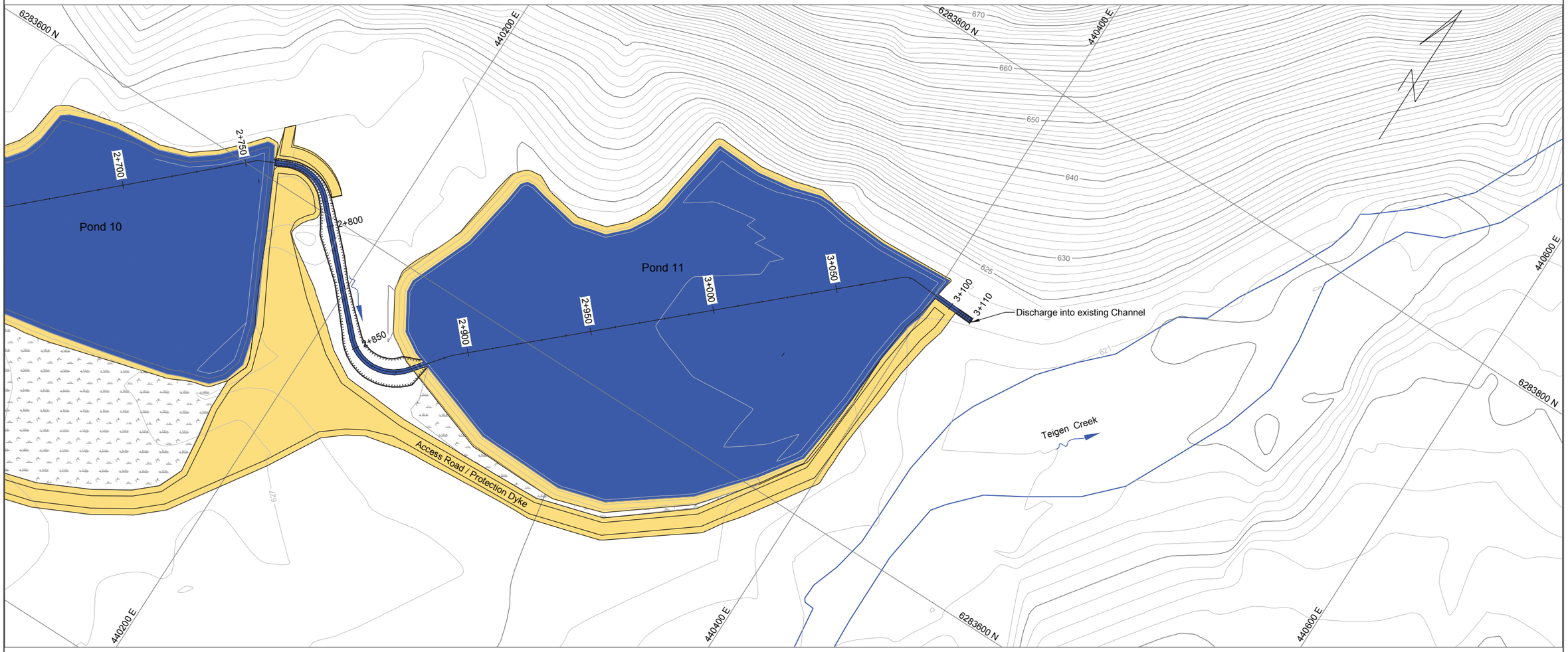


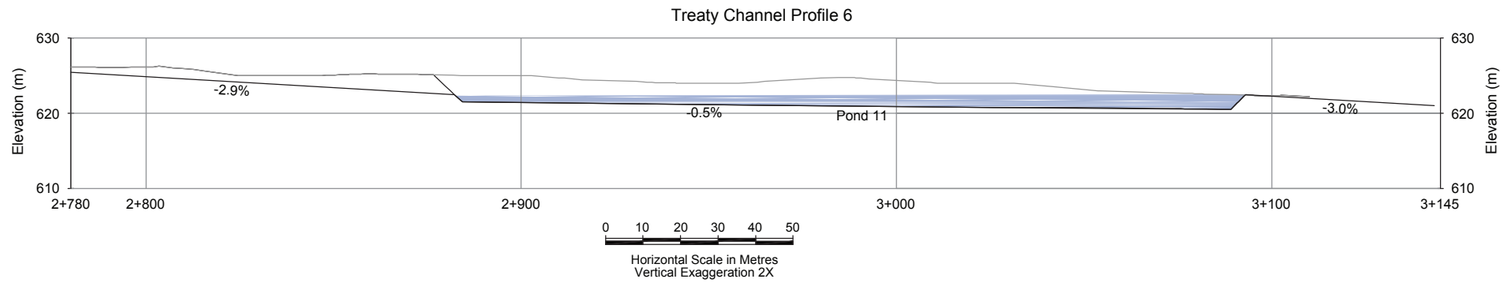
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Figure 6.3-4e

Teigen Creek Site 1 - Plan and Profile View (Station 2+200 to 2+780)



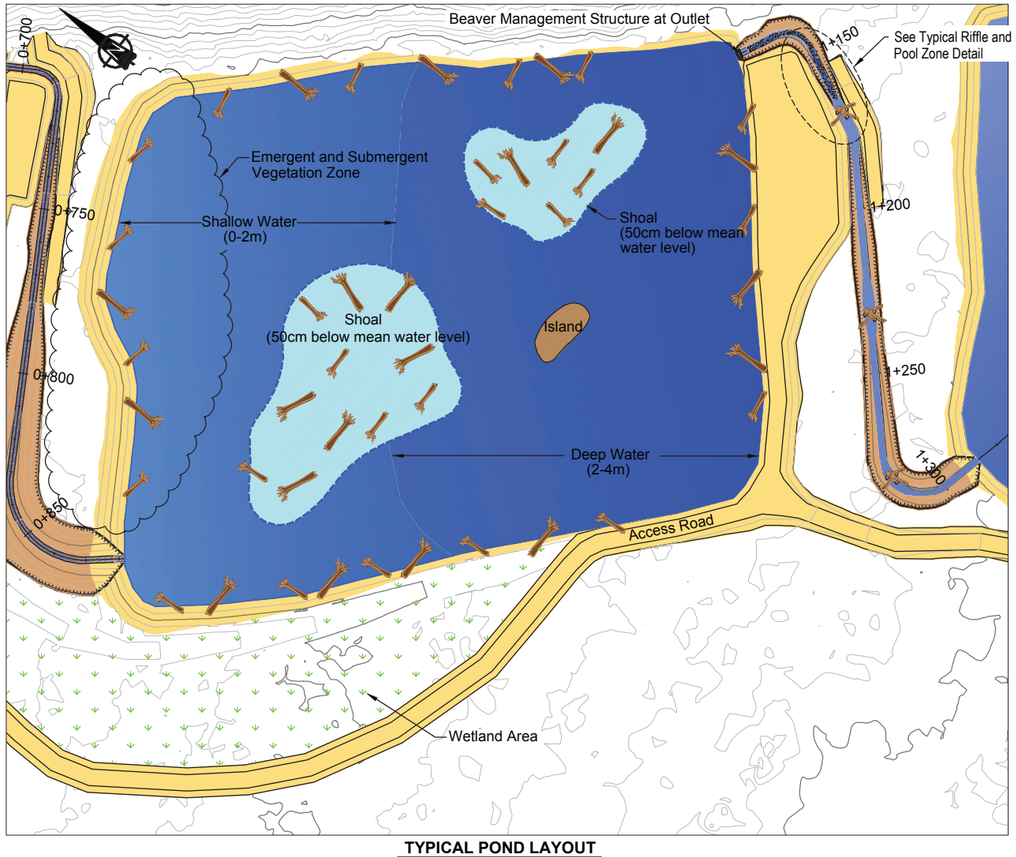


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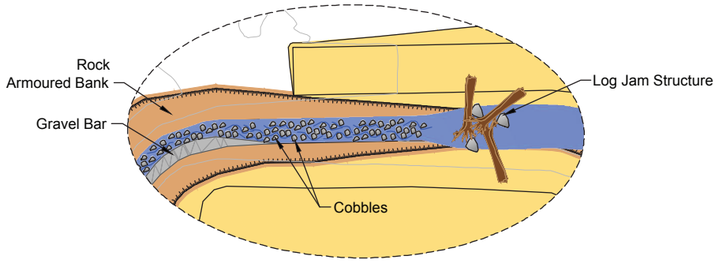
Figure 6.3-4f

Teigen Creek Site 1 – Plan and Profile View (Station 2+780 to 3+110)



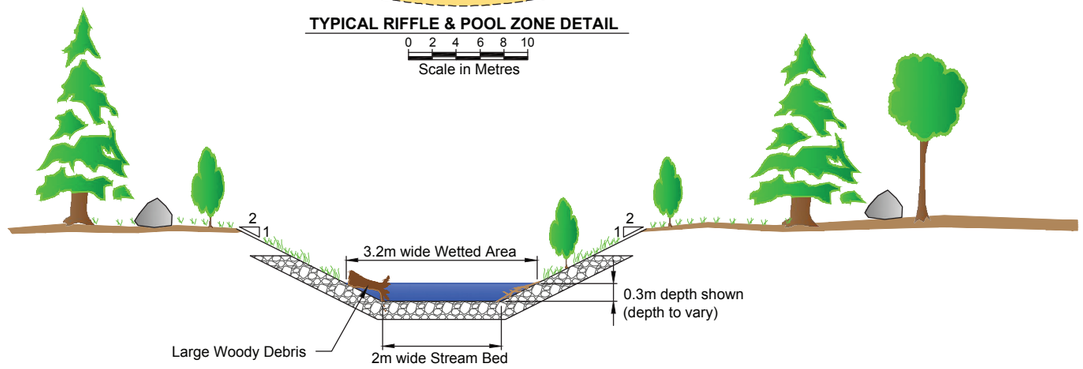
TYPICAL POND LAYOUT

0 5 10 15 20 25
Scale in Metres



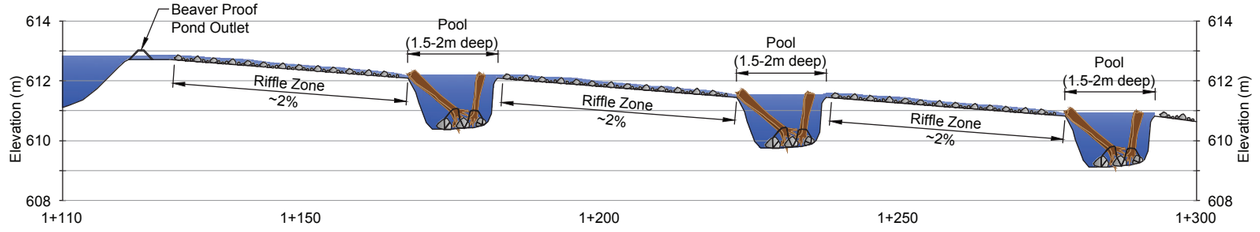
TYPICAL RIFFLE & POOL ZONE DETAIL

0 2 4 6 8 10
Scale in Metres



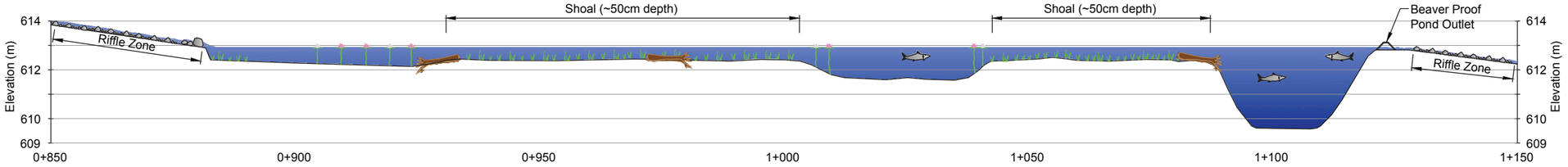
TYPICAL RUN ZONE CHANNEL SECTION

0 0.5 1 1.5 2 2.5
Scale in Metres



TYPICAL CHANNEL PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X



TYPICAL POND PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X

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Figure 6.3-4g

Teigen Creek Site 1 - Pond and Channel Typical Plan and Sections

Eleven large, bermed ponds will replace the existing beaver dams at this site (Figure 6.3-1). The constructed ponds will range from approximately 0.19 to 0.72 ha and will be up to 4 m in depth (Figures 6.1-1, 6.1-2 and 6.3-3). Each pond will be fit to the local topography and existing aquatic features and fish will be salvaged prior to construction (e.g., sedges, wood, etc.). Beaver fencing and structures (e.g., wood accumulations) will be built to prevent channel blockage and damage.

Water supply for the off-channel complex will come from three sources (in order of contribution amount): surface water from Teigen Creek and Creek 1 (spring/summer only) and intercepted groundwater. A water intake structure will be constructed along the east bank of Teigen Creek at the bedrock pool (Plates 6.3-6 and 6.3-7). The intake will be a buried pipe and will not be passable by fish. The withdrawal amount will be determined based upon flow monitoring in Teigen Creek and design volumes for the channels.

Construction of this site will require extensive excavation. It will require excavators, bulldozers, and dump trucks to move materials. No road access exists to the site; however, the proposed roads would be present at the TMF. Logs and rocks will likely be sourced from the excavated footprint.

6.3.1.5 Habitat Gain Summary

Tables 6.3-1 and 6.3-2 summarize stream and wetland habitat gain for the compensation site. Because fish habitat already exists at the compensation site, the existing value of the habitat must be subtracted from the planned enhanced value of the compensation habitat. Coho salmon HSI was used for HU calculation because it is the primary target species. A total of 262,882 HU and 145,114 m^2 will be gained from this site.

Table 6.3-1. Teigen Creek Site 1: Stream Habitat Creation Summary

Altered or Created	Area (m^2)	Coho Salmon Stream Habitat								Total HU
		Adult		Embryonic Stage		Fry Rearing		Parr Rearing		
		HS	HU	HS	HU	HS	HU	HS	HU	
Existing	55	1	55	0.5	28	0.5	28	1	55	165
Created	3,779	0.75	2,834	0.75	2,834	0.75	2,834	0.75	2,834	11,337
Total	**3,724**									**11,172**

Table 6.3-2. Teigen Creek Site 1: Wetland Habitat Creation Summary

Altered or Created	Area (m^2)	Wetland Habitat				Total HU
		Rearing		Overwintering		
		HS	HU	HS	HU	
Existing	2,880	0.5	1,440	0.1	288	1,728
Existing	100	0.1	10	0.1	10	20
Existing	152	0.1	15	0.1	15	30
Existing	100	0.1	10	0.1	10	20
Existing	840	0.5	420	0.75	630	1,050
Created	145,462	1	145,462	0.75	109,097	254,559
Total	**141,390**					**251,710**

6.3.2 Glacier Creek – Site 1

6.3.2.1 Site Description

Location

Glacier Creek is a moderate-size, third-order tributary to the Bell-Irving River which crosses Highway 37 about 20 km south of Bell II Lodge (Figure 6.2-1; Plates 6.3-8 to 6.3-12). Site 1 is located adjacent to Reach 1 of Glacier Creek between the Highway 37 culvert and to the confluence with the Bell-Irving River (Figure 6.3-5). The proposed project is at UTM 9V.460250E.6272800N.

Glacier Creek flows under the highway in a large culvert, 5 m in diameter by 36 m in length, that is an obstruction to fish passage (Plates 6.3-9 and 6.3-11). Reach 1 possesses marginal fish and fish habitat resources downstream of the highway culvert.

This site is 1.5-km long and approximately 300 m in width (Figure 6.3-5). It includes the mainstem and alluvial floodplain terraces on the south side of Glacier Creek. Mature forest exists throughout the floodplain south of the creek. Recently harvested cutblocks are on the north side of the creek beyond a narrow strip of mature trees (Plate 6.3-8). The site is easily accessible from Highway 37 and a road leads from the highway to a boat launch along the river (Plate 6.3-8).

Vegetation and Wildlife

The Glacier Creek site contains remnant glaciofluvial terraces bisected by Glacier Creek. Modern fluvial erosional and depositional features, including floodplains and degrading banks, are present throughout. The area is dominated by upland vegetation associations rather than flood associations, which are present but not extensive enough to be mapped as discrete polygons.

Upland forest is characterized by spruce, subalpine fir, and devils club. Zonal mature coniferous forest occupies the terrace slopes; this transitions to wet forests at the slope base, where soil moisture increases due to both downslope movement of water and contact with the water table. This increase in moisture is indicated by the dominance of hybrid white spruce and devils club. Floodplain ecosystems occur immediately adjacent to the creek. Soils tend to be sandy to silty, with occasional cobbles.

An assessment of provincially and federally rare ecosystems/plants (Rescan 2012e) indicated that rare plant species and provincially rare red- and blue-listed ecosystems are not present at the site (Figure 6.3-6).

Wildlife signs observed included moose tracks and damaged shrubs browsed by moose. An assessment for western toad (*Anaxyrus boreas)* breeding habitat was conducted in 2011 (Rescan 2011b. No western toads were observed at Glacier Creek Site 1) during July breeding surveys. Suitable habitat for breeding does not exist at Glacier Creek Site 1.

Archaeology

An archaeology assessment was conducted at this site in 2011. This area was assessed to have low archaeological potential. Subsurface testing was conducted in areas of low archaeological potential to confirm the assessment, and no archaeological materials were recovered.



Figure 6.3-5

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Glacier Creek Site 1 – Existing Conditions

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Plate 6.3-8. Upstream view of confluence of Glacier Creek and Bell-Irving River, facing east.



Plate 6.3-9. Highway 37 and Glacier Creek culvert 500 m upstream of Bell-Irving River.



Plate 6.3-10. Upstream view of Reach 1 of Glacier Creek, facing east.



Plate 6.3-11. Glacier Creek culvert perched 30 cm above outfall pool at high flow.



Plate 6.3-12. Looking downstream at outlet control of Glacier Creek culvert.

6.3.2.2 Fish Community and Habitat

Glacier Creek has a bankfull width of 10 m, with an average gradient of 3% and primarily cobble substrate (Rescan 2011; FINS 2004). It is a high-velocity creek with few pools and cascade-pool morphology. Glacier Creek is sinuous, with up to 0.5 m high banks, and is unconfined. The creek contains little cover. Cover consists of LWD, boulders, and overstream vegetation, but a low abundance of pools to provide refuge from high velocity. Upstream of the highway the creek has higher banks, coarser substrate, and is more confined without floodplain development.

Glacier Creek has a stable, old alluvial fan downstream of the culvert (Plate 6.3-8). It discharges into the Bell-Irving River near the boat launch (Figure 6.3-5; Plate 6.3-8). Several small, vegetated relic overflow channels exist in the floodplain vegetation along the boat launch road but no major side channels or avulsions exist.

Spawning, rearing, and overwintering habitat exist in Glacier Creek but the overall quality is poor (Rescan 2011; FINS 2004). Spawning habitat was poor due to the lack of deep pools and large cobble substrate. Rearing habitat was also poor due to the lack of cover and refuge from fast flows in the 3% channel. Similarly, limited overwintering habitat exists due to the lack of deep pools. The culvert outfall pool is the best rearing and overwintering habitat since it is up to 1.5 m deep.

The highway culvert, 36 m in length, affects fish distribution within the creek. It is a partial obstruction with high velocities and a perched outlet (40 cm) above a large, deep, outfall pool. It also has several boulders trapped across the culvert invert which creates a steep drop into the culvert and higher velocities than the natural channel (i.e., up to 2 m/s faster). Mean water velocities recorded at moderate flows in July 2010 at the inlet and outlet were 1.5 to 2.5 m/s, whereas mean water velocity recorded in the stream channel was 0.6 m/s. It is unlikely that large-bodied fish (e.g., steelhead, coho) are able to ascend the full culvert length and get past the 1 m drop at the culvert invert.

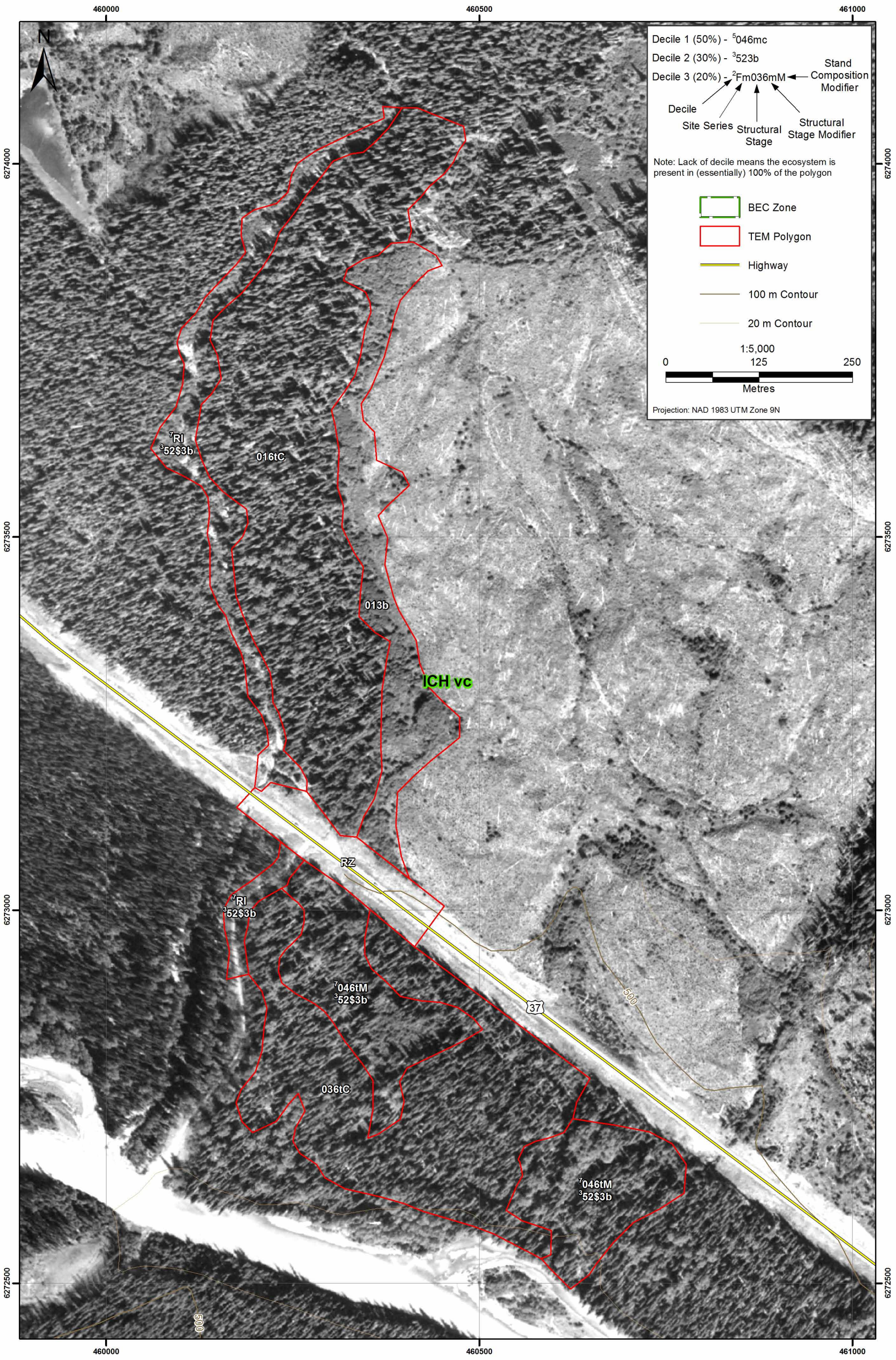


Figure 6.3-6

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Glacier Creek Site 1 - Terrestrial Ecosystems

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Glacier Creek supports a diverse fish community downstream of the culvert compared to upstream of the culvert. Dolly Varden, coho salmon, rainbow trout and mountain whitefish exist below the culvert, but only Dolly Varden exist upstream of it (Rescan 2011; FINS 2004*)*. Sampling in 2003 by FINS found newly emerged mountain whitefish and rainbow trout fry within Reach 1 due to the presence of limited spawning habitat (FINS 2004).

A small creek was present at the southern end of the site, which discharges into the Bell-Irving River. The creek at the south boundary of the proposed project was examined in September 2011 and May 2013. The creek had a mean bankfull width of 1.5 m with shallow riffle-pool morphology and low to moderate gradient. The creek had a moderate gradient (i.e., up to 10%) for the first 10 m upstream of the Bell-Irving River confluence due to the presence of a cobble outwash fan into the Bell-Irving River (Plate 6.3-8). At high flows in the Bell-Irving River, the creek is likely backwatered by the river for 10 to 20 m upstream, and can provide access for juvenile salmonds. The creek was assumed to be fish bearing based upon the low gradient channel upstream of the cobble outwash fan and was anticipated to support rearing fish through the spring and summer seasons.

6.3.2.3 Objectives and Technique

The proposed compensation sites will provide a large amount of permanent, good-quality habitat for rearing and overwintering, along with spawning habitat for coho salmon. Site 1 will support all life stages of two target species: Dolly Varden and coho salmon (Table 6.2-3). This site will address fisheries management objectives for DFO and provincial fisheries agencies, and provide multi-species benefits (Table 6.2-5).

The objectives for Site 1 are:

- construct groundwater fed off-channel habitat, with surface water intake from Glacier Creek, to supply reliable flow into the protected off-channel and through a series of ponds;
- create 1.90 ha of good quality overwintering and rearing habitat in ponds;
- construct 808 m of channels to create 0.16 ha of habitat with complex features (pools, riffles, wood, boulders);
- create functional aspects of wetland ecosystems (e.g., nutrient recycling, water quality improvement, and fish and wildlife habitat);
- provide spawning habitat for coho salmon and Dolly Varden using wood cover, gravel substrate, and deep pools within the constructed channels; and
- maintain fish access and prevent beaver dam construction with beaver-proof fencing and wood structures at pond outlets.

No fish habitat currently exists at Site 1; therefore, 2.06 ha of good quality habitat would be constructed.

A secondary outcome of this off-channel fish habitat project is the creation of wetland functions. These include providing additional fish and wildlife habitat, water quality improvement, water storage, and nutrient cycling.

6.3.2.4 Proposed Design

The preliminary site layout is provided in Figure 6.3-7 and 6.3-8 (a to c) and the components are described below. The off-channel concept is described in Section 6.1. The proposed project includes:

- 808 m of excavated stream channels;
- a water intake from Glacier Creek leading into the off-channel complex;
- flow control structures;
- 1.90 ha of ponds; and
- an outlet channel to an unnamed tributary which discharges into the Bell-Irving River.

The proposed components and features are described below.

The channels will provide high-quality rearing habitat for juvenile coho and Dolly Varden during the ice-free period. The pools in the channels will supply overwintering habitat in addition to the large ponds. The typical pond and channel layout and cross-sections are shown in Figure 6.1-1 to 6.1-3. Final channel dimensions and layout will be shown on construction drawings.

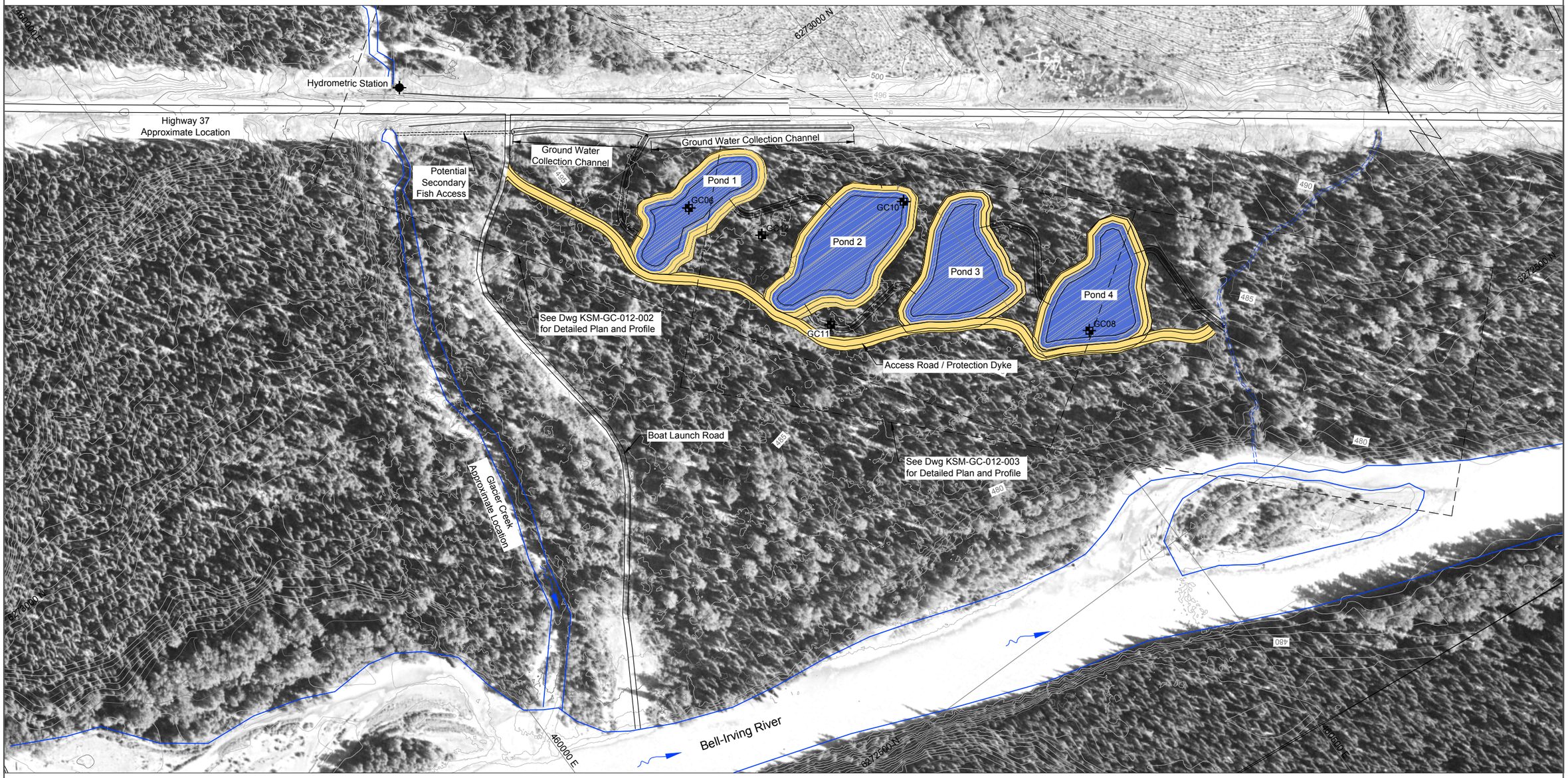
The typical wetted width of the channel will be 2.0-m wide and the channel incision will be 1.5 to 3.0 m in depth. Water depth in channels will depend on slope and will range from 0.05 to 0.3-m deep (excluding pool depth). The channel will be complexed with salvaged materials (i.e., cobble, boulders, LWD, root wads) such that approximately 50% of the channel has overhead or instream cover. Logs and root wads will be partially buried in the bank or cabled to boulders for stability (additional details on anchoring of LWD is presented in Section 6.1). The typical channel arrangement and details are shown in Figure 6.1-3.

Small pools will be excavated along the constructed channels every 20 to 30 m (Figure 6.1-1). Typical pools will be designed to have 1.0 m residual depth. They will be complexed with wood, branches, and boulders to provide cover. The gravel tailouts of pools will provide spawning habitat for the target species.

The channel will be sinuous with riffle/run/pool morphology and gradients from 0.5 to 8.0% (Figure 6.3-7 and 6.3-8 [a to c]). The channel will carry water from the Glacier Creek intake at 495 masl and down to the outlet with the Bell-Irving River (477 masl). Excavated material will be deposited alongside the channel to form a tote road. The working corridor will be 15 to 20 m in width.

Site preparation work prior to excavation will include tree felling and grubbing of root wads; trees and root wads will be incorporated as fish habitat features within the channel.

The key elements of this channel will be the groundwater collection systems and surface intake from Glacier Creek. This intake will be piped downstream of the culvert to the off-channel area and will not be passable by fish. The withdrawal amount will be determined based upon flow monitoring in Glacier Creek and design volumes for the channels. The protected off-channel complex will be situated on a gravel terrace with mature forest. The terrace has adequate space to fit a series of ponds. It gradually drops in elevation down to the same elevation as the floodplain of the Bell-Irving River.



LEGEND

- Stand Pipe Locations

0 20 40 60 80 100
Scale in Metres

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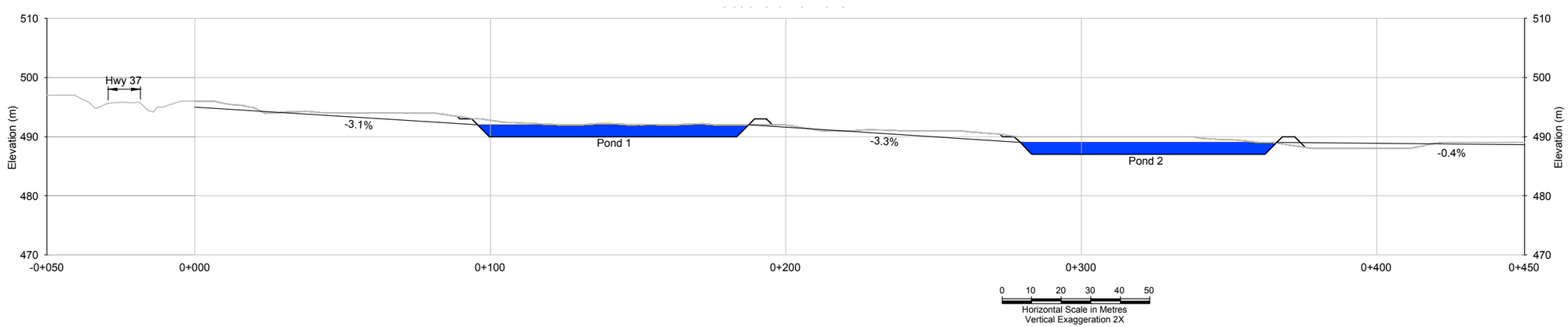
Figure 6.3-7

Glacier Creek Site 1 - Plan View



LEGEND

Stand Pipe Locations

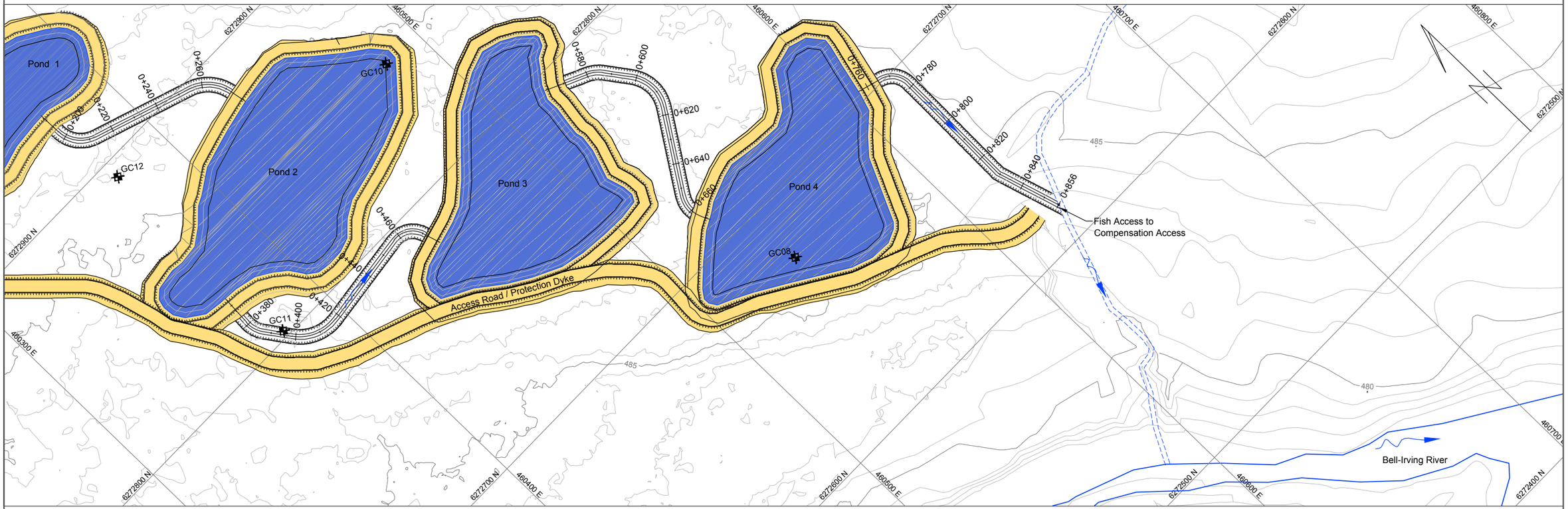


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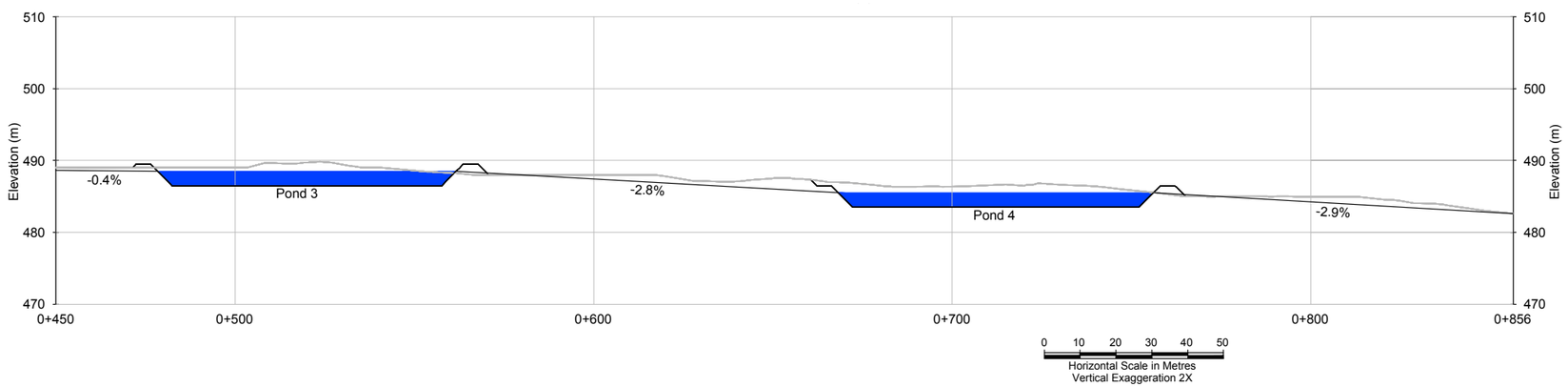
Figure 6.3-8a

Glacier Creek Site 1 - Plan and Profile View (Station 0+000 to 0+450)



LEGEND

Stand Pipe Locations

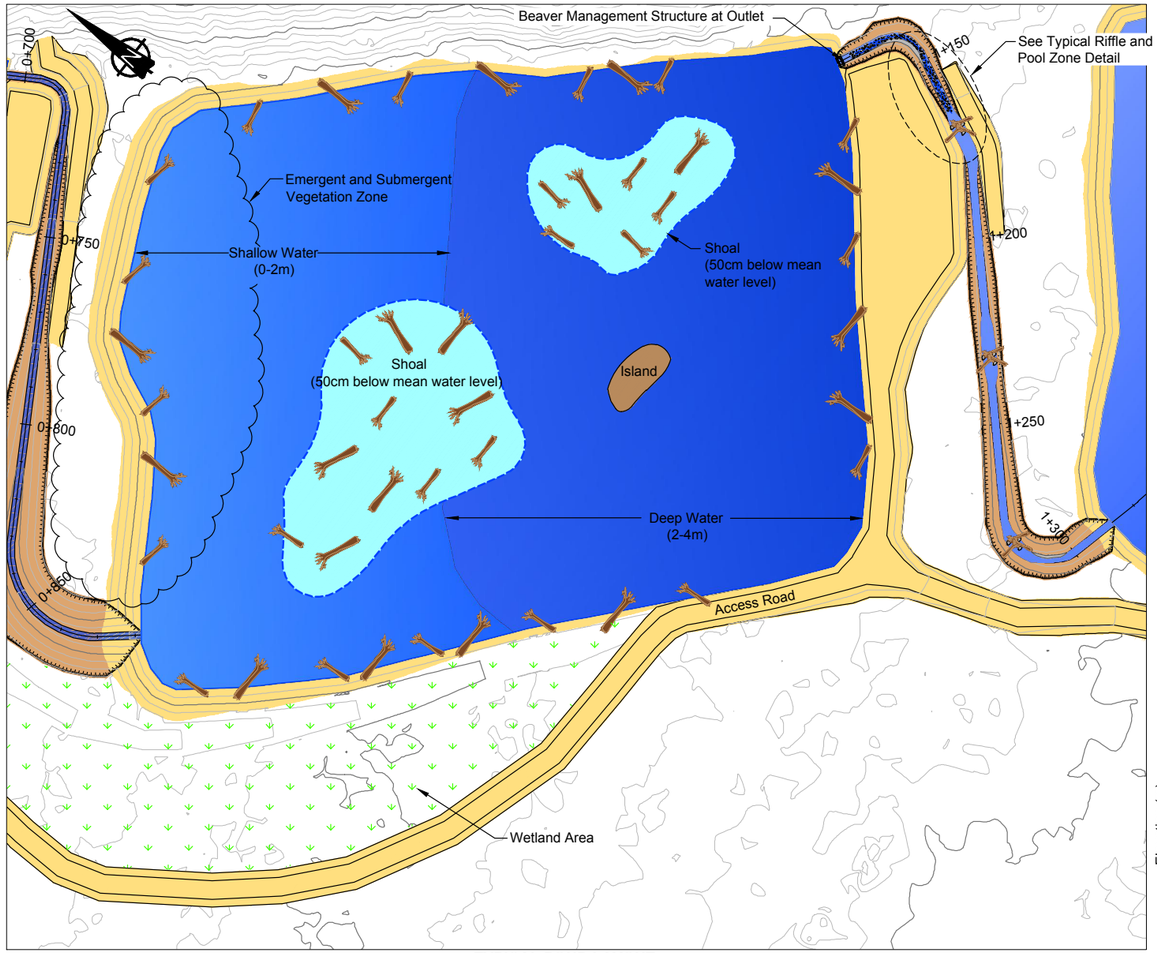


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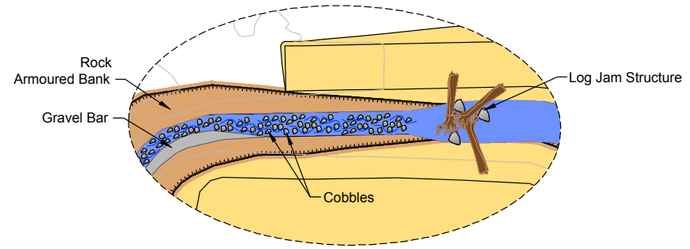
Figure 6.3-8b

Glacier Creek Site 1 - Plan and Profile View (Station 0+450 to 0+856)



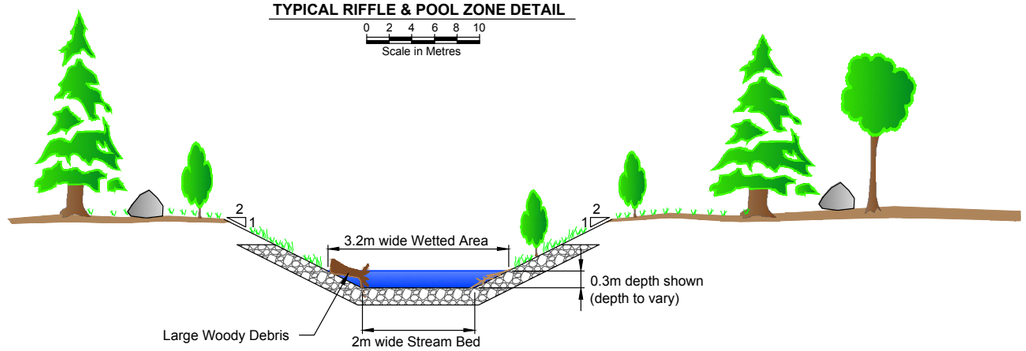
TYPICAL POND LAYOUT

0 5 10 15 20 25
Scale in Metres



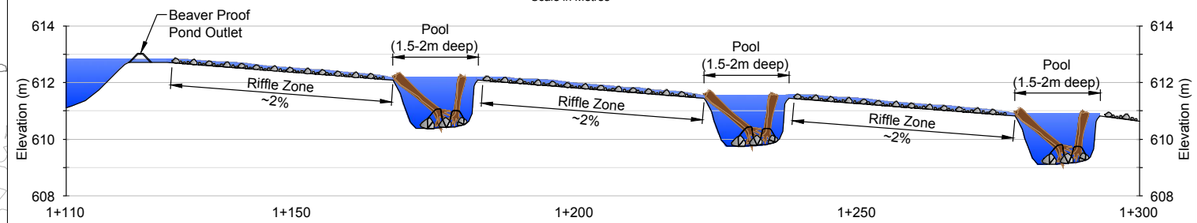
TYPICAL RIFFLE & POOL ZONE DETAIL

0 2 4 6 8 10
Scale in Metres



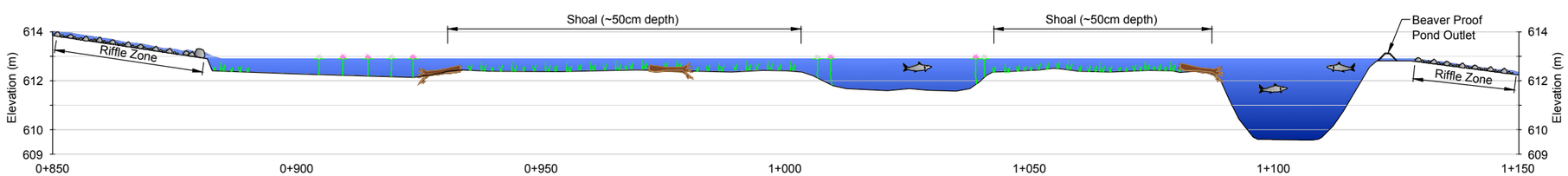
TYPICAL RUN ZONE CHANNEL SECTION

0 0.5 1 1.5 2 2.5
Scale in Metres



TYPICAL CHANNEL PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X



TYPICAL POND PROFILE

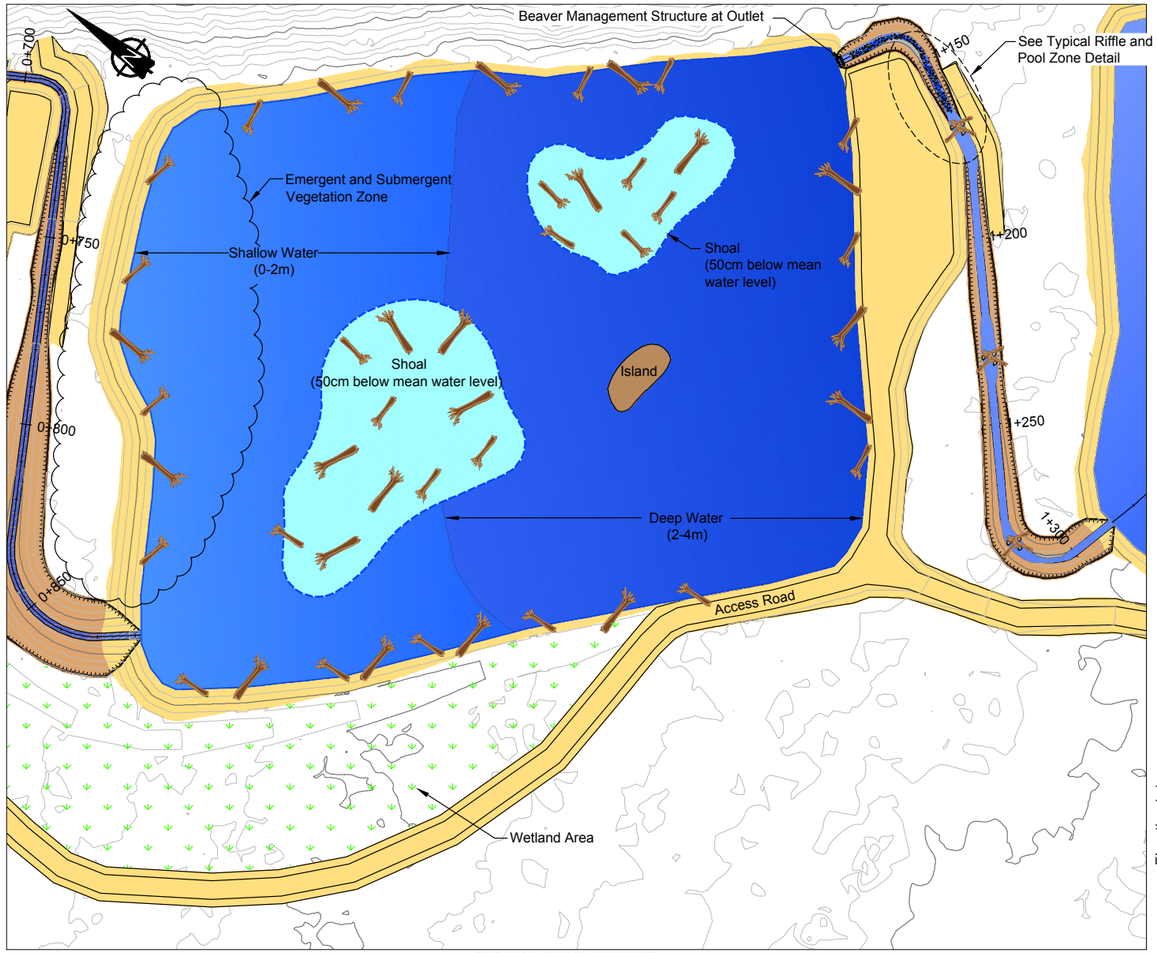
0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X

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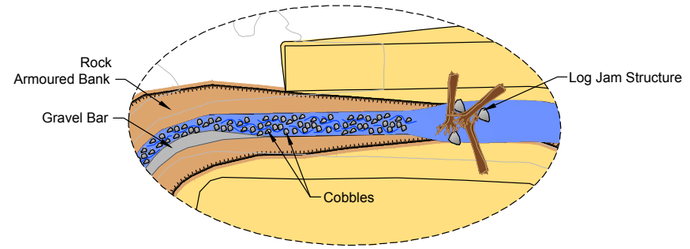
Figure 6.3-8c

Glacier Creek Site 1 - Pond and Channel Typical Plan and Sections



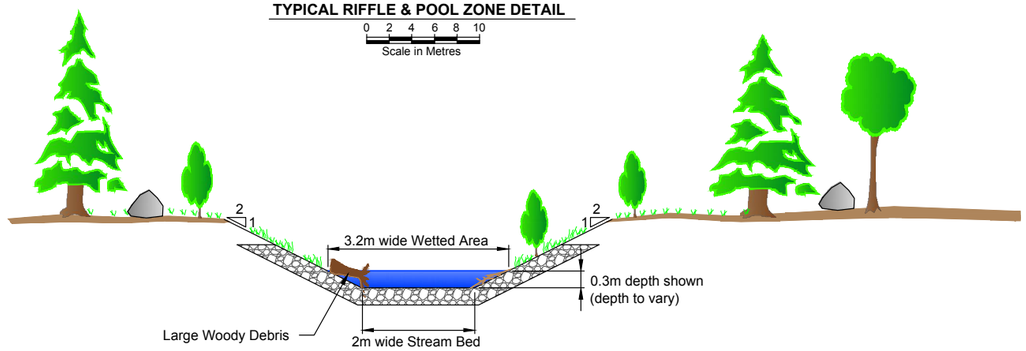
TYPICAL POND LAYOUT

0 5 10 15 20 25
Scale in Metres



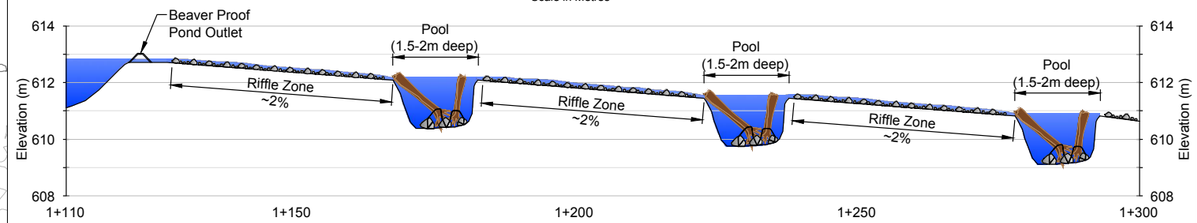
TYPICAL RIFFLE & POOL ZONE DETAIL

0 2 4 6 8 10
Scale in Metres



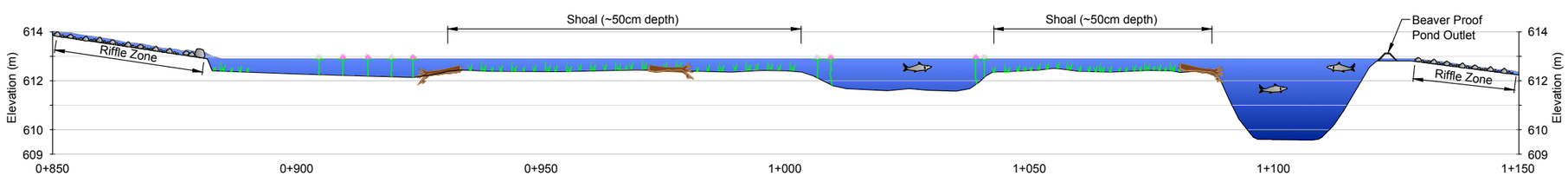
TYPICAL RUN ZONE CHANNEL SECTION

0 0.5 1 1.5 2 2.5
Scale in Metres



TYPICAL CHANNEL PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X



TYPICAL POND PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X

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Figure 6.3-8c

Glacier Creek Site 1 - Pond and Channel Typical Plan and Sections

Four large excavated ponds will be constructed at this site (Figure 6.3-7). The constructed ponds will range from approximately 0.36 to 0.57 ha and will be up to 4 m in depth (Figures 6.1-1, 6.1-2, and 6.3-8). Each pond will be fit to the local topography and existing aquatic features and fish will be salvaged prior to construction (e.g., sedges, wood, etc.). Beaver fencing and beaver structures (e.g., wood accumulations) will be built to prevent channel blockage and damage.

Construction of this site will require extensive excavation. It will require excavators, bulldozers and dump trucks to move materials. Highway 37 and the boat launch road provide excellent access for heavy equipment and crews.

6.3.2.5 Habitat Gain Summary

Tables 6.3-3 and 6.3-4 summarize stream and wetland habitat gain for the compensation site. Coho salmon HSI was used for HU calculation because it is the primary target species. A total of 38,035 HU and 20,580 m^2 will be gained from this site.

Table 6.3-3. Glacier Creek Site 1: Stream Habitat Creation Summary

Altered or Created	Area (m^2)	Coho Salmon Stream Habitat								Total HU
		Adult		Embryonic Stage		Fry Rearing		Parr Rearing		
		HS	HU	HS	HU	HS	HU	HS	HU	
Created	1,616	0.75	1,212	0.75	1,212	0.75	1,212	0.75	1,212	4,848
Total	**1,616**									**4,848**

Table 6.3-4. Glacier Creek Site 1: Wetland Habitat Creation Summary

Altered or Created	Area (m^2)	Wetland Habitat				Total HU
		Rearing		Overwintering		
		HS	HU	HS	HU	
Created	18,964	1	18,964	0.75	14,223	33,187
Total	**18,964**					**33,187**

7. Summary of Habitat Losses and Gains

A total area of 53,734 m^2 (5.37 ha) of fish habitat will be lost from TMF and seepage pond dams, access road crossings, transmission line crossings, and water quantity reductions in North Treaty and South Teigen creeks downstream of the dams. This represents a total of 91,115 HUs (Table 7-1).

A total area of 165,694 m^2 (16.57 ha) of fish habitat will be created as a result of the Teigen and Glacier creek technically feasible compensation projects. This represents a total of 300,917 HUs.

The ratio of compensatory habitat area to lost habitat area is 3.1:1. The ratio of compensatory HUs to lost HUs is 3.3:1, which is greater than the minimum 2:1 ratio typically requested by DFO. Therefore, the requirements to compensate for project related fish habitat loss has been effectively achieved. However, when fish habitat compensation construction proceeds, projects will be built according to a 2:1 ratio of compensatory HUs to lost HUs.

Table 7-1. HADD Compensation Plan Habitat Budget Summary

Habitat Loss		Habitat Gain Teigen Creek Site 1		Habitat Gain Glacier Creek Site 1		Compensation Ratio Achieved (Gained:Lost)	
Area (m^2)	HU	Area (m^2)	HU	Area (m^2)	HU	Area (m^2)	HU
53,734	91,115	145,114	262,882	20,580	38,035	3.1	3.3

8. Construction Management

8.1 CONSTRUCTION PLANNING AND TECHNIQUES

The technically feasible compensation projects will undergo final design development prior to construction. The proposed compensation sites are adjacent to or within fish-bearing streams and wetlands; consequently, construction must be implemented safely and effectively to avoid adverse effects. Implementation of the as built designs will involve construction planning, site preparation, design layout, mobilization of equipment and materials, onsite construction, and demobilization. Management and mitigation of risks and potential adverse effects to existing fish and fish habitat will be critical to the success of the compensation projects. These potential effects include:

- increased sedimentation or dewatering of fish habitat;
- contamination as the result of hazardous substance spills;
- loss or alteration of fish habitat;
- alteration of water and/or sediment quality; and
- alteration of the productive capacity of aquatic habitat.

A Fish and Aquatic Habitat Protection and Mitigation Plan has been developed for the environmental assessment process for construction. The plan will guide similar activities that will be carried out for construction of compensation sites to prevent impacts (Rescan 2012d).

The implementation and construction stages of the Plan are summarized below, including the type of activity and the risks they present to fish habitat. In addition to those measures listed in the Fish and Aquatic Habitat Protection and Mitigation Plan, mitigation measures are summarized in Section 8.2. The construction process will include the following components:

- Layout and site marking will include minor brush clearing and staking of the excavation boundaries for channel and pond arrangements. Crews will undertake danger tree assessment; identify fuel handling and fish salvage locations; and flag access routes, laydown areas, no disturbance and machine-free zones, and temporary stockpile locations, etc. This step poses no risk to fish habitat as no heavy equipment is involved.
- Heavy equipment will either be trucked to access points along existing roads or disassembled and flown into staging areas at remote sites. Airlifting of heavy equipment (e.g. excavator, bulldozer, and spider-hoe) into remote compensation sites will require laydown areas for equipment assembly. Generally, existing openings at least 50 m away from aquatic habitat will be used such that no risk is posed to fish habitat from accidents or spills during re-assembly.
- Temporary access (i.e., tote roads or trails) will be developed at compensation sites with minimal effect on riparian vegetation and fish habitat. Streams will be crossed with temporary structures (e.g., log box) built with onsite materials. Temporary fording of some channels will be required for initial access but only across stable channels with competent banks. Generally, excavated materials from channels and ponds will be spoiled into dikes for use as tote roads. Tote and access roads will be kept narrow (5 to 7-m wide) and avoid sensitive features. Risks to fish habitat along tote roads will be minimized by avoiding aquatic features as much as possible and preventing sedimentation. Temporary access routes will be re-vegetated upon completion to prevent erosion and sedimentation of aquatic habitat.

- Vegetation clearing and tree felling will conducted by hand in sensitive areas or with heavy equipment in non-sensitive areas (e.g., dry areas). It will involve minimal felling into or over existing fish habitat, as most vegetation and trees can be felled away. Clearing of trunks and root wads will be done with an excavator. LWD will be used in ponds and channels for complexing.
- Ponds and channels will be dug by medium to large excavators and a bulldozer will assist with creating berms at backwatered ponds. Dump trucks will be used at road accessible sites. Equipment will be leak-free, well-maintained and, where needed for instream work, will use biodegradable hydraulic fluids. Sedimentation risks to existing fish habitat from excavation will be managed by isolating work sites, constructing temporary diversions for clean stream flow through sites, or installation of sediment control features (e.g., sumps and pumps).
- Logs and boulders will be salvaged from pond and channel footprints or transported into sites by truck or helicopter. Materials sourced from outside the footprint of ponds and channels will come from other areas not situated near aquatic habitat (e.g., hillside wood will be transported by helicopter for instream structures).
- Extensive instream construction is planned and will require heavy equipment (e.g., spider-hoe, excavator) for working in wet and dry stream channels. A spider-hoe is a specialized excavator with wheels and posts instead of tracks and has a minimal footprint. This equipment has been used extensively for instream restoration throughout BC.
- Some existing beaver ponds and channels containing fish and fish habitat will be drained or modified to fit much larger compensation features at the same location. Fish will be salvaged from ponds. Fish will be released in the nearest similar habitat type while vegetation will be stockpiled for re-introduction to compensatory habitat. Water levels will be drained slowly to prevent downstream impacts and ensure a complete fish salvage.
- Environmental monitoring and continuous supervision will be essential for the successful completion of the compensation sites.
- A re-vegetation plan (Section 8.3) will be implemented as soon as construction activity is completed. The re-vegetation plan will include seeding and planting with approved plants and grasses to restore ground cover, stabilize soils, minimize sedimentation, and promote riparian function at all compensation sites.

8.2 MITIGATION MEASURES

8.2.1 Standard Operating Procedures

Relevant standard operating procedures will be followed in all habitat compensation projects. Pertinent legislation includes the *Water Act* (1996), the *Fisheries Act* (1985), and the *Species at Risk Act* (2002). The principles outlined in these and all other relevant federal and provincial enactments will be incorporated in the planning and implementation of all compensation activities. Appropriate permits and approvals will be acquired prior to beginning construction.

Qualified individuals familiar with standard operating procedures will direct and plan the work to maintain compliance with the standard operating procedures.

8.2.2 Best Management Practices for Instream Works

Best management practices (BMPs) will be followed during the construction and maintenance of the compensation projects. Compensation activities will be planned to avoid or minimize the adverse effects of these activities and to prevent long-term deleterious effects. Qualified professionals will manage the design, implementation, and monitoring of these activities to ensure the protection of

habitat and the implementation of BMPs. The general techniques, based on *Standards and Best Practices for Instream Work* (BC MWLAP 2004), *Fish Stream Crossing Guidebook* (BC MOF 2002), and *Riparian Revegetation* (DFO 2000), to be used during construction include:

- keeping machinery clean and preventing fuel leaks or spills;
- delineating work site boundaries and confining disruptive work to within those boundaries;
- designing access routes to minimize disturbance to existing habitat and vegetation;
- performing any in-water work to periods of least risk to fish;
- installing sediment control mechanisms where earth works are to take place; and
- minimizing disturbance to riparian vegetation and seeding and/or replanting riparian areas where vegetation is disturbed.

Additional mitigation measures that may be used during compensation works are detailed below. During the detailed planning stage, site-specific management plans will be created based on the specific construction plan and features of each site.

8.2.3 Site Access

Compensation sites will be accessed via helicopter and/or constructed access roads. Access plans will be made with consideration for individual site characteristics, minimization of environmental impact, and feasibility.

Access by helicopter will require the construction of helicopter landing sites, possibly requiring the clearing of trees and vegetation. The location of these sites will be chosen so that their clearing and use will not have significant adverse effects on bank stability and erosion.

Routes for temporary access roads will also be planned to minimize environmental disturbance. Where possible, crossing fish-bearing streams will be avoided. Where stream crossings are necessary, riparian disturbance will be minimized and fish passage will be provided (BC MOF 2002).

8.2.4 Vegetation Clearing

Trees and vegetation may be cleared during the construction of access roads, helicopter landing sites, stream access points, and refueling and construction zones. Additional clearing may take place during the excavation of new ponds or channels. Grubbing will be minimized, but is likely to occur in excavation projects. In compliance with WorkSafeBC policies, a dangerous tree assessment will take place in the construction area prior to beginning work. The dangerous tree assessment may require the removal of additional trees in the construction area. The effect of these activities on the environment will be mitigated with the following measures:

- trees to be removed, by permits, will be identified individually and will only be removed if it is deemed necessary;
- trees will be felled so that they do not enter the stream channel;
- trees and rootwads removed during construction will be used to build habitat complexity in the enhancement projects;
- work in compensation areas will use the minimum number of access points necessary, and locate them such as to avoid particularly sensitive areas of vegetation or areas where bank stability would be significantly affected (BC MWLAP 2004);

- where possible, machinery that must move down the stream may move along dry portions of the creek bed to avoid damaging vegetation; and
- damaged areas will be revegetated using vegetation salvaged from excavation areas whenever possible, or otherwise replanted and/or seeded with approved vegetation from other sources.

8.2.5 Sediment and Erosion Control Measures

Sediment mobilization and increased erosion are possible risks of construction in stream areas. Construction plans will be designed to maintain bank stability and mitigate or repair any damage caused by compensation work. To control and minimize the sediment mobilization and bank erosion, control measures that may be taken include:

- using water diversion structures to divert dirty water from the work zone to a sediment control area;
- installing silt fencing, geotextile cloth, hay bales, berms, or other sediment control structures;
- conducting instream work from the point farthest away from the access point and working backwards;
- allowing constructed ponds to settle before connecting to the stream;
- storing soil, substrate, removed vegetation and building materials in stable areas away from the channel;
- ensuring that all rock materials used in the stream are inert;
- placing introduced cover structures so that they will not result in unstable or eroding banks;
- ensuring constructed banks are graded at a stable slope; and
- stabilizing excavated materials and areas denuded of vegetation using temporary erosion control blankets, biodegradable mats, planted vegetation, or other erosion control techniques.

A response plan will be created to detail sediment and erosion control measures to be taken in the event of an unexpected increase in overland runoff or saturation of the work area due to precipitation. Additional measures will also be taken in the event that construction monitoring identifies a failure or potential failure of existing sediment control structures.

8.2.6 Fuel Management

The input of fuel or other deleterious substances to the stream will be prevented. Steps to be taken to prevent the occurrence of a spill include:

- inspection of all equipment and machinery prior to and during all work to ensure that it is clean and free of leaks;
- the use of environmentally-friendly hydraulic fluid and fuels in all heavy machinery to be used near/within watercourses;
- placement of drip pans and spill pads underneath pumps or other stationary machinery; and
- provision of readily-accessible spill kits in all areas where machinery or fuel tanks will be used, stored, or refueled, and training of personnel in their use prior to beginning construction.

A Spill Response Plan will be created that will detail the steps to be taken to properly contain, clean up, and report any spills that may take place. To ensure a rapid response to leaks and spills, all construction personnel will be trained in the procedures outlined in the Spill Response Plan.

8.2.7 Waste Management

All waste and excess material created or imported for the compensation projects will be stored and removed to avoid causing environmental harm. Examples of potential waste management include:

- developing protocols for waste reduction, reuse, and recycling during construction;
- storing soil excavated during construction on a stable surface outside of the stream channel and covered or contained by erosion control structures or replanted vegetation;
- managing vegetation removed from the work zone by either storing for salvage and replanting or piling away from the stream banks for storage or burning; and
- removing non-biodegradable materials brought into the site including sediment control structures, equipment, and supplies (BC MWLAP 2002).

8.2.8 Water Management

Should water diversion be required, coffer dams, pumps, or other approved water-diversion methods may be used to temporarily divert water around the construction zone while still maintaining flow downstream. Dirty water will be pumped to a sediment control area where the sediment can settle or be removed before returning to the stream (BC MWLAP 2002). Backup pumps may be kept on site in case of mechanical failure.

As part of enhancement activities, beaver ponds and other areas of standing water may be drained. Where draining of wetted areas occurs, measures will be taken to ensure that the process will not cause erosion of stream banks or terrestrial areas.

8.2.9 Fish Salvage

Prior to dewatering small ponds or streams, fish will be salvaged and removed from the site. As part of the fish salvage and exclusion process, the following steps will be taken to minimize disturbance:

- the pond or stream will be isolated using seine nets;
- passive or active capture techniques, or a combination of the two, will be chosen based on characteristics of the site and used to capture fish;
- fish will be immediately removed to recovery buckets; and
- post-recovery, fish will be moved to the suitable habitat nearest the salvage site.

In larger mainstem areas where isolation and salvage would be difficult, the site will not be sectioned with nets. Instead, electrofishing will be used to encourage fish to move from the immediate area immediately prior to any instream works.

8.2.10 Rare Species and Ecosystems

To mitigate for western toad habitat loss at compensation sites with potential/confirmed toad habitat, the following measures will be implemented in the Design and Construction phases of the projects:

- create ponds with shallow areas that maintain solar radiation of the ponds, allowing for suitable toad larval rearing habitat;
- create ponds with deep areas that increase the hydroperiod of the ponds to maintain pond habitat throughout the breeding and larval development stages;
- plant emergent aquatic vegetation within pond;
- create mudflats along the pond margins to provide breeding habitat; and
- construct compensation projects that will adhere to western toad breeding and rearing timing windows (i.e., mid-May to early September) within toad habitat.

To mitigate for rare ecosystem habitat alteration and/or loss at compensation sites with rare ecosystems, the following measures will be implemented in the Design and Construction phases of the projects:

- develop prescriptions to avoid or minimize degradation to rare ecosystems at a spatial and temporal scale prior to construction (including providing a clear definition of degradation, and methodology on how to measure it);
- assess the historical range of variability at the compensation site (e.g. frequency and magnitude of flood events, and evidence of late seral, longitudinal, and vertical movement of the river) relevant to the reference ecosystem. Assessing this variability will involve an analysis of both soil and vegetation characteristics, as well as channel morphology.
- design off-channel complexes to simulate natural conditions through seasonal flooding.
- ensure clearing activities are coordinated with other timing restrictions for wildlife and fish;
- conduct a rare plant survey prior to construction to identify and relocate plants. Where feasible, seeds or seed capsules will be collected and retained for future restoration efforts;
- consult the *Windthrow Handbook for British Columbia Forests* (Stathers, Rollerson, and Mitchell 1994) for guidance in assessing windthrow risk and for developing prescriptions to reduce the risk;
- minimize clearing dimensions (regardless of clearing size or ecosystem affected);
- manage construction spoil to not affect identified rare ecosystems;
- adopt low disturbance methods to clear vegetation within identified sensitive areas, where clearing cannot be avoided. In such areas, vegetation maintenance and removal techniques such as pruning, mowing, girdling, topping, and select tree removals allow root systems to remain intact, help bind the soil, and encourage rapid colonization of low-growing plant species (BC MOE 2010a);
- re-vegetate using vegetation salvaged from excavation areas whenever possible and/or seed in accordance with the Surface Erosion and Sediment Control Plan.
- preferentially retain mature and old trees (older than 80 years), where the option exists to remove younger stands;
- establish performance indicators that will be used to determine whether particular elements of the compensation plan are being implemented to evaluate how successful effects to listed ecosystems are being levitated; and
- review and summarize monitoring output and make adjustments, if necessary.

8.2.11 Construction Monitoring and Inspections

Throughout the access development and construction processes, a qualified environmental professional familiar with BMP will be present (BC MWLAP 2004). As part of his or her onsite activities, he or she will:

- oversee all work;
- inspect structures and activities;
- be provided with the authority to modify or halt any activity if he or she deems it necessary to protect fish, habitat, wildlife, or safety; and
- consult with the construction manager to ensure that all activities follow BMP.

Following the completion of the Construction Phase, the compensation works will be monitored according to a monitoring plan.

8.3 RE-VEGETATION MANAGEMENT PLAN

8.3.1 Overview

Fish habitat compensation will involve the disturbance and removal of existing vegetation at compensation sites. Vegetation disturbance and removal can expose soils (leading to potential soil erosion), change light regimes (allowing for colonization by invasive species) and disrupt riparian function. In order to both achieve the objectives of fish compensation and mitigate loss of other ecological functions, impacts to what are often pristine sites must be minimized.

The objectives of the Re-vegetation Management plan are to:

- stabilize soils to minimize potential for erosion and sedimentation; and
- promote, to the maximum extent possible, the restoration of diverse ecological functions at all compensation sites.

The Plan will be implemented as soon as construction activity is underway. Site-specific details will be developed and refined once the full extent of disturbance and loss of native vegetation cover, including dominant species, is known. These site specific plans will be developed by a qualified professional and will identify the methods for soil stabilization, vegetation salvage, species selection, timing, storage needs, and planting techniques. The re-vegetation plan will be driven by the scheduling of both mine and compensation site construction to maximize the efficiency of salvage and transplant operations and minimize soil and vegetation exposure.

Mitigation measures, detailed within the Fish and Aquatic Habitat Protection and Mitigation Plan (Chapter 26.18.1), will be adopted for all re-vegetation activities. These include specific measures pertaining to:

- standard operating procedures, which adhere to pertinent Provincial and Federal legislation, such as the Water Act (1996), Fisheries Act (1985) and the Species at Risk Act (2002);
- best management practices for instream works;
- site access;
- vegetation clearing;
- soil management (including mitigation of degrading practices such as compaction and rutting);

- sediment and erosion control measures;
- fuel management;
- waste management;
- water management;
- rare species (including western toad) and ecosystems; and
- construction monitoring and inspections.

Additional information guiding site-specific management activities may be incorporated from the Forest Practices Code Soil Rehabilitation Guidebook (MOF 1995). As described in this guidebook, re-vegetation represents a fundamental process in the rehabilitation process and may be conducted using a variety of techniques depending upon the specific site objectives. This guidebook presents a variety of techniques and solutions to be considered within the rehabilitation plans for re-vegetation of disturbances from:

- landings;
- roads and roadsides;
- excavated and bladed trails;
- compacted logging trails;
- ruts and areas of dispersed disturbance;
- gravel and rock pits; and
- landslides.

In addition to the above mitigation, additional information to incorporate in the development of a site-specific re-vegetation management plan may be incorporated from the following existing KSM Project management plans:

- **Wetlands Management Plan** (Chapter 26.19)
  The primary objective of this Plan is to minimize effects on wetlands through implementing targeted activities, monitoring, and adaptive management.
- **Vegetation Clearing Management Plan (Chapter 26.20.2)**
  The primary objective of this Plan is to minimize the effects of vegetation clearing and degradation (secondary vegetation loss and disturbance) linked to clearing activities. Mitigating the loss of ecosystem function is of critical importance. Ecosystem functions include habitat, hydrological, water quality, and soil stability functions.
- **Invasive Plant Management Plan (Chapter 26.20.2)**
  The primary objectives of this Plan are to minimize the creation of suitable habitat for invasive plant species (with emphasis on the NWIPC priority plant species) and minimize the opportunity for invasive plant seeds or reproductive material to be transported into the site. It will draw upon the Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia (BC MOFR 2010), which outlines an integrated pest management (IPM) approach for invasive alien plants, under the authority of several partnering ministries. The implementation of an IPM approach is also a recommended strategy of the NWIPC (2011).

- **Wildlife Management Plan (Chapter 26.21)**
  The overall objectives of the Wildlife and Wildlife Habitat Management Plan are to minimize wildlife mortality as a direct consequence of the Project; and to avoid any adverse effects on protected species, their habitats, or breeding and feeding activities.

- **Erosion Control Plan (Chapter 26.13)**
  The primary objective of this Plan is the prevention of soil erosion throughout all phases of the Project. As vegetation cover plays a vital role in erosion control, areas where vegetation has been temporarily removed will be re-vegetated with an appropriate seed mix as soon as possible. Additional means of soil surface stabilization will be used while the vegetation is established where required.

8.3.2 Site Review and Re-vegetation Objectives

The site review process involves an inventory of the vegetated ecosystems present within the proposed compensation site, prior to construction works. This allows for the documentation of species assemblages which in turn inform what ecological functions are performed at the site in its pre-disturbance state. The review phase is critical to project success; by documenting what ecological functions are present, reasonable and achievable objectives can be met for re-vegetation for the overall objective of restoring ecological function. This must be done within the limitations imbued to site as a consequence of fish habitat compensation work, the construction and maintenance of which will, in certain cases, mitigate the reestablishment of previously existing ecosystems.

Re-vegetation objectives will therefore be determined by the site review, the type disturbance associated with compensation efforts, and by the expected limitations imposed on the site after compensation features have been established. A like-for-like ecosystem restoration target will not necessarily be promoted, as it may very well not be ecologically feasible. Ecological seral development can result in alternate steady states. While many factors are involved, the type and duration of disturbance plays an important role in what path seral development follows. For example, fish compensation sites will, in many instances, alter local hydrology. This will permanently (or as long as the compensation structures are in place) alter the soil moisture regime in the associated riparian areas, which will affect which plant assemblages are dominant. Therefore, managing for the return of the pre-existing plant community will be a tenuous undertaking.

8.3.3 Selection of Re-vegetation Techniques

The purpose of the Re-vegetation Management Plan is to establish vegetative ground cover to retain ecosystem function and to avoid soil loss and erosion at compensation sites. Detailed plans will be created in order to consider the on-the-ground conditions post-disturbance. These will be site specific. Activities associated with the re-vegetation plan include the following:

1. Determine the future characteristics (soil depth, soil nutrient potential, likely plant species and relative dominance, light regimes during development and maturity) and functions (productivity, hydrologic function, biodiversity, habitat) of the disturbed site in order to determine which type of plant communities should be managed for.
2. Identify appropriate re-vegetation species in consultation with relevant experts that is determined by the following:
   - Biogeoclimatic ecosystem classification (BEC) unit;
   - baseline species assemblage;
   - elevation;
   - terrain type;

- soil type;
- time of planting;
- local weather trends (e.g. dry year vs wet year);
- slope location (lower bank, mid bank, upper bank); and
- disturbance type and intensity.

3. Prepare the site based on the identified end use objective using standard best management practices outlined in the Forest Practices Code Soil Rehabilitation Handbook and in accordance with the Department of Fisheries and Oceans Riparian Areas and Re-vegetation guidance (2000). Site preparation may be altered based on local ecological site requirements. Existing native vegetation will be retained wherever practical, including protection of trunk, limbs and roots from damage through use of machinery;
4. Re-vegetate the site based on standard best management practices outlined in the Forest Practices Code Soil Rehabilitation Handbook. These will include:
   - no planting within shallow open water wetland areas with water depths > 50 cm.
   - shallow emergent vegetation along slopes of less than 3:1 run:rise in areas with less than 50 cm of water depth (seeding and potential cuttings).
   - designated tree planting on elevated berms or mounds throughout the shallow swamp wetland areas (planting of selected seedlings and saplings in specific areas and densities).
   - adjacent forested wetland transition zones (seeding, planting of saplings, and cuttings in selected areas based on the flood or drought tolerance of selected species). Planting will use a combination of seedlings, cuttings and salvaged materials at each site.
5. adjacent upland areas within the wetland buffer that have been disturbed by restoration activities (open soil stabilized against erosion and planting of native sapling and seedling species that replicates the existing stand and shrub structure of the pre-compensation habitat).

8.3.4 Implementation of Re-vegetation Works

While the specific issues, site objectives and disturbance extent and severity may dictate the technique to be used, two re-vegetation techniques commonly used in restoration activities include dormant cuttings and transplants (Babakaiff, Hay, and Fromuth 1997).

Dormant cuttings are used in restoration projects in a variety of ways, including live staking, brush layering, live siltation, brush mats, and bundles (fascines). Dormant cuttings can be harvested from living, woody plants during the winter/early spring (or during the fall if planting will occur in the fall) or purchased from nurseries. Cuttings are collected from plant species that root easily, such as willow, poplar, and cottonwood. Live staking is often used in conjunction with other re-vegetation techniques and is an inexpensive method of re-vegetating a site. It does, however, have a lower survival rate when compared to other re-vegetation techniques. Brush mats constructed of dormant branches provide both erosion control and vegetative cover to an area. They require large amounts of plant material, which will be considered prior to their inclusion in a re-vegetation design.

Transplanting involves the relocation of a plant or plants containing roots and shoots from one area to another. Transplants can vary in size, from large vegetation mats to smaller plugs, sprigs, and single-plant transplants. All types of transplants require careful handling in order to ensure success. Transplanting can be mechanized, depending on the size of material (e.g., vegetation mats). Transplanting is a suitable re-vegetation method used for species that do not root well from cuttings.

Vegetation mats can also be propagated in a greenhouse or outdoors. The benefit of vegetation mats is that they provide an instant plant cover and also help protect the site from soil erosion.

If the introduction of herbaceous vegetation to the area is a desired goal, then the use of a vegetation mat composed of native grasses or sedges will be considered. Similarly, grass and sedge species can be fashioned into a roll, held together with biodegradable fabric and twine (Babakaiff, Hay, and Fromuth 1997). When placed along the bank, the roll provides structural protection as well as an overhanging vegetative cover. Plugs and sprigs are smaller than vegetative mats and often contain only one plant species. They can be collected from a donor location or can be grown in a nursery or greenhouse environment.

8.3.5 Seed Mixes and Plant Species Selection

Target plant species can be those used to either stabilize soil and prevent soil erosion, or to attempt to initiate an ecological seral trajectory. The first priority will be to prevent the loss of the soil resource, as all other restoration objectives are dependent on soil availability.

Where seeding represents the preferred rehabilitation option, an approved seed mix for low elevations will be developed for the fish habitat compensation sites in consultation with local seed source suppliers and/or other experts such as local Ministry Agrologists. Where possible, a locally-sourced mix will be selected based on the detailed site information that will be provided to the seed distributor. Such detailed site information will include the following:

- Project region;
- current provincial biogeoclimatic ecosystem classification (BEC) unit (i.e. Very Wet Cold Interior Cedar Hemlock Subzone, ICHvc) and baseline species assemblage;
- disturbance elevation (or elevation range); and
- disturbance type and intensity.

The types of plants used to re-establish ecological function will be entirely site specific: specification is beyond the scope of this plan. However, plant salvage at the site will be a priority.

8.4 PROPOSED SCHEDULE

The compensation project planning and completion will be composed of six phases: Detailed Design Assessment, Detailed Design Planning, Permitting, Second Year Fisheries Monitoring Assessment, Pre-construction Planning, and Construction (Table 8.4-1). Construction is tentatively scheduled after the permit approval process and within one year after commencement of construction of the KSM Project, but will be subject to changes based on the KSM Project schedule.

Table 8.4-1. Proposed Compensation Schedule

	2012				2013				2014				~1 Year of Project Construction			
Phase	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Detailed Design Assessment																
Detailed Design Plan																
Permitting																
2nd Year Fish Monitoring Assessment																
Pre-construction Planning																
Construction																

"Q" represents quarter of a year.

During the Detailed Design Assessment Phase, the soils, hydrology, water quality, and groundwater influence in the proposed compensation sites will be assessed. Additional physical surveys will be conducted at Teigen Creek to further characterize the site's soils and groundwater.

The Detailed Design Assessment Phase will provide the necessary data for detailed design planning. During the Detailed Design Planning Phase, the physical site information will be used to develop construction plans for the selected sites. The detailed design plans will expand on previous technically feasible plans to include more specific project features and design drawings.

The Permitting Phase will involve identifying and applying for any necessary government tenures, permits and approvals. Permitting also includes EA and Section 35(2) *Fisheries Act* (1985) approvals. The Pre-construction and Construction phases will only be initiated once all permits and approvals are secured.

Additional fisheries assessment info will be collected to complement existing baseline studies. Fish and fish habitat information will be collected at the proposed compensation sites as needed. This baseline data will act as the basis for the post-construction intensive effectiveness monitoring (Section 9.2).

Logistical planning and organization for construction activities will take place during the Pre-construction Phase. Site access routes; construction schedules; and the organization of equipment, supplies, and activities will be addressed during this phase, which will occur prior to and concurrently with the construction.

The Construction Phase will entail constructing physical works as per the specifications outlined in the constructions plans. The plans will be modified where necessary to ensure proper site function. Construction of compensation projects will be staged for effective project management. At the completion of this phase all compensation habitat will have been constructed and the full compensation area created.

After site construction is completed, post-construction monitoring will be carried out according to the plan detailed in Section 9.

8.5 TENURE AND ACCESS

All proposed compensation sites are on Crown Land (Integrated Land and Resource Registries 2010) and will not require permission from private landowners. Permits and authorizations required for this project will include:

- *Fisheries Act* (1985) Authorization to modify fish habitat;
- Water Licence for activities requiring water diversion;
- Ministry of Forests and Range Special Use Permit for construction of access roads;
- *Wildlife Act* (1996) Permit for projects requiring the disturbance of beavers and/or beaver dams;
- Fish Collection Permits from the BC MOE and DFO for salvage of freshwater and anadromous fish species, respectively; and
- Licence to Cut from the BC MOF for the removal of trees in the construction of access roads and new fish habitat.

In addition, consultation with a Navigable Waters Protection Officer will be needed to determine whether approval will be required under the *Navigable Waters Protection Act* (1985). Other necessary permits or approvals may be identified during future compensation planning. All pertinent permits and authorizations will be acquired prior to beginning work.

9. Compliance and Effectiveness Monitoring

9.1 COMPLIANCE AND ROUTINE EFFECTIVENESS MONITORING

Post-construction compliance and routine effectiveness evaluation (REE) monitoring focuses on project integrity, compliance with approved designs, and biological effectiveness. Compliance and REE monitoring is primarily qualitative in nature; however, quantitative data are collected. The primary methods include simple measurements and surveys, observation, and use of existing design documents (Pearson et al. 2005).

Compliance and REE monitoring will be conducted for all compensation projects. An as-built topographical survey will be completed in Year 1 following construction for all instream structure types (e.g., boulder clusters, LWD), to allow for construction materials to settle and allow for bed scour. A checklist for presence and integrity of important project elements will be developed and used to facilitate comparisons (BC MWLAP 2001). Photographic monitoring of important project features (e.g., inlet structures) will be taken.

To verify that a compensation project was implemented as designed and approved, a number of variables will be measured. These variables will include, but not be limited to the following (Pearson et al. 2005; Slaney 2006; BC MWLAP 2001):

- Area: Does the total area of habitat created or restored match that of the specifications of the approved design?
- Configuration: Does the spatial arrangement of habitat types correspond to the approved design?
- Materials: Are the materials used of the type and size specified in the approved design?
- Structural integrity: Are all structures (e.g., inlets, outlets, riffles, rootwads, etc.) in place and functioning as designed? Is there significant structural instability (e.g., erosion) on the site?

As habitat changes over time, additional post-project surveys will be conducted following construction in Years 2 and 5. Monitoring will involve rating of all projects as a four point scoring of performance (i.e., success to failure) in meeting both physical and biological project objectives, structural stability and condition, and maintenance needs (BC MWLAP 2001). Furthermore, informal visual inspections of structural integrity will be conducted as part of intensive effectiveness monitoring (Section 9.2). If a compensation project is not functioning optimally, then project changes and additional construction may be required.

The results of the compliance and REE monitoring will be provided to regulatory agencies, Aboriginal groups, and other stakeholders.

9.2 INTENSIVE EFFECTIVENESS MONITORING

9.2.1 Experimental Design

The objectives of intensive effectiveness monitoring are similar to those of REE monitoring with the exception that measures of biological effectiveness are quantified, usually in terms of net change in habitat productive capacity. Intensive effectiveness monitoring focuses on quantitative experimental design and statistical analysis. Site effectiveness monitoring is typically applied to large and/or complex compensation projects (Pearson et al. 2005).

Site effectiveness monitoring will be conducted for all compensation projects. The approach to effectiveness monitoring will follow a Before After Control Impact (BACI) experimental design for sites with existing habitat to be enhanced (e.g., Treaty Creek Site 1). The approach to effectiveness monitoring will follow a post-treatment experimental design for sites that create new habitat because there is no baseline data with which to compare (e.g., Taft Creek Site 1). Two years of pre-construction monitoring data will be gathered to account for inter-annual variances in the BACI experimental design. Post-construction effectiveness monitoring will follow two, two-year periods to allow for separate statistical testing in each of the two periods (Pearson et al. 2005):

- Short term - Years 1 and 2; and
- Medium term - Years 5 and 6.

After Year 6, compensation project effectiveness will be evaluated and the necessity of future monitoring will be determined.

To quantify a net change in habitat productive capacity multiple key performance criteria will be evaluated and will depend upon the project-specific objectives, target habitats, fish species, and life history stages (Section 9.2.2).

Control sites will be selected (one local and some distant) for compensation projects. This will allow for spatial nesting to permit examination of fish movement effects on local abundance. Control sites will be similar in character to post-construction project sites for BACI experimental designs. For post-treatment experimental designs, control sites will be similar in character to pre-construction project sites. Control sites will be an appropriate distance from the project site in relation to distances typically moved by the species studied.

Accurate, detailed, and standardized records will be kept and will compare the survey results with baseline data, control sites, and performance targets to judge the performance of the compensation projects. The results will be summarized in a review of compensation effectiveness after three years. Should it be determined that the compensation habitat is not functioning properly, remedial actions will be taken that may include modification of the compensation sites.

9.2.2 Monitoring

The concept of productive capacity is central to DFO's fish habitat management activities and is defined as "the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend" (DFO 1986). Fish production is usually defined as fish biomass or population abundance for a defined area of habitat (Randall and Minns 2000). However, productive capacity must take into account the structural (e.g., biodiversity and habitat) and functional (e.g., energy and material flows) ecosystem features essential for sustained natural productivity (Minns et al. 2011).

To assess productive capacity for off-channel habitat projects, a three-tier approach is recommended. The first tier includes individual-based metrics for inferring productive capacity. These metrics include condition and growth, which are indicators of habitat quality and are sensitive indicators of environmental change (Pearson et al. 2005). Condition is used as a measure of fish nutritional status, and fish of "good condition" leading into the onset of winter months have an increased likelihood of survival (Anderson and Neumann 1996; Pope and Kruse 2007). The second tier includes population-based assessment methods for measuring productive capacity. This metric will include abundance (relative catch per unit effort, absolute abundance, density, biomass) by habitat type. The third tier includes ecosystem-based assessment methods for measuring productive capacity. This metric will

include riparian vegetation cover, water temperature, benthic invertebrates (biomass, density, richness, and diversity), and periphyton (biomass, diversity) by habitat type. Table 9.2-1 and the following sections discuss what metrics will be sampled, when sampling will occur, and target species and habitats.

Table 9.2-1. Short and Medium Term Off-channel Habitat Creation Productive Capacity Metrics

Tier	Metric	Measurement	Timing	Target Species and Life History Stage	Habitat Type	Field Method
First	Late Summer Condition	Length vs. Weight Regession Mean Condition Factor	Late May and late August	Coho Salmon - Fry	Stream and Wetland	Electrofishing and Minnow Trapping
				Dolly Varden - Fry	Stream	Electrofishing
	Late Summer Growth	Mean Fork Length Mean Weight	Late May and late August	Coho Salmon - Fry	Stream and Wetland	Electrofishing and Minnow Trapping
				Dolly Varden - Fry	Stream	Electrofishing
	Late Summer Condition	Length vs. Weight Regession Mean Condition Factor	Late August	Coho Salmon - Parr	Stream and Wetland	Electrofishing and Minnow Trapping
				Dolly Varden - Parr, Juvenile, Adult	Stream and Wetland	Electrofishing and Minnow Trapping
Second	Late Summer Abundance	Density/Abundance	Late August	Coho Salmon - Parr	Stream (by habitat unit) and Wetland	Three-Pass-Removal/Mark Recapture
				Dolly Varden - Parr, Juvenile, Adult	Stream (by habitat unit) and Wetland	Three-Pass-Removal/Mark Recapture
	Early Spring Abundance	Density/Abundance	April	Coho - Smolts	Stream and Wetland	Smolt Fence
				Dolly Varden - Parr, Juvenile, Adult	Stream and Wetland	Minnow Trap Mark Recapture
Third	Primary and Secondary Productvity	Biomass/Density/Richness/Diversity	August	Benthic Invertbrate	Stream and Wetland	Surber Sampler
				Periphyton	Stream	Rock Scraping/Hester-Dendy Sampler
	Water Quality	Dissolved Oxygen Nitrate Phosphorus Ammonia pH Suspended Sediment	March and August	NA	Stream and Wetland	Water Quality Meter, Water Samples
	Riparian Vegetation	Percent Cover Species Composition	August	NA	Riparian	Line Transects/Quadrats
	Water Quantity	Discharge	Continuous	NA	Stream and Wetland	Data Logger
	Water Temperature	Temperature	Continuous	NA	Stream	Data Logger

NA = not applicable

Off-channel habitat in the study area is used for summer rearing and overwintering by Dolly Varden and juvenile (fry and parr) coho salmon (Rescan 2007, 2009, 2010, 2011, 2012a). To infer productive capacity of fry throughout the growing season, the average condition/growth (i.e., mean weight and

fork length) attained by stream and wetland rearing fry on a common date in late-summer (before any out-migration or movement) will be quantified and compared to size after fry emergence. This will incorporate condition/growth over the entire post-emergence period. The size (biomass/weight) that fry have attained at the end of summer is important in influencing their subsequent overwinter survival (Holtby 1988; Quinn and Peterson 1996). By quantifying condition/growth of fry by a common date in late-summer, created sites and reference sites can be compared, which can take into consideration differences in fry emergence dates, water temperature, and primary production between streams.

Field assessment data suggest that coho salmon parr (1+) overwinter within off-channel habitats in the study area (Rescan 2007, 2009, 2010, 2011, 2012a). Dolly Varden are resident and reside/overwinter in off-channel habitats for their entire life span (up to six years). To infer productive capacity of parr, juveniles, and adults (Dolly Varden only), the mean condition attained by stream- and wetland-rearing fish on a common date in late-summer will be quantified. This metric is directly related to over-winter survival and subsequent smolt abundance (Thedinga and Koski 1984; Quinn and Peterson 1996).

Density-dependent mortality occurs primarily in the first year (fry) of fish life (Elliot 1987; Ward and Slaney 1993; Crozier and Kennedy 1995; Whalen et al. 2000). Therefore, parr abundance is a more reliable metric of productive capacity for late-summer rearing habitat (streams and wetlands). Furthermore, late-summer standing stock is directly related to smolt production (Quinn and Peterson 1996) in coho salmon. In stream and wetland habitat, parr abundance will be estimated through closed mark-recapture methods (Johnson et al. 2007). The habitat and flow conditions created for off-channel stream habitats will likely be conducive towards the effective use of stop nets. However, three-pass removal methods (Lockwood and Schneider 2000) will be used in stream habitats, if habitat, logistics and flow conditions dictate that mark-recapture methods are not practical.

Peer-reviewed literature suggests that mark-recapture is the preferred approach (Peterson et al. 2004; Johnson et al. 2007) because the severity of the bias is generally lower for mark–recapture estimates of stream fish than reported for multiple removal sampling. Furthermore, mark–recapture estimates are fairly robust to potential bias introduced from crew experience and variable habitat (cover percent).

The number of stream and wetland sites sampled for each off-channel site will be dictated by the length of stream habitat created, and by the number of ponds/wetlands created.

At each site, late-spring coho salmon smolt production will be estimated through the use of a smolt-trap fence. Traps will be checked daily through the duration of the out-migration period. Trap efficiency and capture probability will be determined by weekly mark-recapture studies, in which a sub-sample of captured smolts will be marked and released immediately upstream of the fence and potentially recaptured in the trap. Production estimates will be derived using Darroch Analysis with Rank-Reduction (Carlson, Coggins, and Swanton 1998; Bjorkstedt 2005). Mean condition of smolts will also be assessed. It is recognized that smolt population estimates for each site may result in an underestimate of the true smolt population estimate because of a percentage of late-summer fry and parr movement out of the site. These fish may reside in other overwintering habitats (e.g., Bell-Irving River) to eventually become smolts.

Since Dolly Varden in the fish and aquatic habitat study area are not migratory, late-spring Dolly Varden (juvenile and adult) populations will be estimated in streams (pool habitats) and wetlands through the use of minnow trap mark-recapture methods. Mean condition of resident Dolly Varden will also be assessed.

As a measure of primary and secondary productivity, benthic macroinvertebrates and periphyton will be sampled at created and reference sites during the late-summer. Their community structure

(species richness and diversity, relative abundance) and biomass is responsive to changes in water quality and physical habitat features (e.g., substrate type). Water quality will be monitored at the sites, which will include dissolved oxygen (wetlands and streams), nitrate, phosphorous, ammonia, pH, and suspended sediment (Pearson et al. 2005). Water temperature and water levels will be monitored continuously throughout the year through the use of data loggers at each site.

The function that the riparian zone provides to fish, fish habitat, and productivity (primary and secondary), will be assessed at each site. Measures of riparian cover (e.g., percent area), mean stem density, and species composition will be monitored.

10. Consultation with First Nations and Stakeholders

Key Aboriginal groups and stakeholders, as identified in the Section 11 Order issued by the British Columbia Environmental Assessment Office, within the fisheries study area are: DFO, MOE, Gitanyow First Nation and Wilp Wii'litsxw, Gitxsan First Nation, Skii km Lax Ha, Tahltan Nation, and Nisga'a Nation. Consultation with the DFO, BC MOE, and Aboriginal group representatives was initiated early in the baseline data assessment phase and environmental assessment process through fisheries working group meetings and consultations. The goal of the meetings and consultations is to ensure knowledge and concerns of all parties were brought forward to be addressed and incorporated into the development of the baseline reports and environmental assessment, including compensation strategies. Fisheries working group meetings have been held since 2008 and will be ongoing throughout the compensation development process.

Secondly, Aboriginal groups and stakeholders were invited to review and comment upon baseline work plans and baseline reports and provide suggestions for fish habitat compensation projects within the study area watersheds. Public open houses were held to educate the public about the Project and answer questions and respond to comments.

Consultation with the general public, stakeholders, and Aboriginal groups will be ongoing during the Environmental Assessment Application process. During the application review period, Seabridge will engage the public and Aboriginal groups by publishing notices in local publications and make copies of the Environmental Assessment Application available in local libraries and/or other suitable generally accessible locations. Seabridge will respond to information requests and comments received through the British Columbia Environmental Assessment Office to address specific issues or concerns raised by the participants.

11. Cost Estimate

Preliminary ranges of cost estimates for construction were developed for the sites described in the Plan (Table 11-1). The primary factors affecting the cost of building the proposed fish habitat compensation sites are:

- the location of the sites (i.e., presence of roads);
- overall extent and total area of habitat to build;
- extent of excavation;
- complexity of the proposed features;
- heavy equipment requirements; and
- personnel requirements.

A range of estimates for the duration of construction is provided (i.e., weeks, months, etc.).

Table 11-1. Costs and Planning for Compensation Site

Watershed	Sub-Watershed	Waterbody	Waterbody Site Number	Compensation Project Type	Area to Build (ha)	Heavy-Lift Helicopter Required	Minimum Heavy Equipment Required	Existing Road Access	Access Cost	Construction Complexity and Duration	Onsite Construction Cost (excluding access costs)
Teigen	-	Teigen Creek	1	Off-channel pond and side channel	10.56	Potential	2 excavators, bulldozer	No	High	Complex, 3 to 7 months	3.9 M
Bell-Irving	Glacier	Glacier Creek	1	Off-channel pond and side channel	2.06	No	excavator, bulldozer	Yes	Low	Complex, 1 to 3 months	1.0 M

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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Map Pockets

Rescan™
Engineers and Scientists

Figure 2.2-1
Tailing Management Facility Watersheds:
Channel Morphology

Reach Break
Watershed

Fish Obstacle
Beaver Dam
Cascade
Log Jam
Other

Channel Morphology
Cascade Pool
Large Channel
Riffle Pool
Step Pool
SHIM Wetland

Slope
< 20 % Slope
20 - 30 % Slope
> 30 % Slope
Paved Road
Gravel Road
Rough Road

Topography
River - Indefinite
Beaver Dam
Rapids
Intermittent or Indefinite Lake
Swamp
Marsh
Glacier
Icefield
Sand or Gravel Bar
20 m Contour
100 m Contour
Depression Contour
Indefinite Contour
Access Road

Collection Ditch
Collection Pipeline
Collection Tunnel
Culvert
Diversion Ditch
Diversion Pipeline
Diversion Tunnel
Penstock
Spillway
Valve

Landfarm / Landfill
Rock Storage Facility
Ore Stockpile
Till Stockpile
Subsidence Zone
Haul Road
Borrow Area
Log Landing
Waste Area
Dam
Pond
Glacier Diversion Inlet
Snow Storage

1:10,000

0 500 1,000
Metres

Date: January 2, 2013
File Reference: KSM-06-138
Projection: UTM9, NAD83

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Figure 2.2-2
Tailing Management Facility Watersheds: Rearing Habitat

Fish Obstacle
- Beaver Dam
- Cascade
- Log Jam
- Other

Rearing Habitat Quality Rank
- Good
- Fair
- None
- Poor
- Density Site
- SHIM - Mapped Wetland

Slope
- < 20 % Slope
- 20 - 30 % Slope
- > 30 % Slope

- FHAP Locations
- Reach Break
- Watershed

Topography
- River - Indefinite
- Beaver Dam
- Rapids
- Paved Road
- Gravel Road
- Rough Road
- 20 m Contour
- 100 m Contour
- Depression Contour
- Indefinite Contour
- Intermittent or Indefinite Lake
- Swamp
- Marsh
- Glacier
- Icefield
- Sand or Gravel Bar

Infrastructure
- Incinerator
- Sediment Fence
- Berm
- Diversion Ditch
- Collection Ditch
- Diversion Tunnel
- Pipeline
- Spillway
- Tunnel
- Transmission Line
- Access Road

- Infrastructure
- Dam
- Lined Pond
- Pond
- Gravel Beach Cover
- Tailing Cell
- Borrow Pit
- Landfarm / Landfill
- Ore Stockpile
- Quarry
- Soil Storage
- Haul Road

1:10,000

0 500 1,000

Metres

Date: July 28, 2009
Updated: February 11, 2010
File Reference: KSM-06-028
Projection: UTM9, NAD83

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Figure 2.2-3
Tailing Management Facility Watersheds: Spawning Habitat

Fish Obstacle
- Beaver Dam
- Cascade
- Log Jam
- Other

Spawning Habitat Quality Rank
- Good
- Fair
- None
- Poor
- SHIM - Mapped Wetland

Topography
- River - Indefinite
- Beaver Dam
- Rapids
- FHAP Locations
- Reach Break
- Watershed
- Paved Road
- Gravel Road
- Rough Road

Slope
- < 20 % Slope
- 20 - 30 % Slope
- > 30 % Slope
- Intermittent or Indefinite Lake
- Swamp
- Marsh
- Glacier
- Icefield
- Sand or Gravel Bar
- 20 m Contour
- 100 m Contour
- Depression Contour
- Indefinite Contour
- Snow Storage
- Collection Ditch
- Collection Pipeline
- Collection Tunnel
- Culvert
- Diversion Ditch
- Diversion Pipeline
- Diversion Tunnel
- Penstock
- Spillway
- Valve
- Landfarm / Landfill
- Rock Storage Facility
- Ore Stockpile
- Till Stockpile
- Subsidence Zone
- Haul Road

1:10,000

0 500 1,000

Metres

Date: December 4, 2012
File Reference: KSM-06-139
Projection: NAD 1983 UTM Zone 9N

SEABRIDGE GOLD

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Figure 2.2-4
Tailing Management Facility Watersheds:
Over-Wintering Habitat

- FHAP Locations
- Reach Break
- Watershed

Fish Obstacle
- Beaver Dam
- Cascade
- Log Jam
- Other

Overwintering Habitat Quality Rank
- Good
- Fair
- None
- Poor
- SHIM - Mapped Wetland

Slope
- < 20 % Slope
- 20 - 30 % Slope
- > 30 % Slope

Topography
- River - Indefinite
- Beaver Dam
- Rapids
- Paved Road
- Gravel Road
- Rough Road
- 20 m Contour
- 100 m Contour
- Depression Contour
- Indefinite Contour
- Intermittent or Indefinite Lake
- Swamp
- Marsh
- Glacier
- Icefield
- Sand or Gravel Bar

- Berm
- Collection Ditch
- Collection Pipeline
- Culvert
- Diversion Ditch
- Diversion Pipeline
- Diversion Tunnel
- Pipeline
- Sediment Fence
- Spillway

- Quarry
- Soil Storage
- Stockpile / Borrow Pit
- Till Stockpile
- Dam
- Lined Pond
- Pond
- Rip Rap
- Tailing Cell

1:10,000
0 500 1,000
Metres

Date: December 4, 2012
File Reference: KSM-06-140
Projection: UTM9, NAD83

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Figure 2.2-5
Tailing Management Facility Watersheds:
Overall Habitat

- FHAP Locations
- Reach Break
- Watershed

Fish Obstacle
- Beaver Dam
- Cascade
- Log Jam
- Other

Overall Habitat Quality Rank
- Important
- Marginal
- SHIM - Mapped Wetland

Topography
- River - Indefinite
- Beaver Dam
- Rapids
- Paved Road
- Gravel Road
- Rough Road
- 20 m Contour
- 100 m Contour
- Depression Contour
- Indefinite Contour
- Intermittent or Indefinite Lake
- Swamp
- Marsh
- Glacier
- Icefield
- Sand or Gravel Bar

Slope
- < 20 % Slope
- 20 - 30 % Slope
- > 30 % Slope

Infrastructure
- Incinerator
- Sediment Fence
- Berm
- Diversion Ditch
- Collection Ditch
- Diversion Tunnel
- Pipeline
- Spillway
- Tunnel
- Transmission Line
- Access Road
- Infrastructure
- Dam
- Lined Pond
- Pond
- Gravel Beach Cover
- Tailing Cell
- Borrow Pit
- Landfarm / Landfill
- Ore Stockpile
- Quarry
- Soil Storage
- Haul Road

1:11,000

0 750 1,500

Metres

Date: July 28, 2009
Updated: December 04 2012
File Reference: KSM-06-036
Projection: NAD 1983 UTM Zone 9N

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Appendix 1.1-1

DFO Guideline Letter on Fish Habitat Compensation for the KSM Project

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Engineers and Scientists

Fisheries and Oceans Canada
Pêches et Océans Canada

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Our File Number
08-HPAC-PA1-00001

July 27, 2010

Vivian Au, Project Manager
Canadian Environmental Assessment Agency
Pacific and Yukon Region
757 West Hastings Street, Suite 320
Vancouver, BC V6C 1A1

By email

Dear Vivian,

Subject: KSM Mine Project Draft Application Information Requirements
Fisheries and Oceans Canada Comments

Fisheries and Oceans Canada (DFO) reviewed the draft Application Information Requirements (dAIR) prepared by Rescan Environmental Services Ltd. for Seabridge Gold Inc. (Seabridge), dated June 15, 2010. DFO notes that comments were provided on earlier versions of this document and our comments were incorporated into the June 15, 2010 version.

DFO is providing further information to aid Seabridge in its development of a "conceptual fish habitat compensation plan to offset the potential fish habitat impacts that is consistent with DFO's *Policy for the Management of Fish Habitat*" (Section 11.7.6, Lines 31 and 32). In addition, to avoid possible confusion, DFO recommends the words "conceptual fish habitat compensation plan" be replaced with "a technically feasible fish habitat compensation plan" in this section.

When developing a fish habitat compensation plan, the following factors should be considered in compensation planning and, where applicable, addressed in the compensation plan rationale and objectives:

- DFO's hierarchy of preferences, as described in Section 4.1 of DFO's *Practitioner's Guide to Habitat Compensation*;
- Fish species or stocks targeted in compensation objectives, and any fisheries management objectives, fishery use, or potential use of fish in the project area;

- Opportunities to improve existing impacts or constraints to fish and fish habitat in the watershed;
- First Nations traditional access to fish in the area, and traditional uses and ecological knowledge;
- Compliance of compensation plans with recovery planning for species listed under the *Species at Risk Act*;
- The type, amount and supply of habitat that is at both the impact and compensation sites;
- The amount and temporal nature of impact (whether impacts are permanent or temporary);
- The risk of failure and the time lag until compensatory habitats become fully functional;
- When determining potential compensation work locations, consideration should be given to the potential for the proposed project to adversely affect the compensation works in the future;
- Where existing habitat is to be enhanced, the intrinsic value of this habitat must be considered when determining the amount of productive capacity gained through compensation (i.e., enhancement); and,
- Compensation works should be designed to function in perpetuity.

It is important to note that the KSM Mine Project has two separate regulatory instruments that necessitate fish habitat compensation plans. These include: (1) authorization under subsection 35(2) of the *Fisheries Act* for the harmful alteration, disruption or destruction (HADD) of fish habitat and (2) listing under Schedule 2 of the *Metal Mining Effluent Regulations* (*MMER*). As a result, Seabridge should develop **two separate** fish habitat compensation plans to offset the impacts resulting from the following:

1. The HADD of fish habitat resulting from the project (including the dams and associated infrastructure required for the tailings impoundment area (TIA) and loss of habitat due to downstream flow impacts, transmission lines, road building, etc.); and
2. The impacts to fish habitat resulting from the deposit of a deleterious substance into the TIA.

Both plans should be prepared in accordance with DFO's national *Policy for the Management of Fish Habitat (1986).*

Two separate sections should be added into the dAIR under Section 11.7.7 Mitigation and Environmental Management. One section should be titled "*Fisheries Act* subsection 35(2) Fish Habitat Compensation Plan" and the other should be titled "*MMER* subsection 27.1 Fish Habitat Compensation Plan". Each section of the dAIR should include the appropriate components listed below:

1. ***Fisheries Act* subsection 35(2) Fish Habitat Compensation Plan**

- A detailed description of the fish habitat likely to be impacted (i.e., type of habitat, species present, productivity) and the extent (i.e., square metre/impacted habitat type) and expected duration of impact;
- A rationale summarizing how the above factors were addressed and considered in the compensation plan;
- A clear outline of the objectives of the compensation plan which include species and stocks targetted, linkage to fisheries management objectives, and type and amount of habitat compensation being proposed;
- The option chosen from the hierarchy of preferences (as outlined in DFO's *Policy for the Management of Fish Habitat*), and/or a rationale as to why a combination of the preferences was chosen. If a less preferred compensation option (i.e., lower down DFO's hierarchy of preferences) is proposed, then a rationale should be provided for moving down the hierarchy of preferences;
- A detailed description of the compensation sites and planned compensation works. This should include photographs and sketches/drawings of the sites identifying the approximate location (geographic coordinates), area, number and dimensions of compensation works and structures;
- Characterization of the habitat gains expected from the compensation works (i.e., the type and amount of habitat to be created, the species that will benefit, the habitat function or capacity that will be created, improved or enhanced, and how such gains will offset the HADD and achieve no net loss in the productive capacity of fish habitat);
- If habitat ratios (i.e., compensatory habitat : impacted habitat) were used in developing the compensation plan, a description of how the ratios are intended to offset the losses associated with the HADD should be provided;
- Identification of the factors limiting the productive capacity and habitat function of the area in which the compensation works are being proposed;
- A description of any existing habitat in the area of the proposed compensation (i.e., type, species present, productivity) should be included;
- If applicable, identification of established stakeholder groups (e.g., Nisga'a Nation, First Nations, public) and confirmation that consultation has occurred, where necessary;
- The timeline for implementing the compensation plan;
- The construction details (i.e., machine access routes, mitigation measures to prevent additional HADDs during construction, construction methods, etc.);
- Issues that could compromise the success of the compensation works (e.g., site accessibility, downstream fish obstructions, etc.);

- Confirmation of land tenure, legal right of access, and management authority for compensation works (i.e., evidence to support the ability of Seabridge to construct and maintain the compensation works);
- Environmental monitoring commitments (e.g., a description of compliance and effectiveness monitoring that will take place in relation to the compensation works, a description of post construction compensation monitoring, etc.); and
- Compensation plan costing details – note that DFO requires an irrevocable letter of credit to cover the costs of mitigation, compensation, and monitoring measures for the proposed compensation prior to issuance of an authorization for impacts to fish habitat. An estimate of these costs should be provided to DFO during the environmental assessment.

2. *MMER* subsection 27.1 Fish Habitat Compensation Plan

The compensation plan for impacts resulting from the deposit of deleterious substances into a TIA requires the following information as described in the *MMER* subsection 27.1.

- A description of the location of the tailings impoundment area and the fish habitat affected by the deposit;
- A quantitative impact assessment of the deposit on the fish habitat;
- A description of the measures to be taken to offset the loss of fish habitat caused by the deposit;
- A description of the measures to be taken during the planning and implementation of the compensation plan to mitigate any potential adverse effect on the fish habitat that could result from the plan's implementation;
- A description of measures to be taken to monitor the plan's implementation;
- A description of the measures to be taken to verify the extent to which the plan's purpose has been achieved;
- A description of the time schedule for the plan's implementation, which time schedule shall provide for achievement of the plan's purpose within a reasonable time;
- An estimate of the cost of implementing each element of the plan; and
- An irrevocable letter of credit to cover the plan's implementation costs, which letter of credit shall be payable upon demand on the declining balance of the implemenation costs (required at the time of the final compensation plan). An estimate of the cost should be provided during the environmental assessment.

In addition to the above required information, Seabridge should consider the guidance provided in the section titled "*Fisheries Act* subsection 35(2) Fish Habitat Compensation

Plan", as that section contains greater detail and guidance that may aid in the development of a fish habitat compensation plan that is acceptable to DFO.

It is important to note that fish habitat compensation is considered as mitigation to offset adverse environmental effects identified during the environmental assessment of a proposed project and can inform the determination of the significance of environmental effects.

The information requested above constitutes the information necessary for DFO to determine whether the fish habitat compensation plans will individually result in no net loss in the productive capacity of fish habitat. During its review of the above information, DFO may identify additional information necessary to inform its determination.

Please do not hesitate to contact me at (604) 666-1349 if you have any questions or concerns.

Sincerely,

Brenda Andres
Environmental Assessment Analyst,
Environmental Assessment and Major Projects
Oceans, Habitat & Enhancement Branch

cc: P. Menning, DFO
D. Wensauer, Transport Canada
T. Paul, Environment Canada
K. McPherson, Natural Resources Canada
M. Campbell, Natural Resources Canada

Appendix 3.2-1

Annotated Bibliography of Dolly Varden Habitat Preferences

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Appendix 3.2-1. Annotated Bibliography of Dolly Varden Habitat Preferences

Andrew, J.H., N. Jonsson, B. Jonsson, K. Hindar, and T.G. Northcote. 1992. Changes in use of lake habitat by experimentally segregated populations of cutthroat trout and Dolly Varden char. *Ecography* 15: 245-252.

The role of competition in a lacustrine community of two salmonid species, cutthroat trout *Oncorhynchus clarki* and Dolly Varden char *Salvelinus malma*, was studied in three coastal British Columbia lakes. Habitat use by the species alone (allopatric) and in coexistence with each other (sympatric) was investigated by gill netting at 0-40 m depth contours (surface to bottom) so that several habitats (littoral, epipelagic. pelagic, epibenthic) were sampled. From June to October, trout used mainly littoral and epipelagic habitats in sympatry and allopatry. Char used all habitats in allopatry and deep habitats (pelagic, epibenthic) not frequented by trout in sympatry. The two species were thus spatially segregated with depth in sympatry. Diel (day, night) and seasonal changes (spring, summer, autumn) in habitat use were not pronounced. The shift in habitat use by experimentally allopatric char but not trout suggests that the effects of competition between sympatric trout and char for habitat resources are greater on the char.

Andrusak, H., and T.G. Northcote. 1971. Segregation between adult cutthroat trout (*Salmo clarki*) and Dolly Varden (*Salvelinus malma*) in small coastal British Columbia lakes. *Journal of the Fisheries Research Board of Canada* 28: 1259-1268.

Comparison of spatial distributions and food of allopatric populations of *S. clarki* and *S. malma* in two lakes and of sympatric populations in a third lake suggested interactive segregation throughout the spring and summer but no diel migration was noted. Changes in food habits closely corresponded to seasonal changes in vertical distribution. A wide range of food organisms was eaten from surface, midwater, and benthic sources. Allopatric Dolly Varden underwent diel changes in spatial distribution, with many being caught in onshore waters near the surface at night. They were absent from such areas in the day, apparently occupying offshore waters at greater depths. Their diet throughout summer consisted largely of surface insects and zooplankton, with lesser amounts of bottom fauna. Sympatric cutthroat trout and Dolly Varden were spatially segregated throughout the summer. Cutthroat trout occurred and fed mostly near the surface in littoral areas. In contrast, Dolly Varden were offshore and benthic in distribution and fed primarily on bottom organisms. By comparing distribution and food habitat in allopatric and sympatric populations, it was suggested that competition for food may contribute to their segregation in sympatry. Although segregation of these species when cohabiting may involve interactive processes, the possibility of selective differences being of importance cannot be dismissed.

Baxter, C.V., K.D. Fausch, M. Murakami, and P.L. Chapman. 2004. Fish invasion restructures stream and forest food webs by interrupting reciprocal prey subsidies. *Ecology* 85: 2656-2663.

Habitat alteration and biotic invasions are the two leading causes of global environmental change and biodiversity loss. Recent innovative experiments have shown that habitat disturbance can have drastic effects that cascade to adjacent ecosystems by altering the flow of resource subsidies from donor systems. Likewise, exotic species invasions could alter subsidies and affect distant food webs, but very few studies have tested this experimentally.

Here we report evidence from a large-scale field experiment in northern Japan that invasion of non-native rainbow trout (*Oncorhynchus mykiss*) interrupted reciprocal flows of invertebrate prey that drove stream and adjacent riparian forest food webs. Rainbow trout usurped terrestrial prey that fell into the stream, causing native Dolly Varden charr (*Salvelinus malma*) to shift their foraging to insects that graze algae from the stream bottom. This indirectly increased algal biomass, but also decreased biomass of adult aquatic insects emerging from the stream to the forest. In turn, this led to a 65% reduction in the density of riparian-specialist spiders in the forest. Thus, species invasions can interrupt flows of resources between interconnected ecosystems and have effects that propagate across their boundaries, effects that may be difficult to anticipate without in-depth understanding of food web relationships.

Bjornn, T.C., S.C. Kirking, and W.R. Meehan. 1991. Relation of cover alteration to the summer standing crop of young salmonids in small Southeast Alaska streams. *Transactions of the American Fisheries Society* 120: 562-570.

Summer abundance of young coho salmon *Oncorhynchus kisutch*, steelhead *O. mykiss*, and Dolly Varden *Salvelinus malma* was assessed in small streams on Prince of Wales Island, Alaska, in an attempt to measure the response of these fish to various types of cover alterations. The standing crop of subyearlings decreased during summer, but none of the decrease could be attributed to the changes in cover we made. Subyearling coho salmon (about 75% of the fish present) did not respond either to the removal of natural riparian vegetation or to the addition of simulated riparian canopy, large boulders, woody debris, or simulated undercut banks. Localized movements within the streams were sufficient to provide relatively rapid recolonization of the experimental habitat units. The forms of cover we evaluated were relatively unimportant in regulating abundance of young coho salmon in small streams.

Bramblett, R.G., M.D. Bryant, B.E. Wright, and R.G. White. 2002. Seasonal use of small tributary and main-stem habitats by juvenile steelhead, coho salmon, and Dolly Varden in a southeastern Alaska drainage basin. *Transactions of the American Fisheries Society* 131: 498-506.

The movement of juvenile salmonids between small tributaries and main-stem habitats in southeast Alaska watersheds is poorly understood. We observed movements of steelhead, *Oncorhynchus mykiss*, coho salmon, *O. kisutch*, and Dolly Varden, *Salvelinus malma*, between mainstem and tributary habitats at weirs located on tributaries in the Staney Creek watershed in southeast Alaska. We used seasonal relative abundance (catch per unit effort) in eight main-stem reaches and eight tributaries to corroborate observed movement in the two streams with weirs. We observed juvenile steelhead and coho salmon moving through the weirs into tributaries during the fall as flows increased and temperatures decreased. The relative abundance of steelhead was greater in mainstem sites than in tributaries during the summer, whereas during spring and fall relative abundance in the tributaries was similar to that in the mainstem. Juvenile coho salmon were abundant in tributaries during all seasons. The relative abundance of Dolly Varden was greater in the tributaries than in the mainstem during all seasons. These results underscore the significance of links between mainstem habitats and small tributaries for production of juvenile salmonids.

Bryant, M.D. 1984. Distribution of salmonids in the Trap Bay Basin, Tenakee Inlet. Pages 17-31 In: W.R. Meehan, T.R. Merrell, and T.A. Hanley (editors). *Fish and Wildlife Relationships in Old-Growth Forests: Proceedings of a Symposium*. American Institute of Fisheries Research Biologists, Juneau, Alaska.

Because land management may affect a stream at various points along its progression to the sea, it is important to identify zones used in the watershed by juvenile salmonids. This 2-year study

examined the distribution of juvenile salmonids in an undisturbed, old-growth forest drainage. The purpose of the study was to determine the distribution of juvenile salmonids in a small stream basin from the main stream through the upper tributaries. Differences in density, species ratios and size among juvenile salmonids in main-stream zones, lower tributary zones, and upper tributary zones were observed. Upper reaches of tributaries were used by age-0 coho, cutthroat trout, and Dolly Varden. Lower reaches of tributaries were extensively used by juvenile coho of all age-classes and Dolly Varden up to about 120 mm in length. Main-stream zones were sparsely populated by all species, but where off-channel rearing areas were available, coho were more abundant. Differences in density occurred from early summer to early fall.

Bryant, M.D., N.D. Zymonas, and B.E. Wright. 2004. Salmonids on the fringe: Abundance, species composition, and habitat use of salmonids in high-gradient headwater streams, southeastern Alaska. *Transactions of the American Fisheries Society* 133: 1529-1538.

We evaluated the species distribution, abundance, and habitat relationships of salmonids in small first-to second-order headwater streams in southeast Alaska. Streams were separated into three zones based on gradient and sampled during the spring, summer, and fall. Dolly Varden *Salvelinus malma* were found in all streams where fish were present. They were the dominant species in moderate (mean gradient = 5.5%) and high-gradient (mean gradient = 12.9%) zones. Coho salmon *Oncorhynchus kisutch* fry and parr were the dominant species in the low-gradient zone (mean gradient = 3.1%) but were present in higher-gradient zones. Small numbers of steelhead *O. mykiss* parr were present in all three zones in the spring and fall. Few were captured during the summer. Coastal cutthroat trout O. clarkii were found primarily in one stream and in all three zones. The density of all species decreased as gradient increased. Anadromous Dolly Varden in spawning condition were observed in the fall up to the highest accessible locations in four streams. Salmonids use high-gradient reaches when pools are present and accessible. Headwater tributaries comprise a large proportion of most southeast Alaska watersheds, and the combined contribution from all of these tributaries to the fish community may be large. The results from this study underscore the importance of maintaining access for fish throughout watersheds and into small high-gradient streams.

Bugert, R.M., T.C. Bjornn, and W.R. Meehan. 1991. Summer habitat use young salmonids and their response to cover and predators in a small southeast Alaska stream. *Transactions of the American Fisheries Society* 120: 474-485.

We observed young coho salmon *Oncorhynchus kisutch*, steelhead *O. mykiss*, and Dolly Varden *Salvelinus malma* in a second-order stream on Prince of Wales Island, Alaska, to assess differences between species in habitat use and response to cover and predators. Habitat use by subyearlings of the three species differed primarily in depth of water and position in the water column. Coho salmon selected the relatively deep areas of the small stream; steelhead were more evenly spread across the bottom, regardless of depth; and Dolly Varden were close to the bottom in water less than 20 cm deep. All three species selected lower positions in the water column in pools without cover than in pools with riparian or instream cover. We detected no shift in habitat use in response to fish predators.

Dolloff, C.A. 1986. Effects of stream cleaning on juvenile coho salmon and Dolly Varden in southeast Alaska. *Transactions of the American Fisheries Society* 115: 743-755.

This paper describes the effects of selective removal of woody debris on populations of juvenile coho salmon *Oncorhynchus kisutch* and Dolly Varden *Salvelinus malma* in two small streams on Prince of Wales Island, Alaska, during the summers of 1979-1981. These streams contained debris left when surrounding forests were clear-cut in the late 1960s. Debris smaller

than 60 mm in diameter and larger debris not embedded in the stream channel were manually removed from half of the study reach on each stream in 1979 by state-of-the-art techniques. Immigration and emigration of fish from the study sections and intrastream movements were very limited after an initial period of population adjustment in the spring regardless of treatment. Population densities and production of both species were typically higher in sections where debris accumulations had not been removed. Production of age-0 + and age-1 + coho salmon and age-1 + and age-2 + Dolly Varden during the June-September period ranged from 0.70 to 2.22 g/m^2 in the cleaned sections and from 0.84 to 2.10 g/m^2 in the uncleaned sections. Carrying capacities for both species were lower in cleaned sections despite the use of selective techniques for removing woody debris.

Dolloff, C.A., and G.H. Reeves. 1990. Microhabitat partitioning among stream-dwelling juvenile coho salmon, *Oncorhynchus kisutch*, and Dolly Varden, *Salvelinus malma*. *Canadian Journal of Fisheries and Aquatic Sciences* 47: 2297-2306.

Microhabitat use and partitioning among 0+ and 1+ coho salmon, Oncorhynchus kisutch, and age 0+, 1+ and 2+ Dolly Varden, *Salvelinus malma*, was studied in small (<2 m wide), natural streams on Prince of Wales Island, Alaska, and in laboratory stream channels. Coho salmon occupied midwater positions that they defended from other fish. Dolly Varden were more closely associated with the stream bottom and were seldom territorial. For each species, the depth of water, depth of focal point, and distance of the nearest fish increased with fish size, whereas the distance to nearest cover decreased as fish size increased. Most fish selected focal point velocities between 0.0-9.0 cm/s. Woody debris was the most frequently used cover type and most fish occurred over gravel substrates ranging from 2-100 mm particle diameter. Habitat use by each species in the laboratory was similar to the pattern observed in the field. Each species occupied similar habitats both when alone and when the other species was present. Although habitat use by juveniles of coho salmon and Dolly Varden overlapped among several key parameters, each species primarily exploited resources not readily available to or selected by the other in the natural streams we studied.

Elliott, S.T. 1986. Reduction of a Dolly Varden population and macrobenthos after removal of logging debris. *Transactions of the American Fisheries Society* 115: 392-400.

Logging debris resident for five or more years in small streams of southeastern Alaska is frequently removed to improve salmonid habitat. This practice was evaluated for its effects on juvenile anadromous Dolly Varden *Salvelinus malma* and macrobenthos populations in a small spring-fed stream during 1973-1981. Debris, consisting of limbs, needles, and fragmented logs, was removed by hand from the entire stream in July 1976. The surface area, number, and size of pools was reduced thereafter, and the water velocity increased. Macrobenthos density and invertebrate drift decreased 60-90% immediately after debris removal but returned to pretreatment levels in 1977. The Dolly Varden population decreased from 900 to less than 100 fish by 1978 and then fluctuated sharply between late 1978 and 1981. After 1978, Dolly Varden averaged 27 mm less in length and their biomass decreased from 12.5 to 3.9 g/m^2. Decrease in fish standing crop occurred in two stages: (1) an initial loss of larger fish due to reduced habitat; (2) loss of smaller individuals during November freshets thereafter. This study indicates that removal of old logging debris does not improve habitat and can result in smaller rearing populations. Old debris should not be removed unless a block to migrating adult spawners or impairment of water quality can be demonstrated.

Fausch, K.D., S. Nakano, and K. Ishigaki. 1994. Distribution of two congeneric charrs in streams of Hokkaido Island, Japan: considering multiple factors across scales. *Oecologia* 100: 1-12.

Salvelinus leucomaenis (white-spotted charr) and *S. malma* (Dolly Varden) are distributed throughout Hokkaido Island, Japan, but sites where they occur in sympatry are rare. In general, *S. malma* inhabit upstream reaches and *S. leucomaenis* extend downstream to the ocean. Factors influencing their distribution were analyzed at four spatial scales ranging from the whole island to individual stream pools. At the island scale, *S. leucomaenis* were found in the warmer southwest region and at lower altitudes elsewhere, whereas *S. malma* were found in the colder northeast and at higher altitudes. At a regional scale, the downstream limit of *S. malma* and upstream limit of *S. leucomaenis* shifted to lower altitude from south-west to north-east across the island, coincident with the decrease in temperature. Further analysis showed that transition points from *S. leucomaenis* or sympatry to *S. malma* in individual watersheds were closely related to an index of cumulative mean monthly temperatures exceeding 5°C. However, at the scale of a single watershed, the transition occurred at different altitudes, gradients, and temperatures in two tributaries, apparently because stream discharge, habitat, and disturbances from floods interacted with these abiotic factors to limit distribution. The two charr species developed interspecific dominance hierarchies in individual pools, and there was strong complementary density compensation among stream pools that could be explained by interspecific competition but not by differences in habitat. However, patterns at watershed and regional scales suggested that interspecific competition interacts with temperature in complex ways. We conclude that the importance of various abiotic and biotic factors in shaping Hokkaido charr distributions depends on the scale at which they are viewed.

Fausch, K.D., S. Nakano, and S. Kitano. 1997. Experimentally induced foraging mode shift by sympatric charrs in a Japanese mountain stream. *Behavioral Ecology* 8: 414-420.

Foraging mode shifts may allow animals flexibility to adapt to a variety of ecological conditions. Theory holds that ectotherms such as fishes should shift from ambush to active search modes when prey density declines, to maintain a minimum encounter rate. *Salvelinus malma* (Dolly Varden) sympatric with *S. leucomaenis* (white-spotted charr) in a northern Japan mountain stream were observed to shift from ambushing drifting invertebrates at fixed focal points to picking benthic invertebrates from the substrate along circuitous routes throughout pools, as drift declined throughout summer. Experimentally reducing drift in two pools during early summer when all charr were drift foragers caused subordinate malma to make marked shifts from drift to benthic foraging within 1 h, whereas nearly all leucomaenis remained drift foragers. Some charr of both species responded to reduced drift by emigrating from pools. Combined results of three replicate experiments revealed that malma shifted to benthic foraging when their rate of drift forays was reduced below a specific threshold, thereby upholding predictions of the theory. Adaptive foraging mode shirts may promote coexistence of these congeneric charrs in reaches of Japanese mountain streams.

Hagen, J., and E.B. Taylor. 2001. Resource partitioning as a factor limiting gene flow in hybridizing populations of Dolly Varden char (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*). *Canadian Journal of Fisheries and Aquatic Sciences* 58: 2037-2047.

Dolly Varden char (*Salvelinus malma*) and bull trout (*Salvelinus confluentes*) hydridize in areas of secondary contact in northwestern North America but maintain their genetic integrity in spite gene flow. We examined juvenile stream ecology and adult reproductive ecology of these species in sympatry to test for specializations to alternative niches that that may act as a basis for natural selection against hybrids. Juvenile Dolly Varden occupied deeper, faster water and foraged more during daytime in the drift, whereas bull trout used shallower, slower water and

made more nightime foraging attempts towards the substrate. The species showed extensive diet overlap (Schoener's index = 0.7-0.9), and we found evidence for density compensation between species among sites. Our results suggest no obvious basis for selection against hybrids at the juvenile stream-rearing life-history stage. Bull trout, however, are adfluvial, whereas Dolly Varden are permanent stream residents. Bull trout are also much larger at maturity (50-80 cm vs 12-15 cm) and build redds in faster, deeper water using larger substrate sizes. Consequently, hybrid genotypes may be selected against in these alternative life-history niches or during reproduction owing to their intermediate size at maturity and size-dependent spawning habitat use and mate choice.

Heifetz, J., M.L. Murphy, and K.V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaska streams. *North American Journal of Fisheries Management* 6: 52-58.

Effects of logging on preferred winter habitats of juvenile salmonids in southeastern Alaskan streams were assessed by comparing the area of preferred winter habitat in 54 reaches of 18 streams. Three types of streams were sampled at each of six locations: a stream in a mature, undisturbed forest; a stream in a clear-cut area but logged on at least one bank; and a stream in a clear-cut area with strips of forest (buffer strips) along the stream bank. To identify preferred winter habitats, we classified stream areas in 12 of 18 streams into discrete habitat types and compared the density of salmonids within these habitat types with average density of the entire reach. Most wintering coho salmon (*Oncorhynchus kisutch*), Dolly Varden (*Salvelinus malma*), and steelhead (Salmo gairdneri) occupied deep pools with cover (i.e., upturned tree roots, accumulations of logs, and cobble substrate). Riffles, glides, and pools without cover were not used. Seventy-three percent of all pools were formed by large organic debris. Reaches in clearcut areas without buffer strips had significantly less area of pool habitat than old-growth reaches. Buffer strips protected winter habitat of juvenile salmonids by maintaining pool area and cover within pools. In some cases, blowdown from buffer strips added large organic debris to the stream and increased the cover within pools.

Hume, J.M.B., and T.G. Northcote. 1985. Initial changes in use of space and food by experimentally segregated populations of Dolly Varden (*Salvelinus malma*) and cutthroat trout (*Salmo clarki*). *Canadian Journal of Fisheries and Aquatic Sciences* 42: 101-109.

Dolly Varden (*Salvelinus malma*) (N = 881) and cutthroat trout (*Salmo clarki*) (N = 1571) were captured from a native lacustrine sympatric stock and transferred to two nearby lakes, formerly fishless, to establish allopatric populations with genetic backgrounds similar to the donor stock. Nearshore (5- and 10-m depth contours) vertical distributions of segregated Dolly Varden and cutthroat trout, between spring and autumn of the first 18 months after transfer, did not differ significantly from those in their sympatric lake. Dolly Varden were captured mainly near the bottom while cutthroat trout were more evenly distributed throughout the water column. Nevertheless, initially the allopatric Dolly Varden rapidly became highly planktivorous, virtually eliminating midwater populations of Chaobourus trivittatus and C. americanus (third and fourth instar larvae) within a year. These results suggest that while there may be genetic control restricting broad vertical use of space by formerly sympatric Dolly Varden shortly after being placed in allopatry, such control is flexible enough that a highly benthofagous stock in sympatry quickly becomes planktovorous in the absence of cutthroat trout.

Johnson, S.W., J.F. Thedinga, and A.S. Feldhausen. 1994. Juvenile salmonid densities and habitat use in the main-stem Situk River, Alaska, and potential effects of glacial flooding. *Northwest Science* 68: 284-293.

Densities and habitat use of juvenile coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*O. nerka*), steelhead (*O. mykiss*), and Dolly Varden (*Salvelinus malma*) were determined in the main-stem Situk River, Alaska. Three habitat types (channel edges, willow edges, and debris pools) were sampled at two downstream sites (lower river) and at two upstream sites (upper river) biweekly from May to September and once in November 1989. For most species, fry (age 0) most often used channel edges with little cover, whereas parr (age greater than or equal to 1) almost exclusively occupied willow edges and debris pools. Within the same habitat types, densities were significantly greater for most species and life-history stages in the upper than in the lower river; steelhead parr, with densities similar in like habitats in the upper and lower river, were a notable exception. Peak fry densities (fish/100 m^2) were 2,331 coho, 155 steelhead, and 14 sockeye, whereas peak parr densities were 281 coho, 82 steelhead, and 44 Dolly Varden. Mean length of fry and parr of all species was greater in the lower river than in the upper river. With baseline information from this study, fisheries managers can identify strategies to restore fish and habitat that could be impacted by flooding in the Situk River. Hubbard Glacier is expected to advance and dam Russell Fiord by the year 2000, and overflow from the fiord will flood the Situk River, drastically altering fish rearing habitat.

Keith, R.M., T.C. Bjornn, W.R. Meehan, N.J. Hetrick and M.A. Brusven. 1998. Response of juvenile salmonids to riparian and instream cover modifications in small streams flowing through second growth forests of southeast Alaska. *Transactions of the American Fisheries Society* 127: 889-907.

We manipulated the canopy of second-growth red alder Alnus rubra and instream cover to assess the effects on abundance of juvenile salmonids in small streams of Prince of Wales Island, southeast Alaska, in 1988 and 1989. Sections of red alder canopy were removed to compare responses of salmonids to open- and closed-canopy sections. At the start of the study, all potential instream cover was removed from the study pools. Alder brush bundles were then placed in half the pools to test the response of juvenile salmonids to the addition of instream cover. Abundance of age-0 coho salmon *Oncorhynchus kisutch* decreased in both open- and closed-canopy sections during both summers, but abundance decreased at a higher rate in closed canopy sections. More age-0 Dolly Varden *Salvelinus malma* were found in open-canopy sections than in closed-canopy during both summers. Numbers of age-1 and older coho salmon and Dolly Varden were relatively constant during both summers, and there was no significant difference in abundance detected between open- and closed-canopy sections. Abundance of age-0 coho salmon decreased in pools with and without additional instream cover during both summers. Abundance of age-1 and older coho salmon and age-0 Dolly Varden did not differ significantly in pools with or without added cover during either summer. Abundance of age-1 and older Dolly Varden was higher in pools with added instream cover than in pools without cover during both summers. Age-0 coho salmon decreased in abundance throughout the summer in both years. Emigration was measured in 1989 and accounted for most of the decrease in abundance. Age-0 coho salmon emigrants were significantly smaller than age-0 coho salmon that remained in the stream.

Kishi, D., M. Murakami, S. Nakano, and Y. Tanuguchi. 2004. Effects of forestry on the thermal habitat of Dolly Varden (*Salvelinus malma*). *Ecological Research* 19: 283-290.

Forestry activities in riparian areas are known to affect stream communities considerably. Not only do riparian deforestation resulting from agriculture or urbanization developments affect

stream communities but extensive commercial plantation and forestry practices can alter stream environments adjacent to remaining, intact or secondary forests. Because forestry often includes the construction of logging roads through the riparian zone, this can directly degrade stream environments. Twelve streams in the Shiretoko Peninsula, Hokkaido were investigated so as to determine the effects of forestry practices on stream temperature, periphyton biomass, grazer (benthic invertebrates) biomass and Dolly Varden (*Salvelinus malma Walbaum*) biomass. The greater the proportion of planted area in the catchment, the higher the stream temperature. Stream temperature directly affects periphyton biomass and Dolly Varden biomass negatively. Neither stream temperature nor periphyton biomass predicted grazer biomass, whereas a positive correlation was found between grazer biomass and Dolly Varden biomass that forage on invertebrates. The overall results indicated that Dolly Varden in the Shiretoko streams were negatively affected by forestry practices and the resultant stream temperature increases. Without effective future riparian forest management, the complex effects of both riparian disturbance and ongoing global warming could further reduce Dolly Varden populations in the region.

Kitano, S., and K. Shimazaki. 1995. Spawning habitat and nest depth of female Dolly Varden, *Salvelinus malma*, of different body size. *Fisheries Science (Tokyo)* 61: 776-779.

Spawning habitat and nest depth in relation to female body size were studies in a small population of Dolly Varden *Salvelinus malma*. Females selected areas where gravel was prevalent and currents were slow for spawning. Neither substrate score, water depth, nor current velocity was significantly correlated with the female body size. Nest depth, however, was strongly correlated with female size. These results suggest that nest made by smaller females are more vulnerable to destruction both from flooding and from nest site reuse by later-spawning females.

Lough, M.J., S.E. Hay, D. Lowe, and D.W. Rimmer. 2003. *Life History Characteristics of Dolly Varden in the Campbell River and Puntledge River Watersheds*. Prepared for the British Columbia Ministry of Water, Land and Air Protection, Fish and Wildlife Sciences Allocation Section, by MJL Environmental Consultants. February 2003.

General life history information.

Milner, A.M., and R.G. Bailey. 1989. Salmonid colonization of new streams in Glacier Bay National Park, Alaska. *Aquaculture and Fisheries Management* 20: 179-192.

Following the rapid recession of a neoglacial ice sheet within the last 250 years, colonization of recently deglaciated streams by salmonid fishes was investigated in Glacier Bay National Park, south-eastern Alaska. The primary factors governing the establishment, species diversity composition and abundance of salmonids in Glacier Bay streams were water temperature, sediment loading and stream discharge. No salmonids were found in the turbid meltwater streams emerging from retreating ice. Coho, *Oncorhynchus kisutch* (Walbaum), and sockeye, *Oncorhynchus nerka* (Walbaum), salmon and Dolly Varden, *Salvelinus malma* (Walbaum), charr were the first salmonids to colonize the youngest clearwater stream.

Murphy, M.L., J. Heifetz, S.W. Johnson, K.V. Koski, and J.F. Thedinga. 1986. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaskan streams. *Canadian Journal of Fisheries and Aquatic Sciences* 43: 1521-1533.

To assess short-term effects of logging on juvenile *Oncorhynchus kisutch, Salvelinus malma, Salmo gairdneri,* and *Salmo clarki* in southeastern Alaska, we compared fish density and habitat in summer and winter in 18 streams in old-growth forest and in clearcuts with and without

buffer strips. Buffered reaches did not consistently differ from old-growth reaches; clear-cut reaches had more periphyton, lower channel stability, and less canopy, pool volume, large woody debris, and undercut banks than old-growth reaches. In summer, if areas had underlying limestone, clear-cut reaches and buffered reaches with open canopy had more periphyton, benthos and coho salmon fry (age-0) than old-growth reaches. In winter, abundance of parr (age>0) depended on amount of debris. If debris was left in clear-cut reaches, or added in buffered reaches, coho salmon parr were abundance (10-22/100 m^2). If debris had been removed from clear-cut reaches, parr were scarce (<2/100 m^2). Thus, clear-cutting may increase fry abundance in summer in some streams by increasing primary production, but may reduce abundance of parr in winter if debris is removed. Use of buffer strips maintains or increases debris, protects habitat, allows increased primary production, and can increase abundance of fry and parr.

Murphy, M.L., J.F. Thedinga, K.V. Koski, and G.E. Grette. 1984. A stream ecosystem in an old-growth forest in southeastern Alaska. Part V: seasonal changes in habitat utilization by juvenile salmonids. Pages 89-98 In: W.R. Meehan, T.R. Merrell, Jr., and T.A. Hanley (editors). *Fish and Wildlife Relationships in Old-Growth Forests: Proceedings of a Symposium*. American Institute of Fisheries Research Biologists, Juneau, Alaska.

Seasonal changes in distribution and habitat selection by juvenile salmonid fishes were studies in Porcupine Creek, a small coastal stream in an old-growth forest in southeastern Alaska. During summer, coho salmon (*Oncorhynchus kisutch*) were distributed in both stream/estuary ecotones and freshwater reaches, and biomass (g per m^2) was directly related to total pool volume. Trout (*Salmo gairdneri*) AND Dolly Varden char (*Salvelinus malma*) were not common in the stream/estuary ecotones but were common in freshwater. Total salmonid biomass during summer was directly related to the amount of large organic debris in the stream. Tagged salmonids showed little movement during summer but redistributed themselves within the Porcupine Creek system before winter. Coho moved out of the stream/estuary ecotones to upstream freshwater areas to overwinter. In late autumn, coho used primarily large mainstream pools, backwater pools and secondary-channel pools, and trout and char used primarily debris or undercut banks on the edge of riffles. Resource managers need to take into account seasonal changes in habitat requirements when assessing the effects of logging or other land uses on fish habitat in streams.

Nakano, S., and T. Furukawa-Tanaka. 1994. Intra- and interspecific dominance hierarchies and variation in foraging tactics of two species of stream-dwelling chars. *Ecological Research* 9: 9-20.

Aggressive interactions, foraging behavior, habitat use and diet were studied in sympatric populations of white-sported char, *Salvelinus leucomaenis*, and Dolly Varden, *Salvelinus malma*, in a Japanese mountain stream. Underwater observations on individuals of both species revealed two distinct behavioral regimes: aggressive drift foragers and non-aggressive benthos foragers. Aggressive drift foragers defended partial territories around focal points from which they made forays to capture invertebrates drifting in the water column. Non-aggressive benthos foragers cruised around and beneath cobble in large foraging ranges that overlapped each other. Intraand interspecific, size-dependent dominance hierarchies were recognized among aggressive drift foragers, whereas non-aggressive benthos foragers showed no such relationships. Terrestrial invertebrates were the most abundant prey in the diets of drift foragers, whereas a very small proportion of the diet of benthos foragers was made up of these taxa. Benthos foragers showed more complex diet composition than drift foragers. These results suggest that non-aggressive benthos foragers may avoid not only interference but also exploitative competition by using alternative foraging tactics. The proportion of drift foragers

to benthos foragers among whitespotted char was more than 35 times that among Dolly Varden. The significant difference in the proportion of each species using the two types of foraging strategy results in interspecific food segregation in sympatric populations.

Nakano, S., F. Kitano, and K. Maekawa. 1996. Potential fragmentation and loss of thermal habitats for charrs in the Japanese archipelago due to climatic warming. *Freshwater Biology* 36: 711-722.

The upper thermal limits of the present distributions of two charr species, Dolly Varden, *Salvelinus malm*a, and white-spotted charr, *S. leucomaenis*, in streams of the Japanese archipelago were examined using groundwater temperature as an index of thermal condition. The lower limits of the altitudinal distributions of Dolly Varden and white-spotted charr were delineated, respectively, by 8 and 16°C groundwater isotherms. The potential impact of future climatic warming on the geographical distribution, habitat extent and population fragmentation of each species was predicted at both the full archipelago and individual catchment levels. For Dolly Varden, analysis at the full archipelago level indicated a loss of 27.6, 67.2, 79.6 and 89.6% of the current geographical range, respectively, for a 1, 2, 3 and 4°C increase in mean annual air temperature. The present distribution area of white-spotted charr would likewise reduce by 4.1, 20.5, 33.8 and 45.6%, respectively. Based on the analyses of three individual catchments, one for Dolly Varden and two for whitespotted charr, the lower habitat boundaries for the two charr species could be expected to rise increasingly to higher elevations in each catchment as warming proceeded. As a consequence, there would be large reductions in mean habitat area, with increasing habitat fragmentation followed by localized extinctions of the two species.

Northcote, T.G. 1995. Confessions of a four decade affair with Dolly Varden: a synthesis and critique of experimental tests for interactive segregation between Dolly Varden char (*Salvelinus malma*) and cutthroat trout (*Oncorhynchus clarkii*). *Nordic Journal of Freshwater Research* 71: 49-67.

Validation of the competitive exclusion principle has been attempted over a forty year period for species pairs of British Columbia freshwater fishes, mainly Dolly Varden and cutthroat trout, by field comparisons in sympatry and allopatry on their use of space and food resources, by laboratory study of their trophic and visual structures, by large-scale field manipulation experiments, and by controlled laboratory behavioural experiments. Although much information has been obtained on ecological interactions between the species pairs, little insight has been gained into the validity of the principle itself or the mechanisms which might support it. Probably this is the result of difficulties and lack of precision in concept definition as well as in design of appropriate experiments to test its assumptions. Precise definition of the principle may not be practical and it may be more useful to consider competitive exclusion between closely related species pairs as a quasi-permanent final state of genetically determined difference realized by a series of less fixed steps brought about by interactive segregation.

Palmisano, J.J., and W.T. Helm. 1971. Freshwater food habits of "*Salvelinus malma*" (Walbaum) on Amchitka Island, Alaska. *BioScience* 21: 637-641.

Stomachs from 3,672 Dolly Varden collected from September 1967 to November 1968 were examined. Aquatic invertebrates (insects and crustaceans) comprised over 90% of the diet. Food habits differed in lakes and streams. As fish size increased, diet changed and feeding activity decreased. Char selected large food items. Feeding activity was highest during summer and autumn. Feeding was more intense during daylight.

Plante, C., and J.A. Downing. 1993. Relationship of salmonine production to lake trophic status and temperature. *Canadian Journal of Fisheries and Aquatic Sciences* 50: 1324-1328.

Data on trout, char, and salmon from lakes in several geographic areas indicate that salmonine production (P, kilograms per hectare per year) increases with total phosphorus concentration (TP, micrograms per litre) as log10(P) = 0.47 + 0.95log10(TP) (r2 = 0.61). A positive relationship was also found between P and phytoplankton productivity and this relationship suggests that energy transfer efficiencies from phytoplankton to salmonines are reduced in eutrophic lakes. Lake area and mean depth had no significant statistical effect on P but salmonine production was significantly lower in warmer climates. Analysis of these data suggests that projected global increases in air temperatures could lead to about 50% reductions in salmonine production and yield in the north temperate zone.

Sandstrom, S.J., C.B. Chetkiewicz, and L.A. Harwood. 2001. *Overwintering habitat of juvenile Dolly Varden (*Salvelinus malma *W.) in the Rat River, Nunavut, as determined by radio telemetry*. Canadian Science Advisory Secretariat Research Document No. 2001/092.

In late-September 1995, a survey of the Rat River Dolly Varden (*Salvelinus malma*) stock was conducted by seining the various pools and riffle areas at the spawning and overwintering site on Fish Creek, a headwater tributary. Although this study determined the main overwintering location of the adult component of the population, it failed to find appreciable numbers of anadromous juvenile char (i.e., <400 mm) at this site. In an attempt to determine where the juvenile component of the stock resides during the late-fall, and perhaps document whether additional overwintering habitat exists for this stock, sixteen anadromous juvenile char were radio tagged on August 26 and 27, 1996, near the mouth of the river, approximately 150 km downstream of the spawning/overwintering site. Four radio-tracking flights were made along the Rat River and the Fish Creek tributary on August 30, October 6, November 9, 1996 and March 20, 1997. Results of these tracking flights found that juvenile char use the same areas for overwintering as do the adult char, i.e., several deep pools just upstream of the aufeis field. However, unlike adults juvenile char do not move into these areas until well after freeze-up. Upon completing their upstream migration to the Fish Creek tributary by mid- to late-September juvenile char first occupy areas in Fish Creek within and below the main aufeis field. Final upstream movement into the overwintering pools above the main aufeis field likely does not occur until sometime in late November. It is speculated that this behaviour may be to avoid antagonistic interactions with the spawning adult char upstream. This region of the river may also provide better cover from predators and/or may provide an area of lower energy requirement prior to freeze-up.

Swales, S., F. Caron, J.R. Irvine, and C.D. Levings. 1988. Overwintering habitats of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Keogh River system, British Columbia. *Canadian Journal of Zoology* 66: 254-261.

Catches of overwintering juvenile coho salmon (*Oncorhynchus kisutch*) in the Keogh River system, Vancouver Island, were higher in two small (8 and 25 ha), shallow (mean depth 2-3 m) lakes and their outlet and inlet streams than in the main river, where steelhead trout (*Salmo gairdneri*) were predominant. Dolly Varden char (*Salvelinus malma*), cutthroat trout (*Salmo clarki*), and threespine stickleback (*Gasterosteus aculeatus*) were also present in the lakes. The distribution of coho salmon in the lakes was restricted largely to areas close to the bank, with few fish being captured in offshore areas or in mid-water. The population density and biomass of coho salmon overwintering in Long Lake were estimated to be 176 fish/ha and 1.14 kg/ha, respectively. The mean length of coho salmon in the lakes was greater than that of coho salmon in the tributary streams and main river, and the mean length of the salmon in the lakes generally increased with distance away from shore.

Swales, S., R.B. Lauzier, and C.D. Levings. 1986. Winter habitat preferences of juvenile salmonids in two interior rivers in British Columbia. *Canadian Journal of Zoology* 64: 1506-1514.

The winter distribution and abundance of juvenile salmonids was investigated in various main channel and off-channel habitats in the Coldwater and Nicola rivers in the southern interior of British Columbia. Catches were generally low in all main channel habitats, with coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*) being most abundant and Chinook salmon and Dolly Varden char being present in smaller numbers. Coho salmon and steelhead trout catches were generally highest in pools with abundant instream and riparian cover. Steelhead trout was the main species in riprap bank protected areas, although catches were generally low. Highest overall catches were recorded in side channels and off-channel ponds, where water temperatures were usually several degrees higher than in the main river. The authors conclude that juvenile salmonids in the rivers investigated showed considerable habitat segregation during the winter. As in coastal rivers, juvenile coho salmon made extensive use of off-channel ponds, while rainbow trout and chinook salmon were generally most abundant in riprap and deep pools containing log debris, respectively.

Swales, S., and C.D. Levings. 1989. Role of off-channel ponds in the life cycle of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Coldwater River, British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 46: 232-242.

Off-channel ponds in the upper reaches of the Coldwater River, British Columbia, were major rearing areas for juvenile coho salmon (*Oncorhynchus kisutch*). Chinook salmon (*Oncorhynchus tshawytscha),* steelhead trout (*Salmo gairdneri*), and Dolly Varden char (*Salvelinus malma*) were generally scarce in the ponds, although they were numerous in the main river. Coho salmon were predominant at "natural" river sites while steelhead trout was the main species at sites with "rip-rap" bank stabilization. Catches of juvenile coho were much lower in the main river than in the ponds where they were the main species, and were more variable in the river. Population density and biomass estimates of juvenile coho in the ponds ranged from 0.100 fish/m^2 and 1.00 g/m^2 to 1.00 fish/m^2 and 5.15 g/m^2, compared with density estimates of 0.08-0.23 fish/m^2 in the river.

Takami, T., F. Kitano, and S. Nakano. 1997. High water temperature influences on foraging responses and thermal deaths of Dolly Varden, *Salvelinus malma*, and white-spotted charr, *S. leucomaenis*, in a laboratory. *Fisheries Science (Tokyo)* 63: 6-8.

Water temperature effects on foraging responses and thermal tolerances of two congeneric charrs, Dolly Varden *Salvelinus malma* and white-spotted charr *S. leucomaenis*, were examined in aquarium settings. Appetites decreased at ≥16°C for Dolly Varden at ≥24°C for white-spotted charr. The lethal temperatures were ≥20°C for Dolly Varden and ≥26°C for white-spotted charr. The upper limits of preferred temperature ranges and the lethal temperatures for Dolly Varden were significantly lower than those of white-spotted charr. Temperature preferences and thermal tolerance probably play a major role in the distribution of these two species.

Underwood, T.J., M.J. Millard, and L.A. Thorpe. 1996. Relative abundance, length frequency, age, and maturity of Dolly Varden in nearshore waters of the Arctic National Wildlife Refuge, Alaska. *Transactions of the American Fisheries Society* 125: 719–728.

Uncertainty about the environmental effects of oil development prompted a study of Dolly Varden *Salvelinus malma* in the nearshore waters of the Arctic National Wildlife Refuge, Alaska. Abundance of fish less than 400 mm fork length (FL), as indexed by fyke net catch per unit effort (CPUE), was significantly different among years, with the highest daily catch rates occurring in 1991, a year of heavy pack ice and relatively cold water temperatures. The CPUE

for fish 400 mm or greater did not differ significantly among years. Within each sampling year, both large and small fish appeared to be more abundant in nearshore waters earlier in the summer. Lengths ranged from 53 to 734 mm. Growth was greater early in the season and in the years 1989 and 1990, and site-specific temporal changes in distribution were reflected in analysis of length data. Individual fish were aged at 1–13 years. A gonadosomatic index indicated that sexually mature fish were greater than 400 mm FL. Wide summer dispersal makes Dolly Varden less vulnerable to local coastal perturbations during the summer; however, vulnerability may be greater for stocks that must migrate seasonally through particular areas (e.g., a river mouth during fall migrations). The significant differences in local abundance patterns makes effective monitoring of the overall population size difficult. Monitoring spawners or overwintering fish in freshwater may be a more accurate means of assessing overall abundance trends.

Appendix 4.2-1

Photographs of Impacted Watercourses (HADD)

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Appendix 4.2-1. Photographs of Impacted Watercourses (HADD)

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Plate 1. Stream Site 1001.



Plate 2. Stream Site 1001.



Plate 3. Stream Site 1002.



Plate 4. Stream Site 1003.



Plate 5. Stream Site 1004.



Plate 6. Stream Site 1027.



Plate 7. Stream Site 1051.



Plate 8. Stream Site 1051.



Plate 9. Stream Site 1052.



Plate 10. Stream Site 1053.



Plate 11. Stream Site 1090.



Plate 12. Stream Site 1091.



Plate 13. Stream Site 1093.



Plate 14. Stream Site 1110.



Plate 15. Stream Site 1150.



Plate 16. Stream Site 1151.



Plate 17. Stream Site 1205.



Plate 18. Stream Site 1205.



Plate 19. Stream Site 1029.



Plate 20. Stream Site 1030.



Plate 21. North Treaty Reach 1.



Plate 22. North Treaty Reach 1.



Plate 23. North Treaty Reach 2.



Plate 24. North Treaty Reach 2.



Plate 25. South Teigen Reach 8.



Plate 26. South Teigen Reach 8.



Plate 27. South Teigen Reach 7.



Plate 28. South Teigen Reach 6.



Plate 29. South Teigen Reach 4.



Plate 30. South Teigen Reach 4.



Plate 31. Stream Site 2008.



Plate 32. Stream Site 2008.



Plate 33. Stream Site 2009.



Plate 34. Stream Site 2009.



Plate 35. Stream Site 2001.



Plate 36. Stream Site 2001.



Plate 37. Stream Site 2025.



Plate 38. Stream Site 2035.



Plate 39. Stream Site 2036.



Plate 40. Stream Site 2037.



Plate 41. Stream Site 2039.



Plate 42. South Teigen – 2045.



Plate 43. Stream Site 2045.



Plate 44. Stream Site 3030.



Plate 45. Stream Site 3030.



Plate 46. Unuk River – 1025.



Plate 47. Unuk River – 1025.

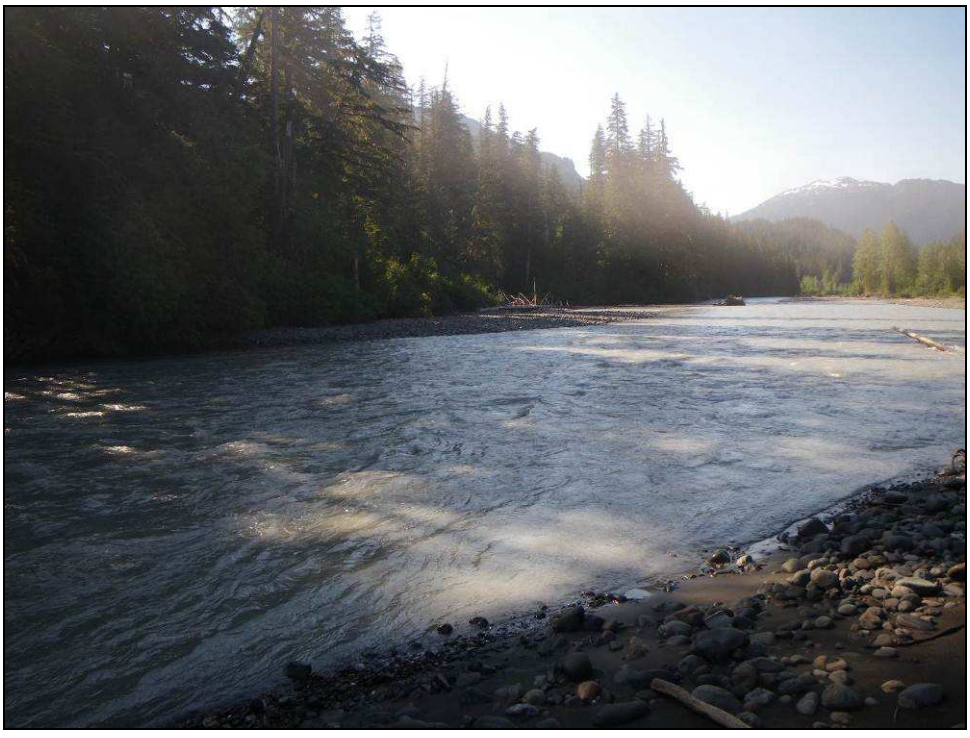


Plate 48. Unuk River – 1025.



Plate 49. Unuk River – 1025.



Plate 50. Stream Site 2060.

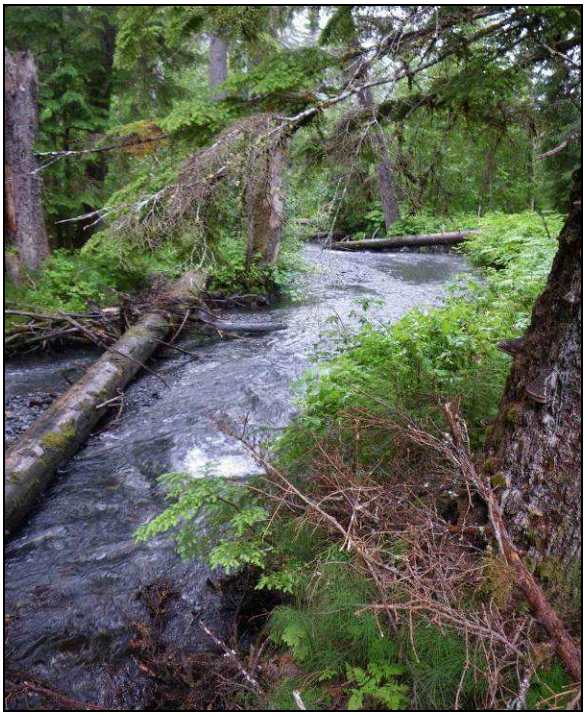


Plate 51. Coulter Creek – 2061.



Plate 52. Coulter Creek – 2061.

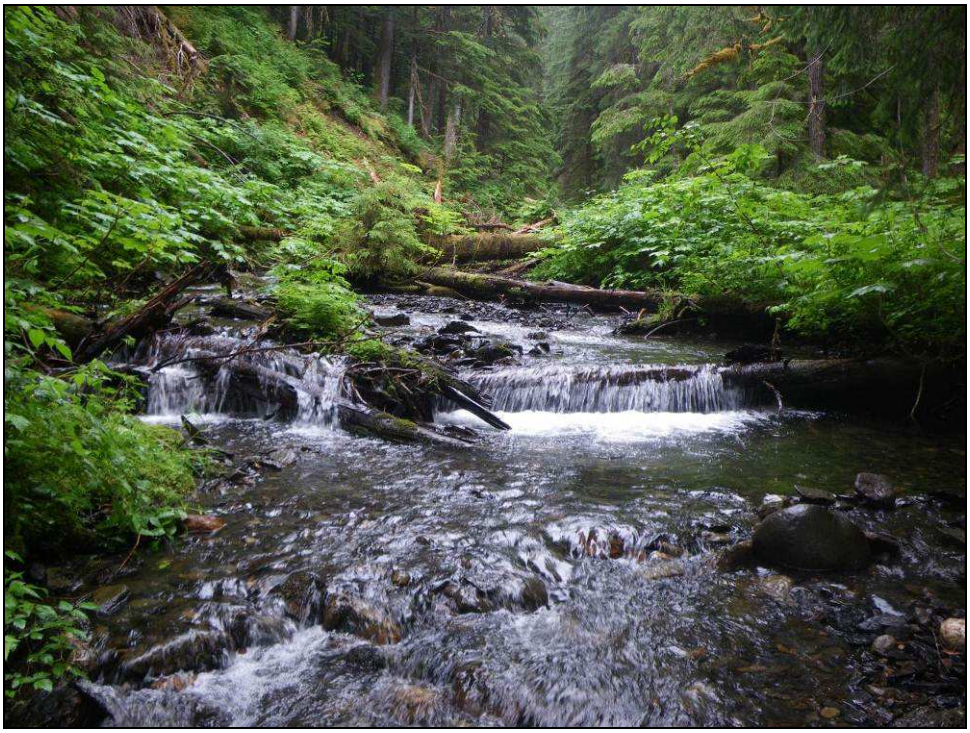


Plate 53. Stream Site 2063.



Plate 54. Stream Site 2063.



Plate 55. Stream Site 2064.



Plate 56. Stream Site 5008.



Plate 57. Stream Site 5007.



Plate 58. Stream Site 5007.



Plate 59. Stream Site 1012.

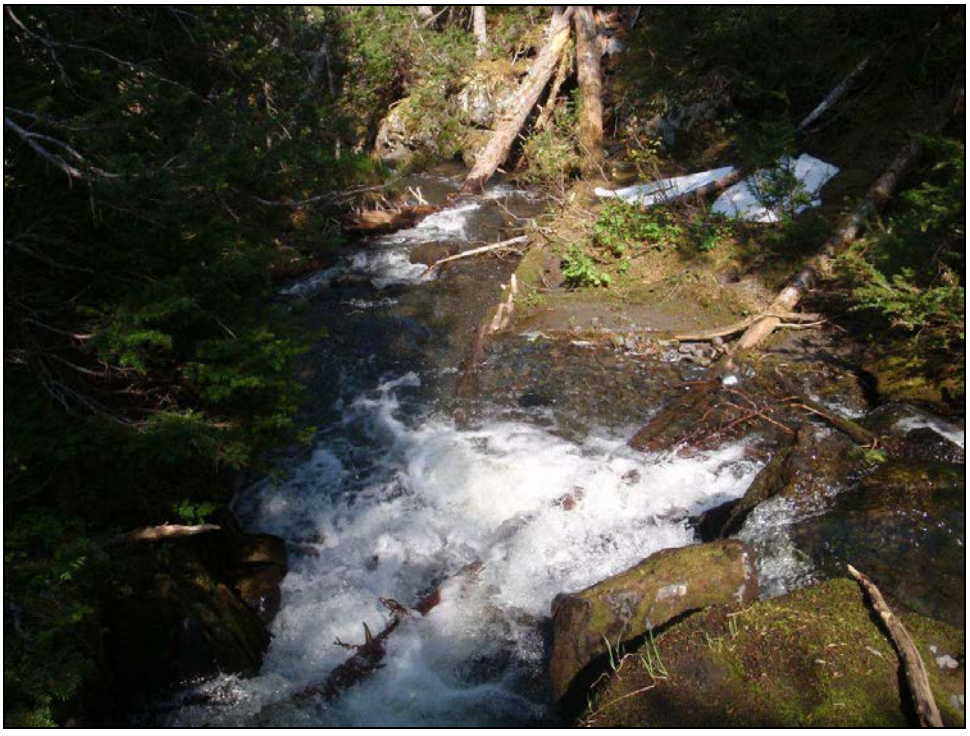


Plate 60. Stream Site 1012.



Plate 61. Stream Site 1014.



Plate 62. Stream Site 1015.



Plate 63. Stream Site 1015.



Plate 64. Stream Site 1016.



Plate 65. Stream Site 1016.



Plate 66. Stream Site 1017.



Plate 67. Stream Site 1207.



Plate 68. Stream Site 243.



Plate 69. Stream Site 243.



Plate 70. Stream Site 114.



Plate 71. Stream Site 114.



Plate 72. Stream Site 108.



Plate 73. Stream Site 108.



Plate 74. Stream Site 244.



Plate 75. Stream Site 244.



Plate 76. Stream Site 210.



Plate 77. Stream Site 210.



Plate 78. Stream Site 209.



Plate 79. Stream Site 209.



Plate 80. Stream Site 205.



Plate 81. Stream Site 205.



Plate 82. Stream Site 204.



Plate 83. Stream Site 100.



Plate 84. Stream Site 100.



Plate 85. Stream Site 4004 – Bell Irving River.



Plate 86. Stream Site 4004 – Bell Irving River.



Plate 87. Stream Site 4004 – Bell Irving River.



Plate 88. Stream Site 4005 – Bell Irving River.



Plate 89. Stream Site 4005 – Bell Irving River.

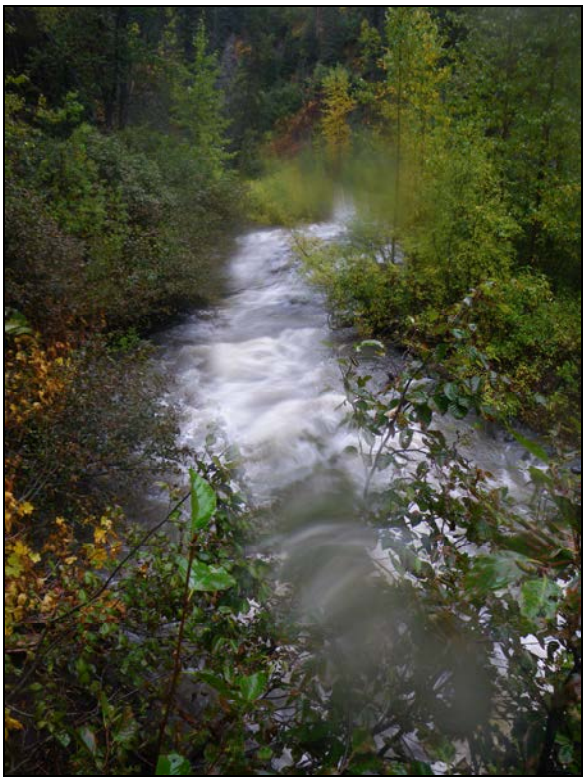


Plate 90. Stream Site 4011 – North Treaty Creek.

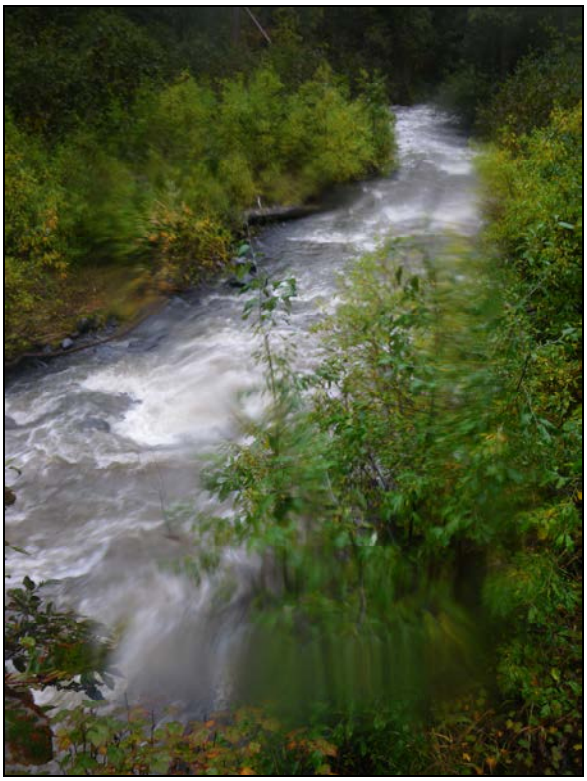


Plate 91. Stream Site 4011 – North Treaty Creek.

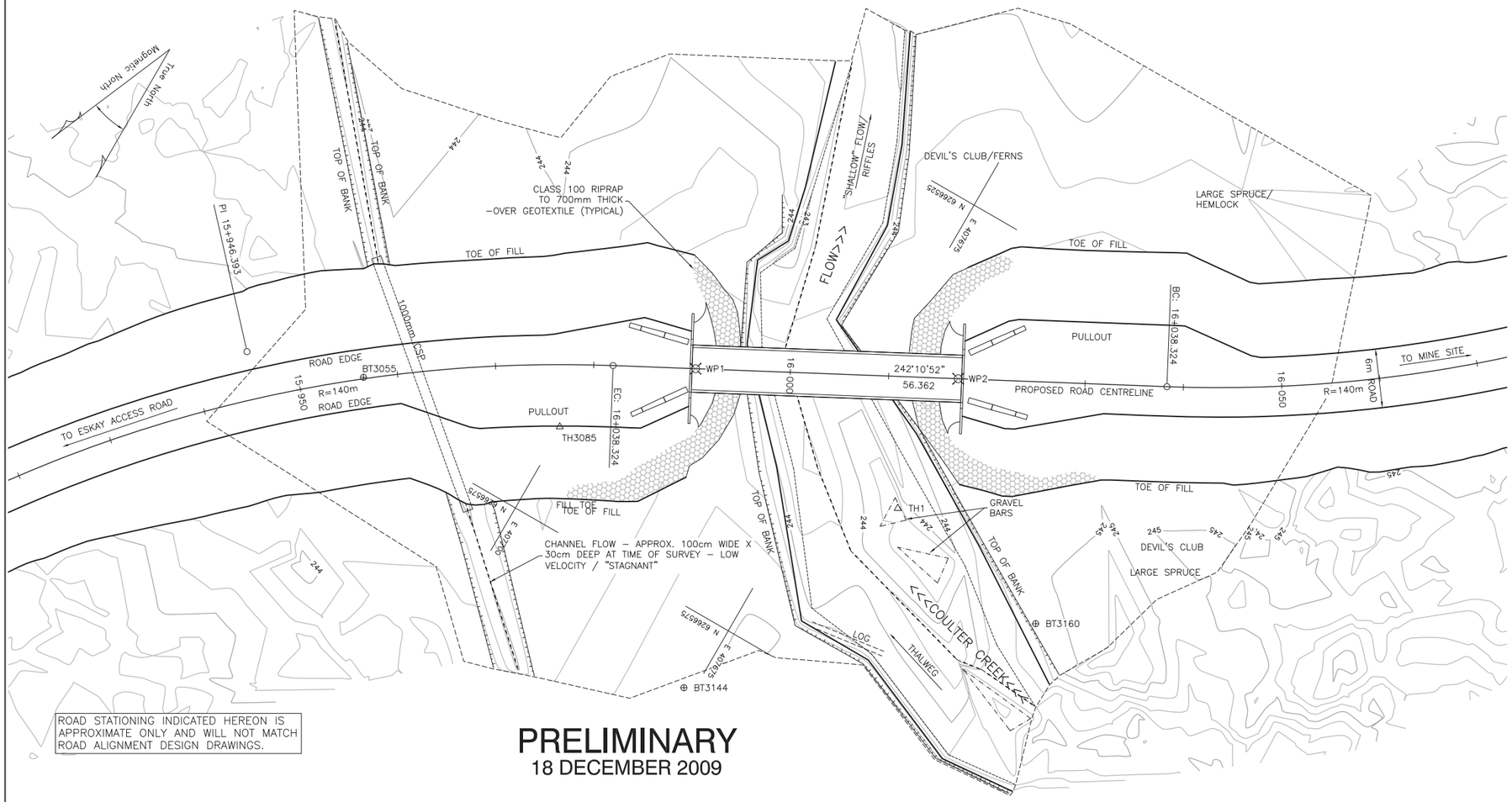


Plate 92. Stream Site 4006 – Glacier Creek.

Appendix 4.2-2

Bridge Crossing Designs for Impacted Watercourses

Rescan™
Engineers and Scientists



ROAD STATIONING INDICATED HEREON IS APPROXIMATE ONLY AND WILL NOT MATCH ROAD ALIGNMENT DESIGN DRAWINGS.

PRELIMINARY
18 DECEMBER 2009

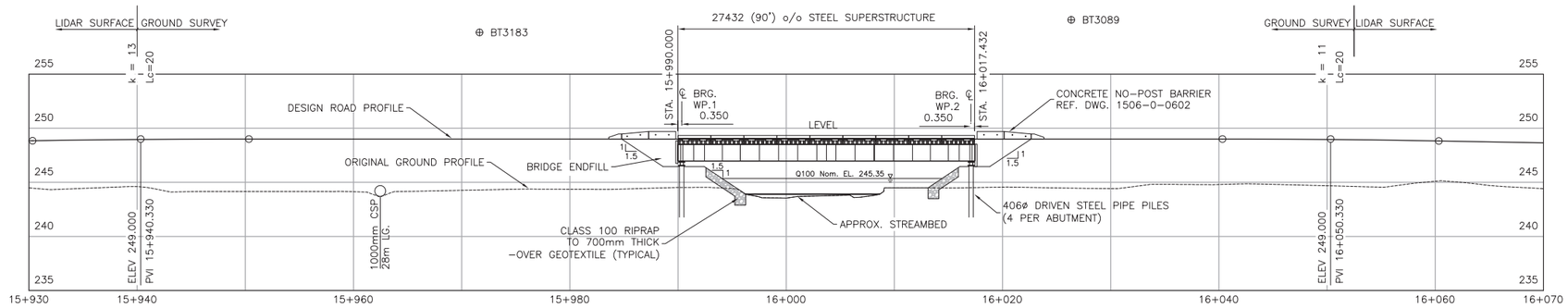
SURVEY CONTROL					
Point	Northing	Easting	Elevation	H.D.	Bearing
1	6266555.596	407666.306	244.500	---	---
3055 – B.S.	6266571.222	407720.019	246.115	55.940	73–46–44
3085	6266565.600	407700.206	244.353	35.345	73–33–29
3089	6266576.778	407640.104	247.097	33.693	308–57–07
3144	6266582.267	407676.015	247.418	28.383	20–00–08
3160	6266558.737	407648.290	246.867	18.288	279–53–27
3183	6266605.133	407686.896	246.561	53.646	22–34–11
WP1	6266553.576	407691.213	249.000*	24.988	94–38–08
WP2	6266541.101	407667.570	249.000*	14.550	175–00–57

* WP's LOCATED AT CENTRELINE OF ROADWAY AND CENTRELINE OF BEARING. ELEVATIONS ARE AT FINISHED GRADE.

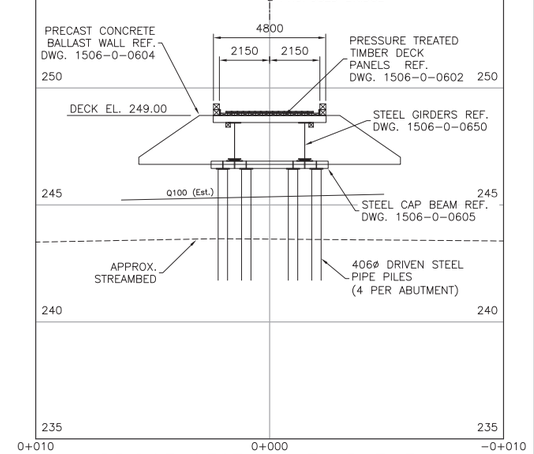
THIS STRUCTURE HAS BEEN DESIGNED IN ACCORDANCE WITH THE APPROPRIATE CODES AND STANDARDS TO SUSTAIN DEAD LOADS, AND THE GIVEN LIVE LOAD WHEN COMPLETE. IT HAS BEEN DESIGNED TO SUSTAIN REASONABLE LOADS DURING CONSTRUCTION BUT MUST BE CHECKED AGAINST THE LOADINGS IMPOSED BY THE CONTRACTOR'S SPECIFIC METHOD OF CONSTRUCTION. IN ACCORDANCE WITH THE BYLAWS OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF B.C. CLAUSE 14 (b) (4), FIELD REVIEW OF PROJECTS DURING CONSTRUCTION IS A REQUIREMENT. FAILURE TO RETAIN THE ENGINEER, OR HIS CHOICE OF THIRD PARTY, TO REVIEW THE CONTRACTOR'S PROCEDURES AND MONITOR CONSTRUCTION WILL RESULT IN McELHANNEY CONSULTING SERVICES LTD. BEING UNABLE TO CERTIFY THE CONSTRUCTED WORKS.

DESIGN NOTES/SPECIFICATIONS

1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6–2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506–0–601 TO 1506–0–605 AND 1506–0–650.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.



PROFILE – ALONG PROPOSED ROAD CENTERLINE
LOOKING DOWNSTREAM



BRIDGE SECTION AT ABUTMENT
LOOKING UP–CHAINAGE

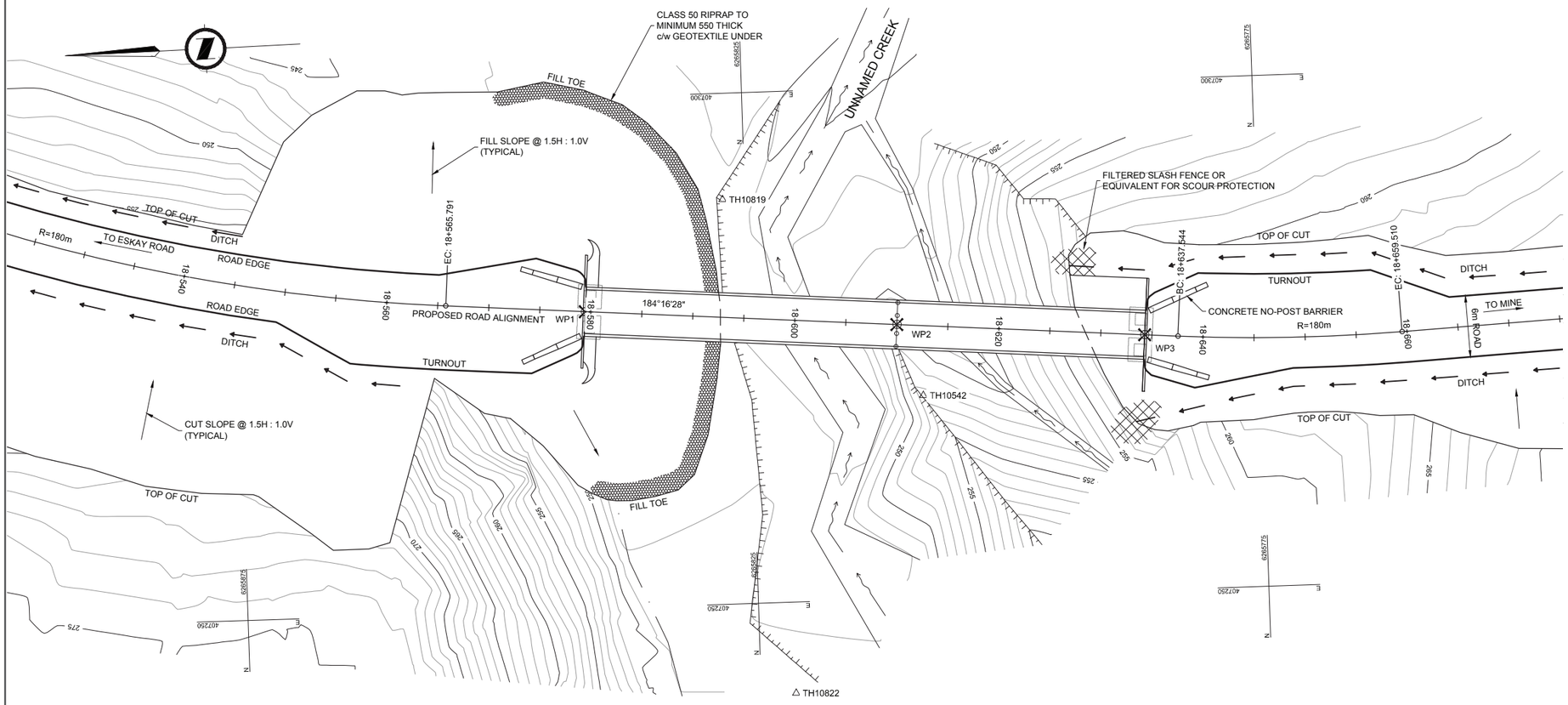
0 1:250 10

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT
Rescan™ Engineers & Scientists

Appendix 4.2-2a

Coulter Creek Access Road: Coulter Creek (2061) and 2060 Crossings



PLAN

ROAD STATIONING INDICATED HEREON IS APPROXIMATE ONLY AND WILL NOT MATCH ROAD ALIGNMENT DESIGN DRAWINGS.

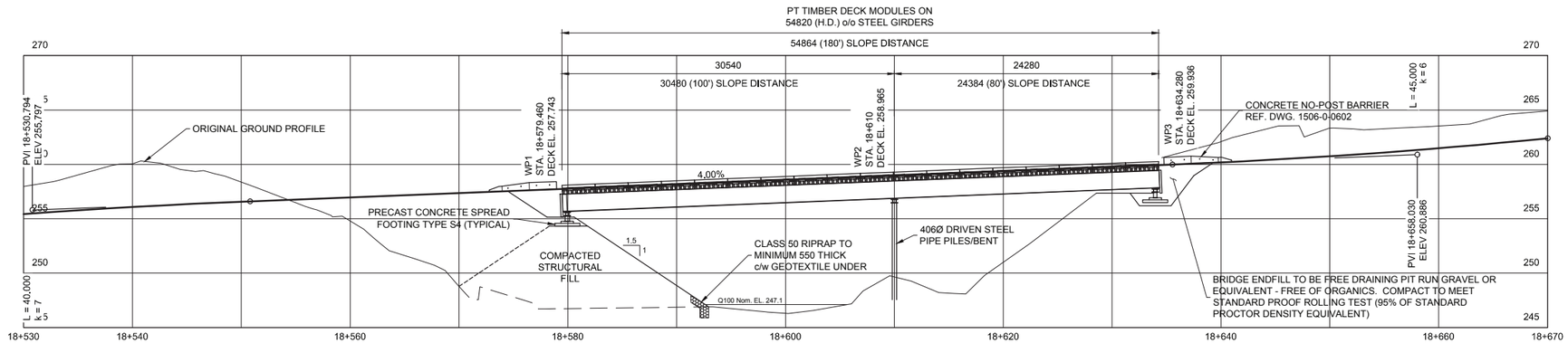
SURVEY CONTROL					
Point	Northing	Easting	Elevation	H.D.	Bearing
TH10822	6265821.612	407241.102	249.017	– – –	– – –
TH10542 - B.S.	6265808.200	407269.795	252.478	31.673	115-03-14
TH10819	6265827.198	407289.603	246.568	48.821	83-25-50
WP1	6265841.002	407279.089	257.743 *	42.649	62-57-30
WP2	6265810.547	407276.812	258.965 *	37.385	107-12-59
WP3	6265786.335	407275.003	259.936 *	48.926	136-08-26

*NOMINAL DECK ELEVATION

THIS STRUCTURE HAS BEEN DESIGNED IN ACCORDANCE WITH THE APPROPRIATE CODES AND STANDARDS TO SUSTAIN DEAD LOADS, AND THE GIVEN LIVE LOAD WHEN COMPLETE. IT HAS BEEN DESIGNED TO SUSTAIN REASONABLE LOADS DURING CONSTRUCTION BUT MUST BE CHECKED AGAINST THE LOADINGS IMPOSED BY THE CONTRACTOR'S SPECIFIC METHOD OF CONSTRUCTION. IN ACCORDANCE WITH THE BYLAWS OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF B.C. CLAUSE 14 (b) (4), FIELD REVIEW OF PROJECTS DURING CONSTRUCTION IS A REQUIREMENT. FAILURE TO RETAIN THE ENGINEER, OR HIS CHOICE OF THIRD PARTY, TO REVIEW THE CONTRACTOR'S PROCEDURES AND MONITOR CONSTRUCTION WILL RESULT IN McELHANNEY CONSULTING SERVICES LTD. BEING UNABLE TO CERTIFY THE CONSTRUCTED WORKS.

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2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601 TO 1506-0-605.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-224-04.



PROFILE - ALONG PROPOSED ROAD CENTERLINE

LOOKING DOWNSTREAM

DRAFT - NOT FOR CONSTRUCTION

0 25

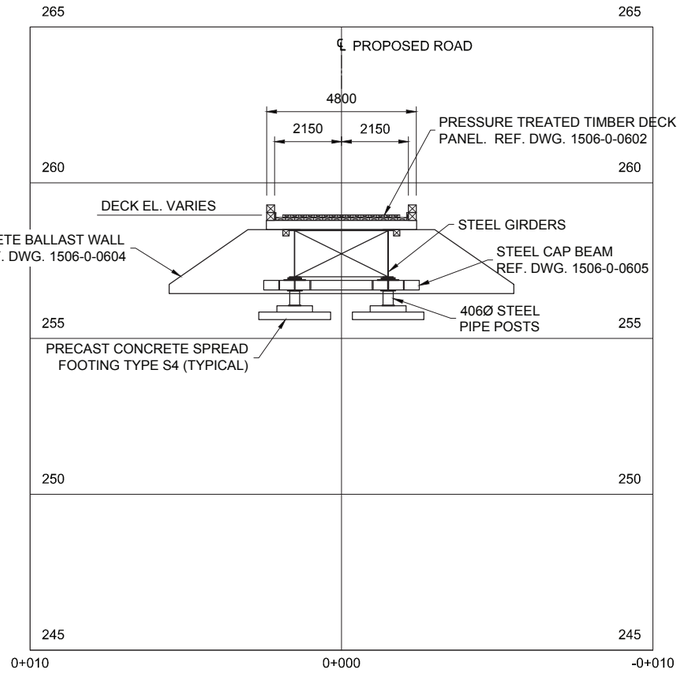
Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT

Rescan™ Engineers & Scientists

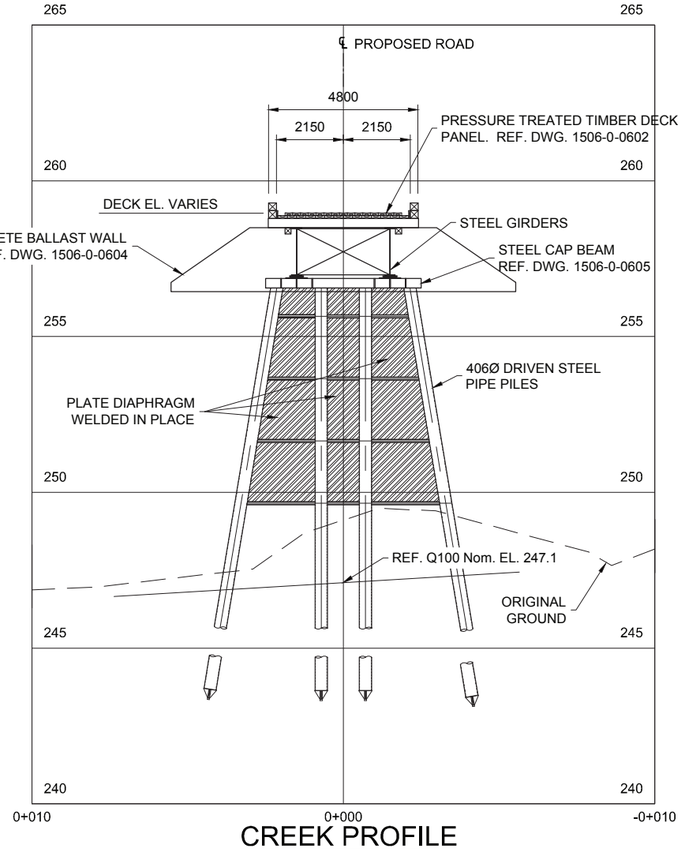
Appendix 4.2-2b

Coulter Creek Access Road: Stream Crossings 2063 and 2064



CREEK PROFILE

LOW AND HIGH CHAINAGE SIMILAR



CREEK PROFILE

LOOKING UP-CHAINAGE
STA. 18-610

ROAD STATIONING INDICATED HEREON IS APPROXIMATE ONLY AND WILL NOT MATCH ROAD ALIGNMENT DESIGN DRAWINGS.

DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

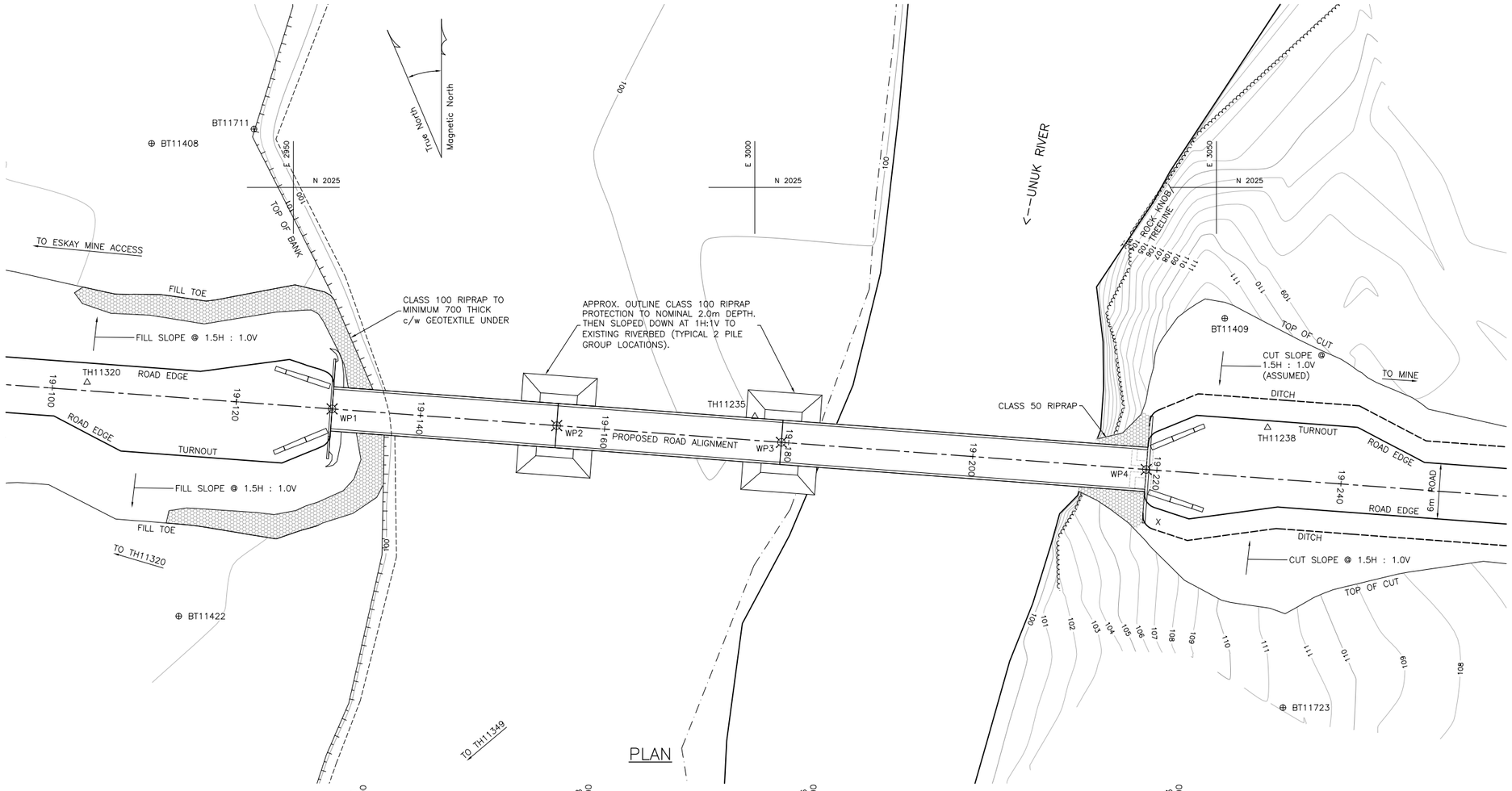
0 10
Metres

SEABRIDGE GOLD
KSM PROJECT

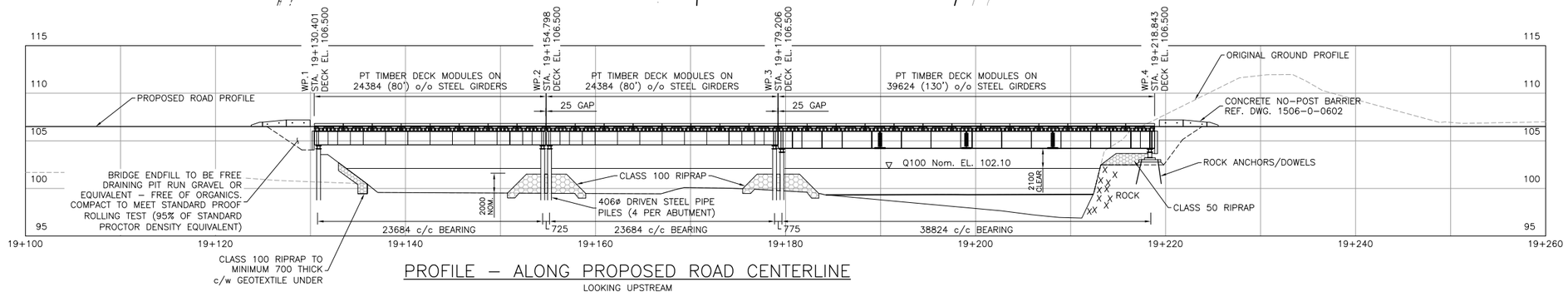
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Appendix 4.2-2c

Coulter Creek Access Road:
Stream Crossings 2063 and 2064



PLAN



PROFILE – ALONG PROPOSED ROAD CENTERLINE

LOOKING UPSTREAM

SURVEY CONTROL					
Point	Northing	Easting	Elevation	H.D.	Bearing
TH11320	2003.890	2927.661	101.532	---	---
BT11422–B.S.	1978.563	2937.587	101.099	27.203	158–35–57
WP1	2001.013	2954.200	106.500*	26.695	96–11–13
WP2	1999.203	2978.529	106.500*	51.084	95–15–50
WP3	1997.393	3002.871	106.500*	75.490	94–56–14
WP4	1994.453	3042.398	106.500*	115.125	94–42–07
TH11235	2000.000	3000.000	100.000	---	---
TH11238	1998.993	3055.546	112.675	---	---
BT11723	1968.653	3057.202	112.470	---	---
BT11409	2010.824	3050.904	113.091	---	---
BT11711	2031.330	2945.735	103.349	---	---
BT11408	2029.776	2934.642	101.489	---	---
BT11349	1932.413	2945.993	102.117	---	---

* NOMINAL DECK ELEVATION

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DESIGN NOTES/SPECIFICATIONS

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2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506–0–601 TO 1506–0–605, 1506–0–645 AND 1506–0–670.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506–210–01.

0 5 10 15 20 25

Metres

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT

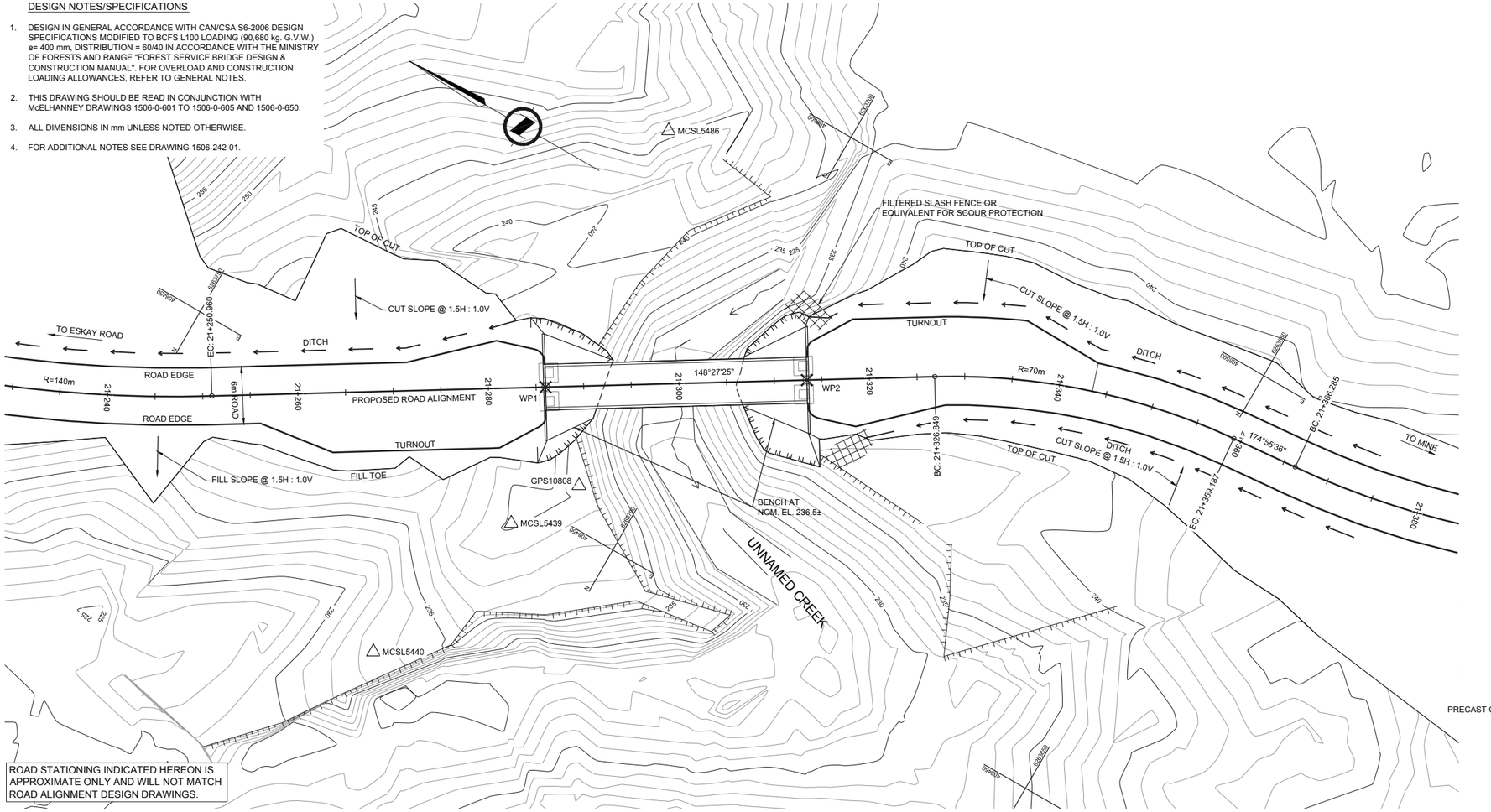
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Appendix 4.2-2d

Coulter Creek Access Road: Unuk River (1025) Crossing

DESIGN NOTES/SPECIFICATIONS

1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6-2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601 TO 1506-0-605 AND 1506-0-650.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-242-01.

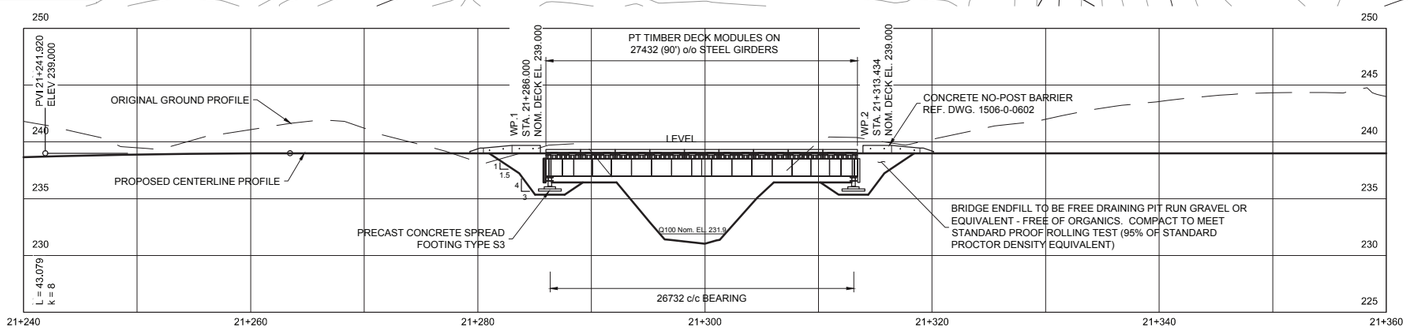


SURVEY CONTROL					
Point	Northing	Easting	Elevation	H.D.	Bearing
WP1	6263714.660	408461.282	239.000	– – –	– – –
WP2 - B.S.	6263691.281	408475.632	239.000	38.400	254-10-07
MCSL5486	6263716.934	408491.035	248.895	44.373	261-50-05
GPS10808	6263706.458	408454.092	239.155	62.855	269-31-58
MCSL5439	6263710.632	408447.111	240.242 *	29.840	265-37-50
MCSL5440	6263716.421	408428.182	233.523 *	29.921	210-58-54

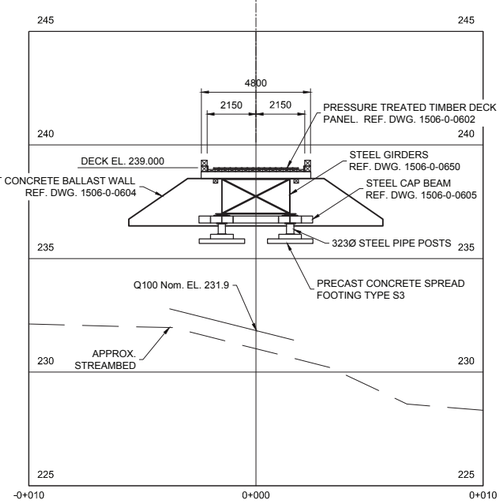
*NOMINAL DECK ELEVATION

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0 1:500 25
UNLESS NOTED OTHERWISE



PROFILE - ALONG PROPOSED ROAD CENTERLINE
LOOKING UPSTREAM



CREEK PROFILE
LOOKING UP-CHAINAGE

0 1:250 10

DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT
Rescan™ Engineers & Scientists

Appendix 4.2-2e

Coulter Creek Access Road: Stream Crossing 5007

DESIGN NOTES/SPECIFICATIONS

1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6-2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601 TO 1506-0-605, 1506-0-635 AND 1506-0-640.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-0-234-01.

THIS STRUCTURE HAS BEEN DESIGNED IN ACCORDANCE WITH THE APPROPRIATE CODES AND STANDARDS TO SUSTAIN DEAD LOADS, AND THE GIVEN LIVE LOAD WHEN COMPLETE. IT HAS BEEN DESIGNED TO SUSTAIN REASONABLE LOADS DURING CONSTRUCTION BUT MUST BE CHECKED AGAINST THE LOADINGS IMPOSED BY THE CONTRACTOR'S SPECIFIC METHOD OF CONSTRUCTION. IN ACCORDANCE WITH THE BYLAWS OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF B.C. CLAUSE 14 (b) (4), FIELD REVIEW OF PROJECTS DURING CONSTRUCTION IS A REQUIREMENT. FAILURE TO RETAIN THE ENGINEER, OR HIS CHOICE OF THIRD PARTY, TO REVIEW THE CONTRACTOR'S PROCEDURES AND MONITOR CONSTRUCTION WILL RESULT IN McELHANNEY CONSULTING SERVICES LTD. BEING UNABLE TO CERTIFY THE CONSTRUCTED WORKS.

SURVEY CONTROL - SECONDARY CHANNEL					
Point	Northing	Easting	Elevation	H.D.	Bearing
MCSL5354	6270621.239	457131.549	567.045	---	---
BM5398 - B.S.	6270647.809	457149.389	570.761	32.004	33-52-43
MCSL5397	6270609.170	457103.023	566.997	30.974	247-04-02
MCSL5396	6270619.533	457177.592	566.099	46.075	92-07-20
BM5399	6270573.098	457152.575	566.194	52.532	156-24-19
WP1	6270614.785	457146.734	570.300 *	16.500	113-01-26
WP2	6270611.037	457128.836	570.300 *	10.557	194-53-21

SURVEY CONTROL - PRIMARY CHANNEL					
Point	Northing	Easting	Elevation	H.D.	Bearing
MCSL5355	6270604.311	457073.393	565.463	---	---
MCSL10753- B.S.	6270581.721	457069.841	564.948	22.868	188-56-07
BM5351	6270539.255	457067.525	565.280	65.321	185-09-14
MCSL5356	6270588.223	457021.368	564.370	54.455	252-48-56
BM5353	6270634.064	457060.505	569.952	32.424	336-34-47
MCSL5397	6270609.170	457103.023	566.997	30.026	80-41-17
MCSL10788	6270615.601	457071.784	565.941	11.404	351-53-28
WP3	6270602.281	457087.031	569.550 *	13.789	98-28-01
WP4	6270597.908	457066.148	569.550 *	9.669	228-31-29

*NOMINAL DECK ELEVATION

BM5399
BM5351
MCSL10753
18288 (60') STEEL GIRDER BRIDGE WITH TIMBER DECK
21336 (70') STEEL GIRDER BRIDGE WITH TIMBER DECK
FILL TOE
TO HIGHWAY 37
TO TUNNEL PORTALS
FILL SLOPE @ 1.5H : 1.0V (TYPICAL)
FILL SLOPE @ 1.5H : 1.0V (GRANULAR)
ROAD EDGE
8m ROAD
10m ROAD
CONCRETE NO-POST BARRIER (TYPICAL)
MCSL5396
WP1
WP2
WP3
WP4
PROPOSED ROAD ALIGNMENT
MCSL5397
MCSL5356
MCSL5355
MCSL5354
MCSL10788
SECONDARY CHANNEL
PRIMARY CHANNEL
CLASS 50 RIPRAP TO MINIMUM 550 THICK c/w GEOTEXTILE UNDER (TYPICAL)
BM5398
BM5353
4-600
4-620
4-640
4-660
4-680
4-700
4-720
4-740
4-760
4-780
6270650
457100
6270675
457050
6270600
457150
6270625
457100
564
565
566
567
568
569

ROAD STATIONING INDICATED HEREON IS APPROXIMATE ONLY AND WILL NOT MATCH ROAD ALIGNMENT DESIGN DRAWINGS.

DRAFT - NOT FOR CONSTRUCTION

0 1:500 25

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT

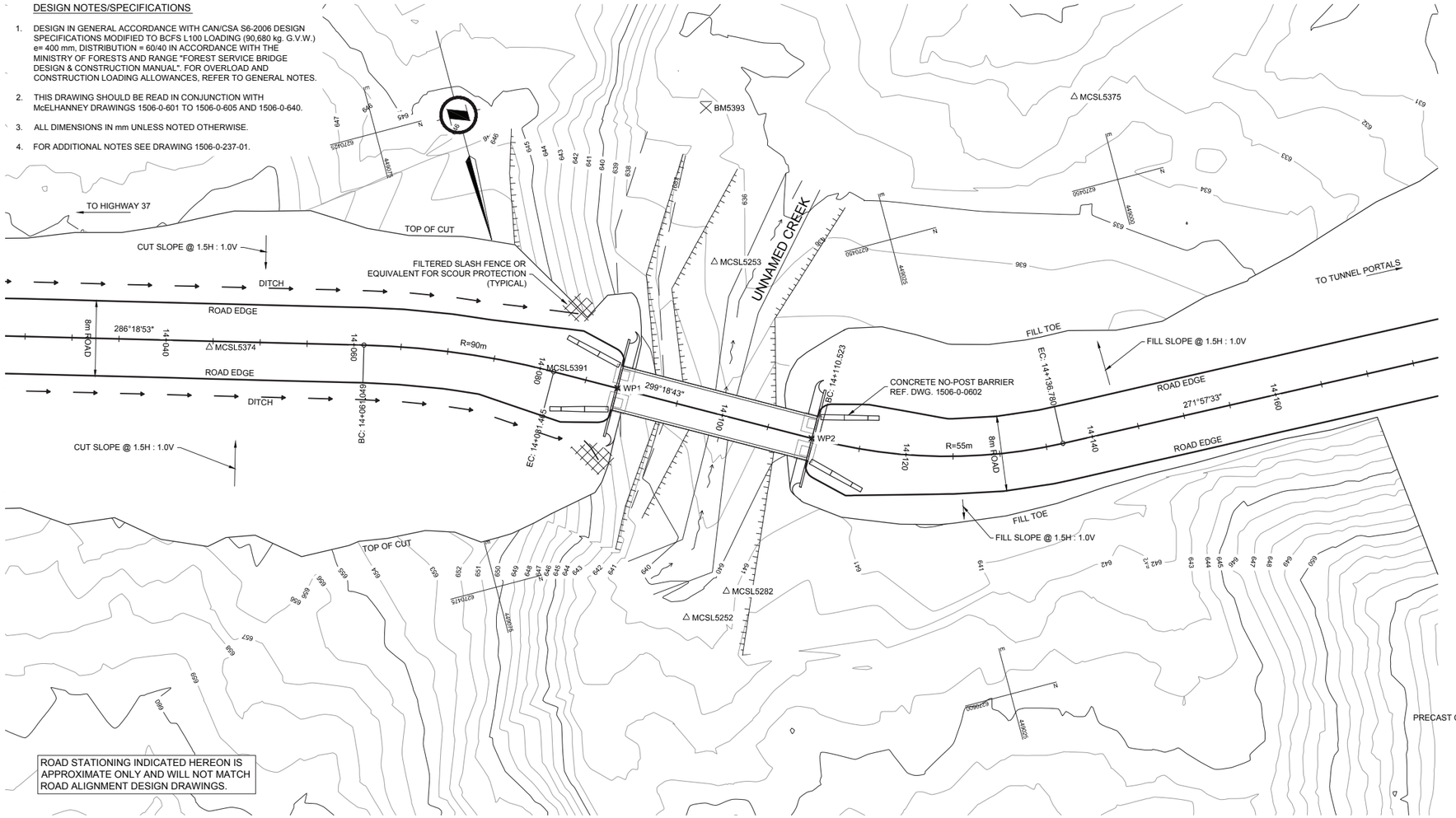
Rescan™ Engineers & Scientists

Appendix 4.2-2f

Treaty Creek Access Road: Stream Crossing 100

DESIGN NOTES/SPECIFICATIONS

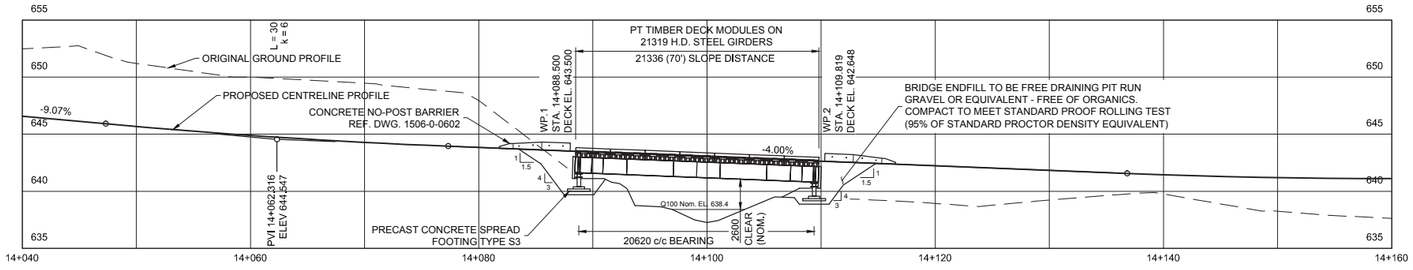
1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6-2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601 TO 1506-0-605 AND 1506-0-640.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-0-237-01.



SURVEY CONTROL					
Point	Northing	Easting	Elevation	H.D.	Bearing
MCSL5252	6270483.314	449056.265	641.395	---	---
MCSL5253 - B.S.	6270447.512	449043.681	636.734	37.950	199-21-59
MCSL5282	6270481.691	449051.427	640.541	5.103	251-26-52
MCSL5374	6270442.518	449097.933	652.846	58.314	134-23-40
MCSL5375	6270440.336	449002.203	632.791	69.064	231-30-59
MCSL5391	6270453.667	449064.410	647.880	30.746	164-38-22
BM5393	6270431.439	449040.358	638.443	54.259	197-02-53
WP1	6270457.853	449057.084	643.500 *	25.475	178-09-29
WP2	6270468.290	449038.495	642.648 *	23.271	229-47-10

*NOMINAL DECK ELEVATION

THIS STRUCTURE HAS BEEN DESIGNED IN ACCORDANCE WITH THE APPROPRIATE CODES AND STANDARDS TO SUSTAIN DEAD LOADS, AND THE GIVEN LIVE LOAD WHEN COMPLETE. IT HAS BEEN DESIGNED TO SUSTAIN REASONABLE LOADS DURING CONSTRUCTION BUT MUST BE CHECKED AGAINST THE LOADINGS IMPOSED BY THE CONTRACTOR'S SPECIFIC METHOD OF CONSTRUCTION. IN ACCORDANCE WITH THE BYLAWS OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF B.C. CLAUSE 14 (b) (4), FIELD REVIEW OF PROJECTS DURING CONSTRUCTION IS A REQUIREMENT. FAILURE TO RETAIN THE ENGINEER, OR HIS CHOICE OF THIRD PARTY, TO REVIEW THE CONTRACTOR'S PROCEDURES AND MONITOR CONSTRUCTION WILL RESULT IN McELHANNEY CONSULTING SERVICES LTD. BEING UNABLE TO CERTIFY THE CONSTRUCTED WORKS.

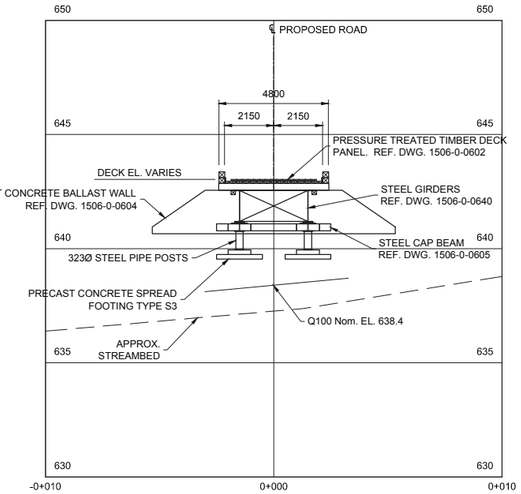


PROFILE - ALONG PROPOSED ROAD CENTERLINE

LOOKING DOWNSTREAM

0 25

UNLESS OTHERWISE NOTED



CREEK PROFILE

LOOKING UP-CHAINAGE

0 1:250 10

DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT

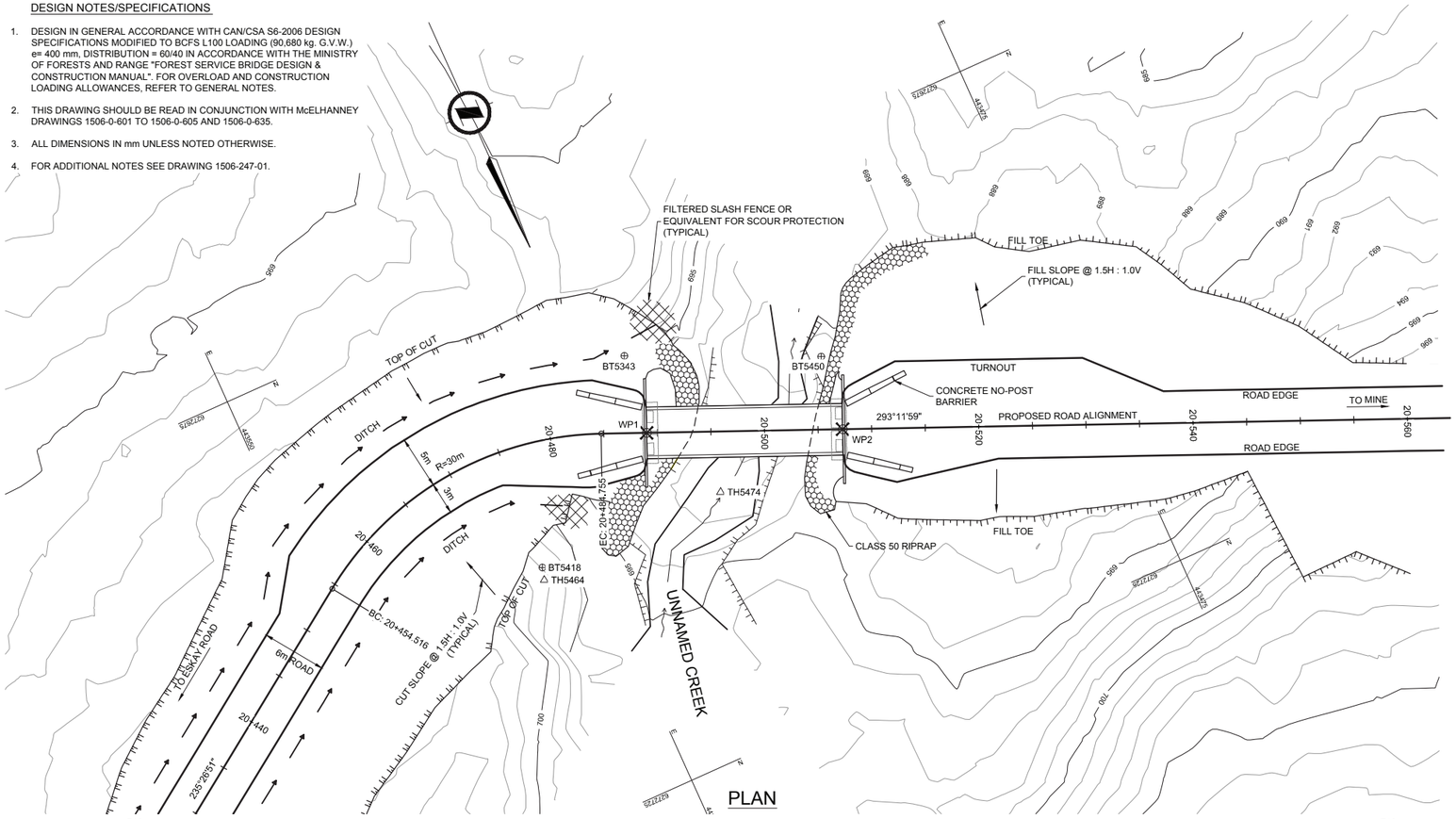
Rescan™ Engineers & Scientists

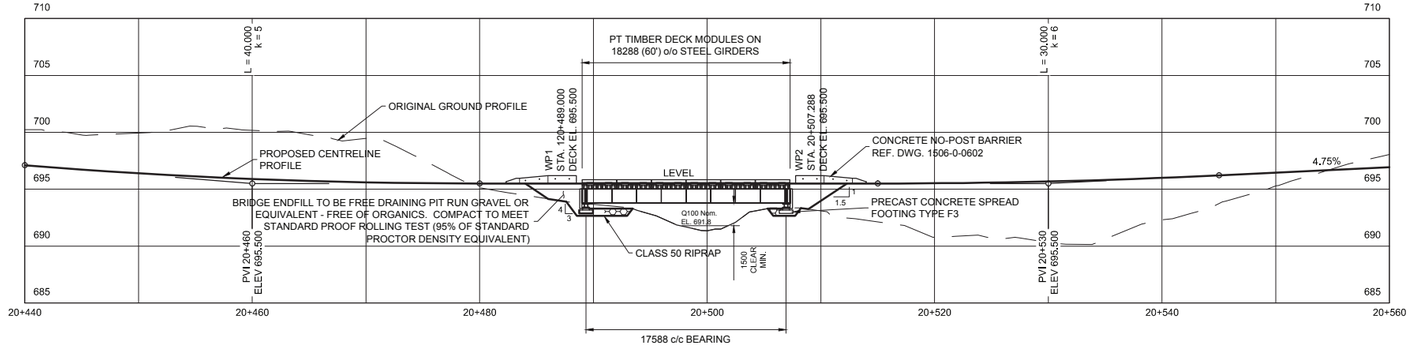
Appendix 4.2-2g

Treaty Creek Access Road: Stream Crossing 114

DESIGN NOTES/SPECIFICATIONS

1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6-2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601 TO 1506-0-605 AND 1506-0-635.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-247-01.





PROFILE - ALONG PROPOSED ROAD CENTERLINE

LOOKING DOWNSTREAM

0 1:500 25

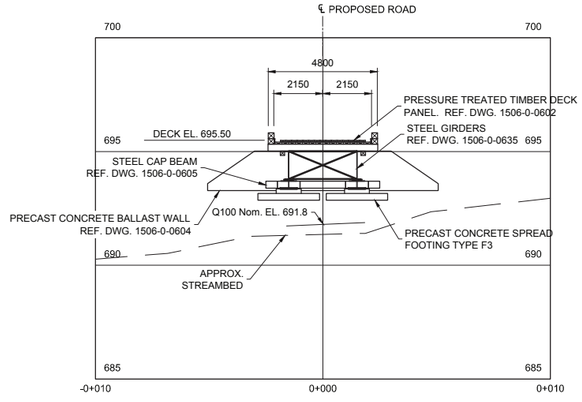
UNLESS NOTED OTHERWISE

SURVEY CONTROL					
Point	Northing	Easting	Elevation	H.D.	Bearing
TH5474	6272701.591	443511.499	692.822	– – –	– – –
TH5464 - B.S.	6272702.308	443529.860	698.340	18.375	87-45-47
BT5418	6272701.169	443529.543	699.537	18.050	91-20-20
BT5450	6272693.918	443497.743	693.763	15.750	240-50-51
BT5343	6272686.311	443514.457	696.993	15.564	169-02-27
WP1	6272693.715	443515.515	695.500 *	8.842	152-58-48
WP2	6272700.919	443498.706	695.500 *	12.810	266-59-32

*NOMINAL DECK ELEVATION

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ROAD STATIONING INDICATED HEREON IS APPROXIMATE ONLY AND WILL NOT MATCH ROAD ALIGNMENT DESIGN DRAWINGS.



CREEK PROFILE

LOOKING UP-CHAINAGE

0 1:250 10

DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT

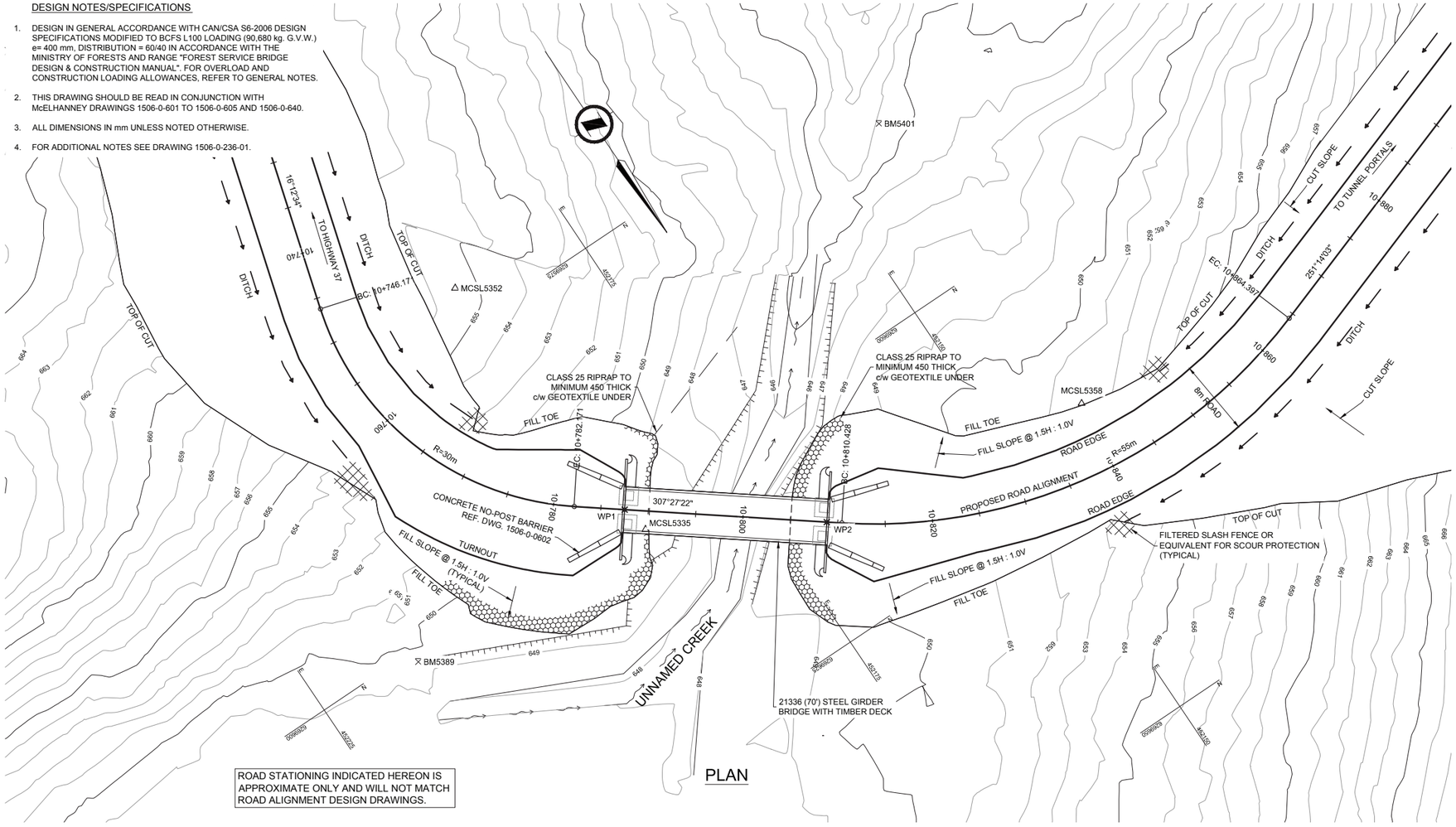
Rescan™ Engineers & Scientists

Appendix 4.2-2h

Treaty Creek Access Road: Stream Crossing 243

DESIGN NOTES/SPECIFICATIONS

1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6-2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601 TO 1506-0-605 AND 1506-0-640.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-0-236-01.



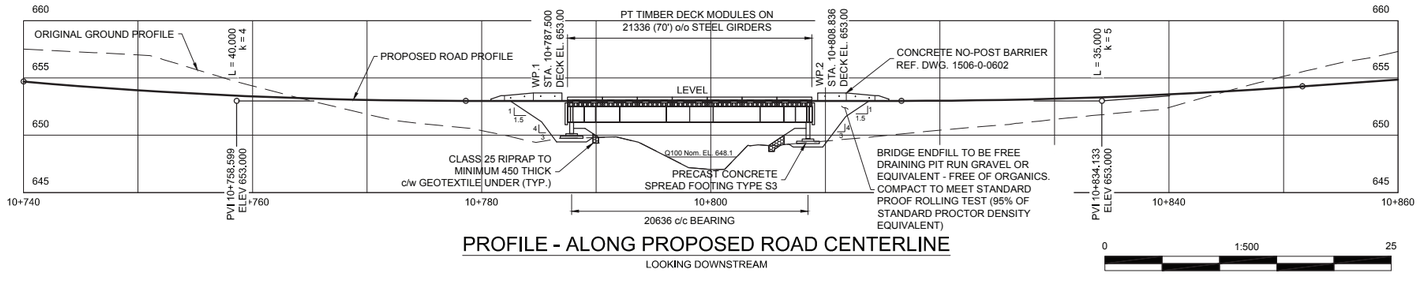
PLAN

ROAD STATIONING INDICATED HEREON IS APPROXIMATE ONLY AND WILL NOT MATCH ROAD ALIGNMENT DESIGN DRAWINGS.

SURVEY CONTROL					
Point	Northing	Easting	Elevation	H.D.	Bearing
MCSL5335	6269603.102	452186.295	650.250	---	---
MCSL5352 - B.S.	6269570.819	452188.743	656.772	32.376	175-39-44
WP1	6269600.146	452186.950	653.000*	3.028	167-29-19
WP2	6269613.121	452170.013	653.000*	19.117	301-36-34
MCSL5358	6269617.721	452140.760	651.374	47.824	287-48-00
BM5389	6269601.320	452213.930	650.910	27.693	93-41-18
BM5401	6269581.370	452142.020	646.250	49.320	243-51-24

*NOMINAL DECK ELEVATION

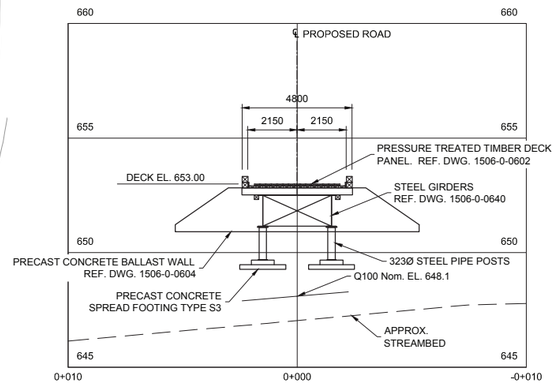
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PROFILE - ALONG PROPOSED ROAD CENTERLINE

LOOKING DOWNSTREAM

0 1:500 25



CREEK PROFILE

LOOKING UP-CHAINAGE

0 1:250 10

DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT

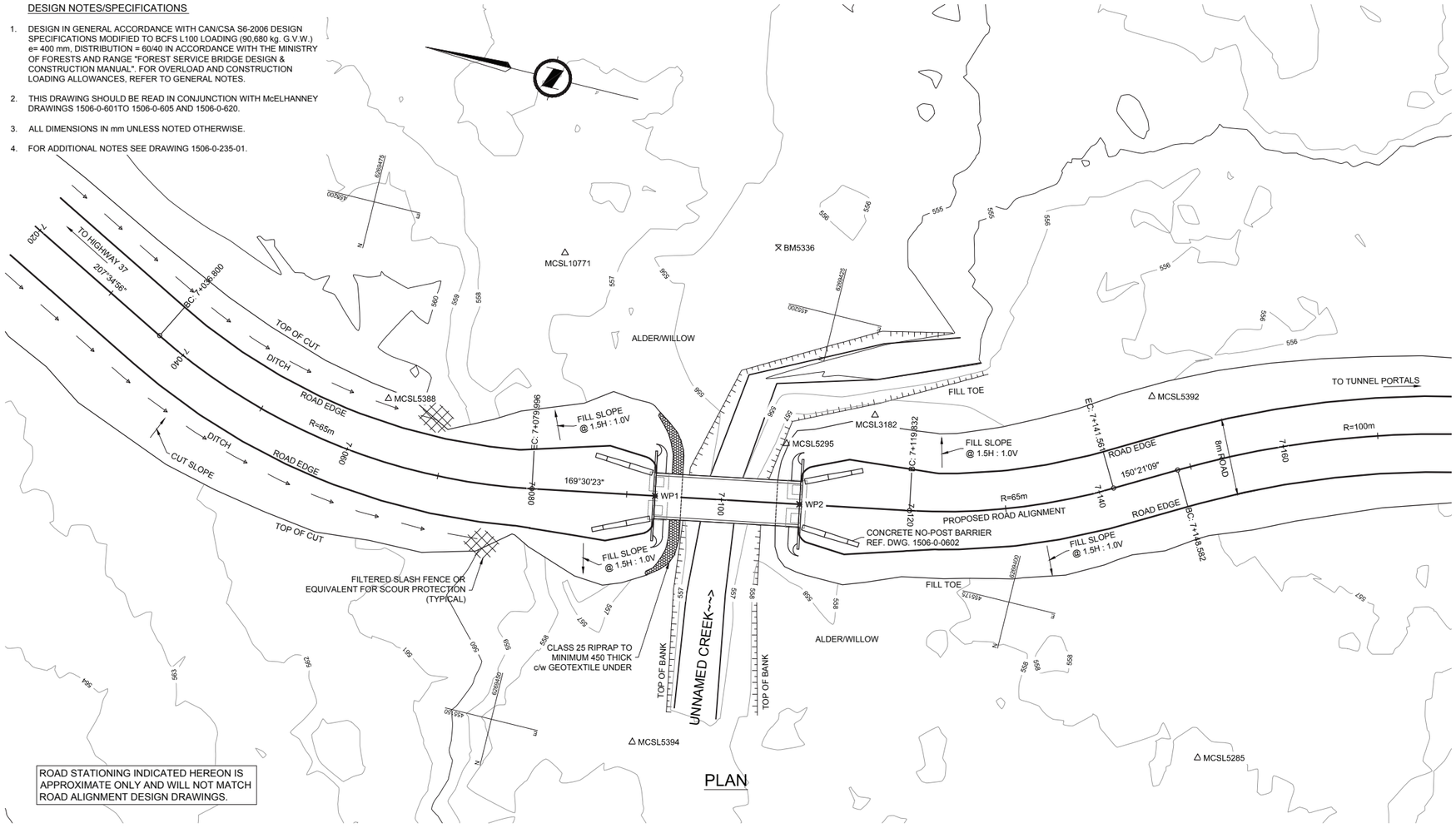
Rescan™ Engineers & Scientists

Appendix 4.2-2i

Treaty Creek Access Road: Stream Crossing 244

DESIGN NOTES/SPECIFICATIONS

1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6-2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601TO 1506-0-605 AND 1506-0-620.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-0-235-01.

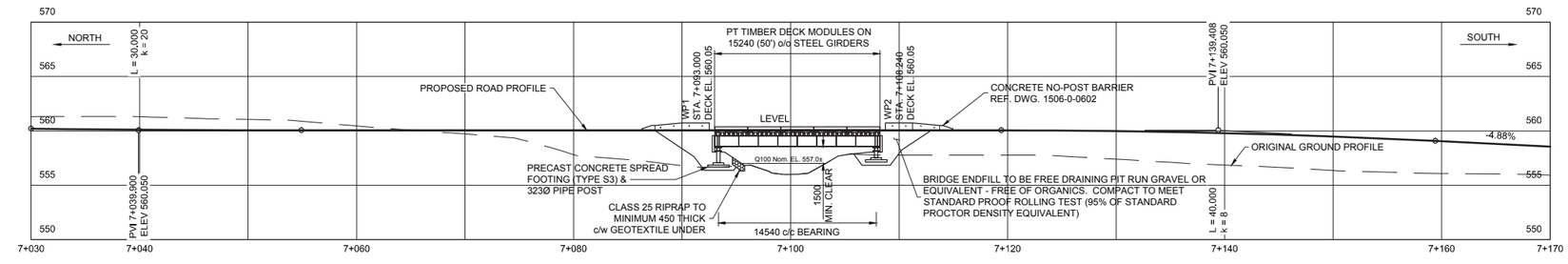


PLAN

SURVEY CONTROL					
Point	Northing	Easting	Elevation	H.D.	Bearing
MCSL5295	6269426.715	455185.620	557.659	---	---
MCSL10771- B.S.	6269454.196	455199.572	557.455	30.820	26-54-58
MCSL5388	6269468.561	455180.219	560.228	42.193	352-38-40
MCSL5394	6269435.001	455151.209	557.752	35.395	283-32-20
BM5336	6269432.470	455205.460	557.600	20.657	73-49-23
MCSL3182	6269418.398	455190.760	557.408	9.777	148-17-17
MCSL5392	6269390.530	455199.624	556.027	38.800	158-50-37
MCSL5285	6269376.773	455163.796	558.122	54.502	203-36-18
WP1	6269438.861	455176.968	560.050 *	14.913	324-32-13
WP2	6269423.876	455179.744	560.050 *	6.526	244-13-10

*NOMINAL DECK ELEVATION

THIS STRUCTURE HAS BEEN DESIGNED IN ACCORDANCE WITH THE APPROPRIATE CODES AND STANDARDS TO SUSTAIN DEAD LOADS, AND THE GIVEN LIVE LOAD WHEN COMPLETE. IT HAS BEEN DESIGNED TO SUSTAIN REASONABLE LOADS DURING CONSTRUCTION BUT MUST BE CHECKED AGAINST THE LOADINGS IMPOSED BY THE CONTRACTOR'S SPECIFIC METHOD OF CONSTRUCTION. IN ACCORDANCE WITH THE BYLAWS OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF B.C. CLAUSE 14 (b) (4), FIELD REVIEW OF PROJECTS DURING CONSTRUCTION IS A REQUIREMENT. FAILURE TO RETAIN THE ENGINEER, OR HIS CHOICE OF THIRD PARTY, TO REVIEW THE CONTRACTOR'S PROCEDURES AND MONITOR CONSTRUCTION WILL RESULT IN McELHANNEY CONSULTING SERVICES LTD. BEING UNABLE TO CERTIFY THE CONSTRUCTED WORKS.

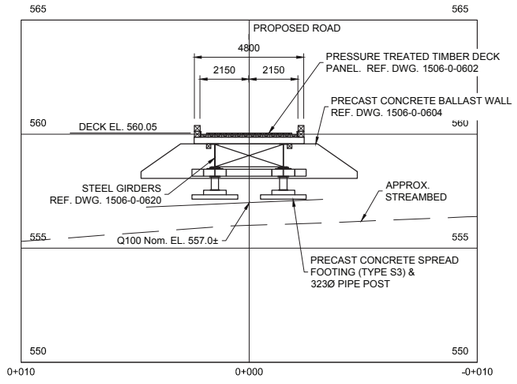


PROFILE - ALONG PROPOSED ROAD CENTERLINE

LOOKING DOWNSTREAM

0 25

UNLESS OTHERWISE NOTED



CREEK PROFILE

LOOKING UP-CHAINAGE

0 1:250 10

DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD
KSM PROJECT

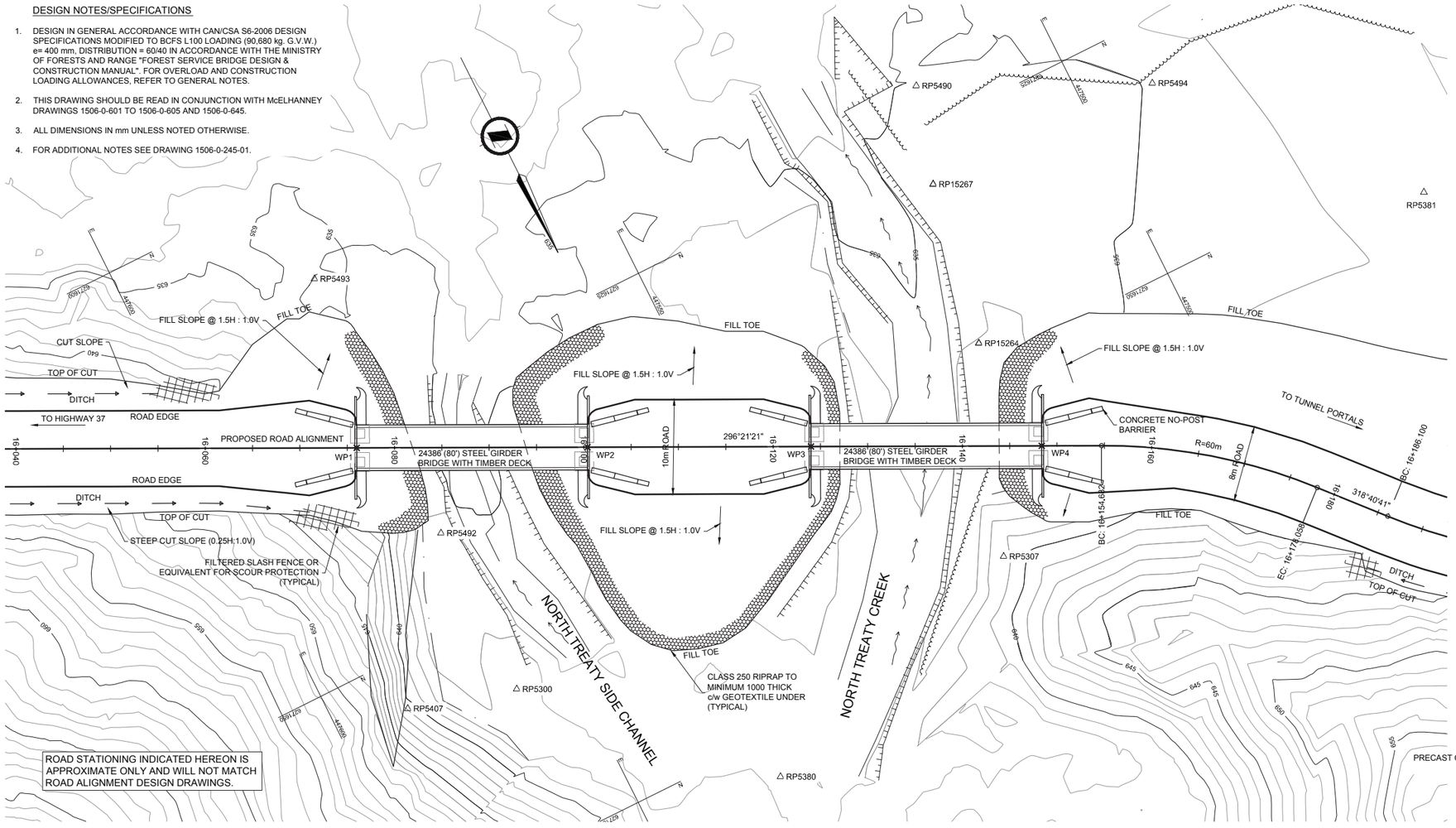
Rescan™ Engineers & Scientists

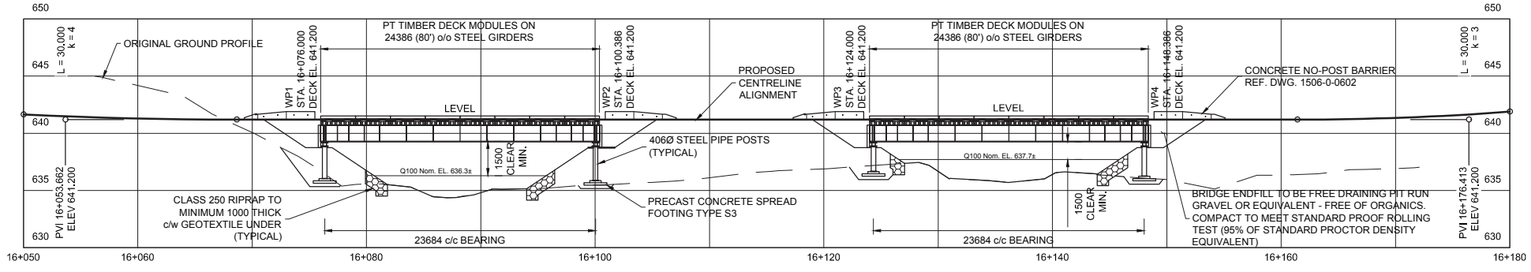
Appendix 4.2-2j

Treaty Creek Access Road: Stream Crossing 210

DESIGN NOTES/SPECIFICATIONS

1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6-2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601 TO 1506-0-605 AND 1506-0-645.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-0-245-01.





PROFILE - ALONG PROPOSED ROAD CENTERLINE

LOOKING UPSTREAM

0 25

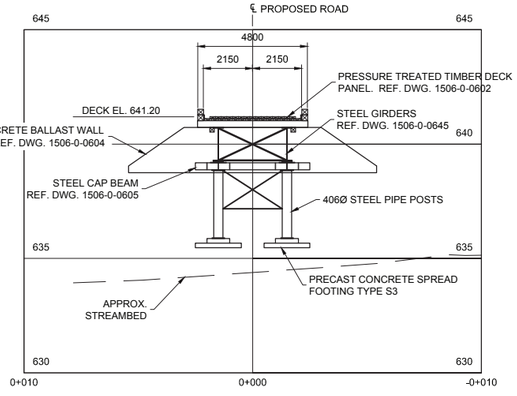
UNLESS OTHERWISE NOTED

SURVEY CONTROL - NORTH TREATY SIDE CHANNEL					
Point	Northing	Easting	Elevation	H.D.	Bearing
RP5407	6271655.256	447592.348	641.311	---	---
RP5300 - B.S.	6271658.558	447581.132	639.077	11.692	286-24-14
RP5493	6271610.240	447580.903	634.999	46.448	194-15-53
WP1	6271628.207	447584.885	641.200 *	28.059	195-25-31
WP2	6271639.032	447563.035	641.200 *	33.503	241-02-13

SURVEY CONTROL - NORTH TREATY CREEK					
Point	Northing	Easting	Elevation	H.D.	Bearing
RP15264	6271647.682	447521.123	636.251	---	---
RP5307 - B.S.	6271669.002	447528.842	639.796	22.674	19-54-12
RP5380	6271679.285	447560.327	637.372	50.356	51-07-37
RP15267	6271630.495	447517.950	635.983	17.480	190-27-31
RP5490	6271620.396	447514.903	636.708	27.986	192-50-26
RP5494	6271631.295	447492.456	636.637	33.020	240-14-46
RP5381	6271654.415	447471.930	635.243	49.652	277-47-37
WP3	6271649.517	447541.874	641.200 *	20.832	84-56-51
WP4	6271660.342	447520.025	641.200 *	12.707	355-02-32

*NOMINAL DECK ELEVATION

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CREEK PROFILE

LOOKING UP-CHAINAGE
-LOW CHAINAGE SHOWN
-HIGH CHAINAGE SIMILAR

0 10

DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT

Rescan™ Engineers & Scientists

Appendix 4.2-2k

Treaty Creek Access Road: North Treaty Creek (4011) Crossing

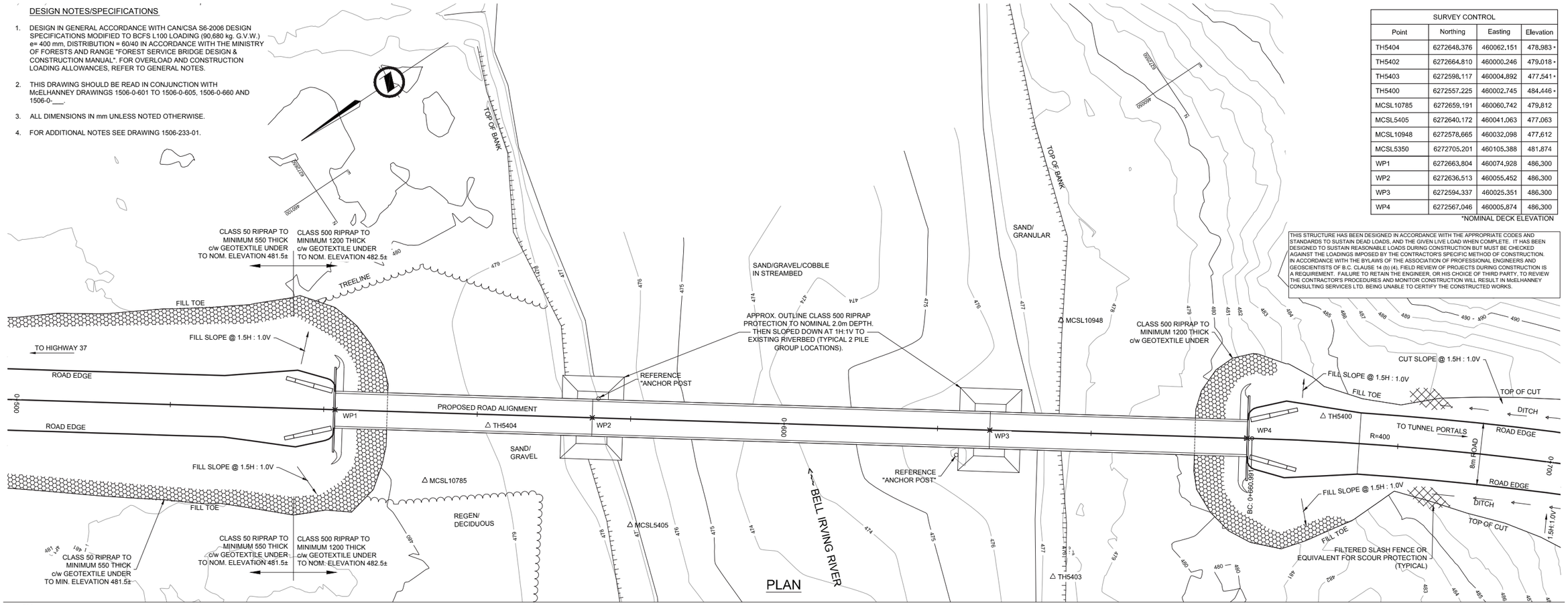
DESIGN NOTES/SPECIFICATIONS

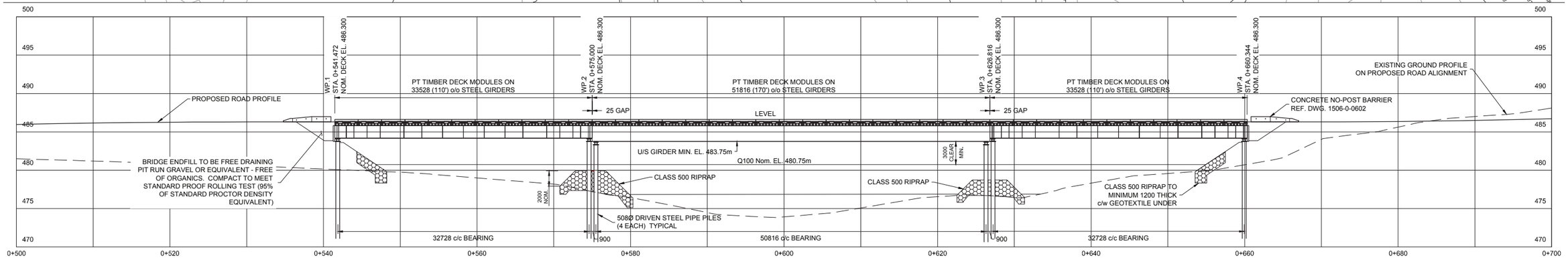
1. DESIGN IN GENERAL ACCORDANCE WITH CAN/CSA S6-2006 DESIGN SPECIFICATIONS MODIFIED TO BCFS L100 LOADING (90,680 kg. G.V.W.) e= 400 mm, DISTRIBUTION = 60/40 IN ACCORDANCE WITH THE MINISTRY OF FORESTS AND RANGE "FOREST SERVICE BRIDGE DESIGN & CONSTRUCTION MANUAL". FOR OVERLOAD AND CONSTRUCTION LOADING ALLOWANCES, REFER TO GENERAL NOTES.
2. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH McELHANNEY DRAWINGS 1506-0-601 TO 1506-0-605, 1506-0-660 AND 1506-0-___.
3. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
4. FOR ADDITIONAL NOTES SEE DRAWING 1506-233-01.

SURVEY CONTROL			
Point	Northing	Easting	Elevation
TH5404	6272648.376	460062.151	478.983 •
TH5402	6272664.810	460000.246	479.018 •
TH5403	6272598.117	460004.892	477.541 •
TH5400	6272557.225	460002.745	484.446 •
MCSL10785	6272659.191	460060.742	479.812
MCSL5405	6272640.172	460041.063	477.063
MCSL10948	6272578.665	460032.098	477.612
MCSL5350	6272705.201	460105.388	481.874
WP1	6272663.804	460074.928	486.300
WP2	6272636.513	460055.452	486.300
WP3	6272594.337	460025.351	486.300
WP4	6272567.046	460005.874	486.300

*NOMINAL DECK ELEVATION

THIS STRUCTURE HAS BEEN DESIGNED IN ACCORDANCE WITH THE APPROPRIATE CODES AND STANDARDS TO SUSTAIN DEAD LOADS, AND THE GIVEN LIVE LOAD WHEN COMPLETE. IT HAS BEEN DESIGNED TO SUSTAIN REASONABLE LOADS DURING CONSTRUCTION BUT MUST BE CHECKED AGAINST THE LOADINGS IMPOSED BY THE CONTRACTOR'S SPECIFIC METHOD OF CONSTRUCTION. IN ACCORDANCE WITH THE BYLAWS OF THE ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF B.C. CLAUSE 14 (b) (4), FIELD REVIEW OF PROJECTS DURING CONSTRUCTION IS A REQUIREMENT. FAILURE TO RETAIN THE ENGINEER, OR HIS CHOICE OF THIRD PARTY, TO REVIEW THE CONTRACTOR'S PROCEDURES AND MONITOR CONSTRUCTION WILL RESULT IN McELHANNEY CONSULTING SERVICES LTD. BEING UNABLE TO CERTIFY THE CONSTRUCTED WORKS.





ROAD STATIONING INDICATED HEREON IS APPROXIMATE ONLY AND WILL NOT MATCH ROAD ALIGNMENT DESIGN DRAWINGS.

PROFILE - ALONG PROPOSED ROAD CENTERLINE
LOOKING DOWNSTREAM

0 25

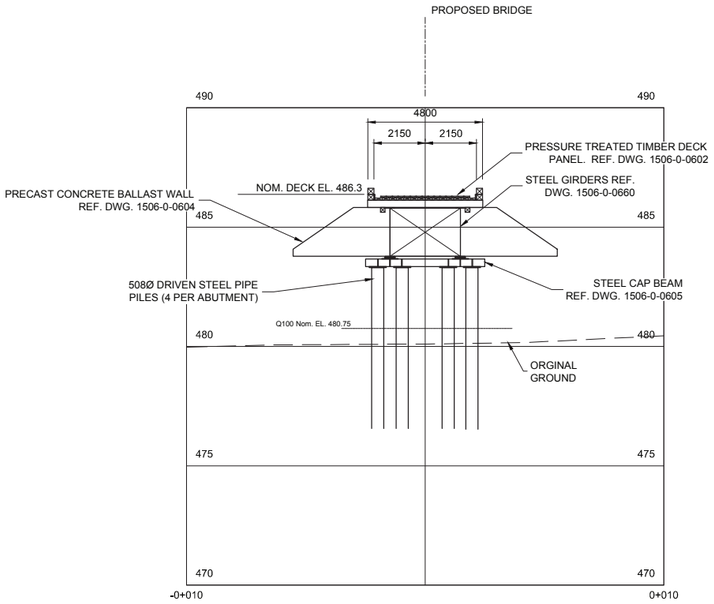
DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD KSM PROJECT
Rescan™ Engineers & Scientists

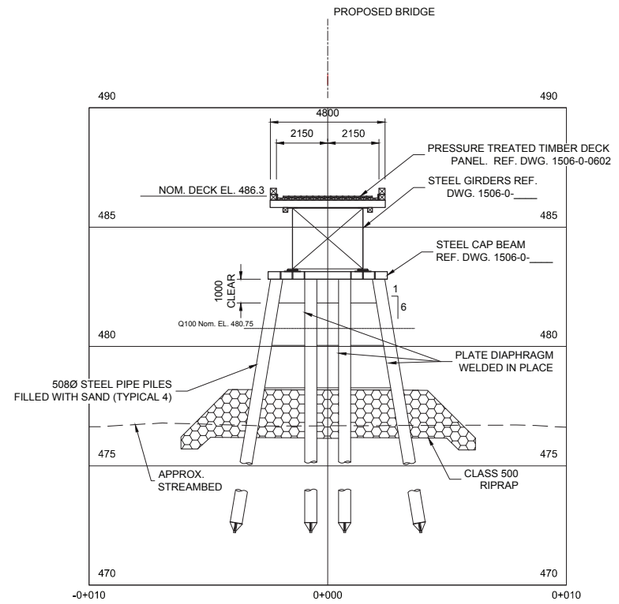
Appendix 4.2-2l

Treaty Creek Access Road: Bell Irving River (4004) Crossing



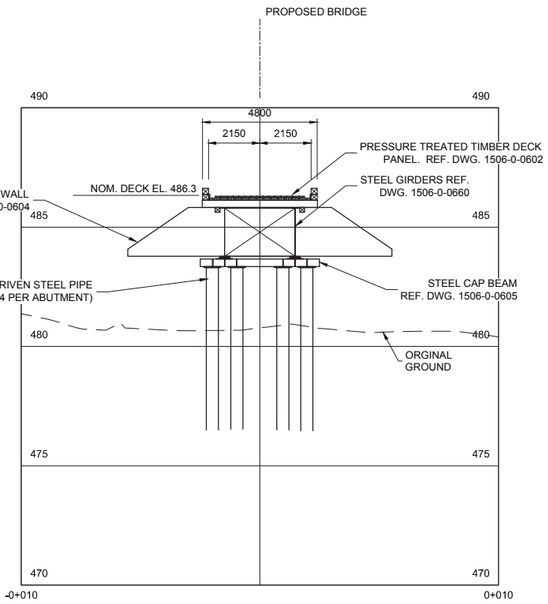
ELEVATION - LOW CHAINAGE ABUTMENT

LOOKING DOWN-CHAINAGE



ELEVATION - MID-CHANNEL PIERS (2)

LOOKING UP-CHAINAGE



ELEVATION - HIGH CHAINAGE ABUTMENT

LOOKING UP-CHAINAGE



DRAFT - NOT FOR CONSTRUCTION

Source: McElhanney Consulting Services Ltd.

SEABRIDGE GOLD
KSM PROJECT

Rescan™ Engineers & Scientists

Appendix 4.2-2m

Treaty Creek Access Road:
Bell Irving River (4004) Crossing

Appendix 4.3-1

HSI Ratings and Values for Impacted Watercourses (HADD)

Rescan™
Engineers and Scientists

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1002 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	46.0	5
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	46.0	46
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0.7/0.3/0	High	1		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	46.0	5
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.7/0.3/0	High	1		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	46.0	5
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1003 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	78.7	8
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		70	***Poor***	***0.1***	78.7	8
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.3/0.7	***Poor***	***0.1***		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	78.7	8
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.3/0.7	***Poor***	***0.1***		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	78.7	8
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1004

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	985.1	99
Vegetation index of riparian zone		133	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	985.1	985
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.7/0.3/0	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	985.1	99
Vegetation index of riparian zone		133	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.7/0.3/0	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	985.1	99
Vegetation index of riparian zone		133	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1012

Watershed **South Teigen**

ILP **ILP 1012**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		10	***Moderate***	***0.5***	432	216
Cover (%)		26	High	1		
Percent pools (%)		27	***Moderate***	***0.5***		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		4	***High***	***1***	432	432
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		10	***Moderate***	***0.5***	432	216
Substrate (% gravel and rubble(A/B/C))		0.39/0.37/0.04	***Moderate***	***0.5***		
Cover (%)		26	High	1		
Percent pools (%)		27	***Moderate***	***0.5***		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		10	***Moderate***	***0.5***	432	216
Substrate (% gravel and rubble(A/B/C))		0.39/0.37/0.04	***Moderate***	***0.5***		
Cover (%)		26	High	1		
Percent pools (%)		27	***Moderate***	***0.5***		
Vegetation index of riparian zone		100	***Moderate***	***0.5***		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1013

Watershed South Teigen

ILP ILP 1013

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		50	High	1		
Percent pools (%)		0	***None***	***0.1***	28	3
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	28	28
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		1.0/0/0	High	1		
Cover (%)		50	High	1		
Percent pools (%)		0	***None***	***0.1***	28	3
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		1.0/0/0	High	1		
Cover (%)		50	High	1		
Percent pools (%)		0	***None***	***0.1***	28	3
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1014

Watershed **South Teigen**

ILP **ILP 1014**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		25	High	1		
Percent pools (%)		0	***None***	***0.1***	35.75	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		100	***Poor***	***0.1***	35.75	4
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		25	High	1		
Percent pools (%)		0	***None***	***0.1***	35.75	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		25	High	1		
Percent pools (%)		0	***None***	***0.1***	35.75	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1015

Watershed **South Teigen**

ILP **ILP 1015**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3	High	1		
Cover (%)		0	***None***	***0.1***		
Percent pools (%)		0	***None***	***0.1***	67.5	7
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		75	***Poor***	***0.1***	67.5	7
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.25/0.75	***Poor***	***0.1***		
Cover (%)		0	***None***	***0.1***		
Percent pools (%)		0	***None***	***0.1***	67.5	7
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.25/0.75	***Poor***	***0.1***		
Cover (%)		0	***None***	***0.1***		
Percent pools (%)		0	***None***	***0.1***	67.5	7
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1016

Watershed **South Teigen**

ILP **ILP 1016**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		12	Moderate	0.5		
Cover (%)		7.4	***Low***	***0.25***	1794	449
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	1794	1794
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		12	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0.2/0.8/0	Moderate	0.5		
Cover (%)		7.4	***Low***	***0.25***	1794	449
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		12	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0.2/0.8/0	Moderate	0.5		
Cover (%)		7.4	***Low***	***0.25***	1794	449
Percent pools (%)		10	Moderate	0.5		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1017

Watershed **South Teigen**

ILP **ILP 1017**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		0	***Poor***	***0.1***	245	25
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		100	***Poor***	***0.1***	245	25
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***	245	25
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***	245	25
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1018

Watershed **South Teigen**

ILP **ILP 1018**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		0	High	1		
Cover (%)		0	***Poor***	***0.1***	36	4
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		100	***Poor***	***0.1***	36	4
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		0	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***	36	4
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		0	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***	36	4
Percent pools (%)		0	***Poor***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1205

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	86.8	9
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		30	***Poor***	***1***	86.8	87
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.98/0.02	Low	0.2		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	86.8	9
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.98/0.02	Low	0.2		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	86.8	9
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1027 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		17	***Poor***	***0.1***	101.5	10
Cover (%)		0	***None***	***0.1***		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	101.5	102
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		17	***Poor***	***0.1***	101.5	10
Substrate (% gravel and rubble(A/B/C))		0/1.0/0	Low	0.25		
Cover (%)		0	***None***	***0.1***		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		17	***Poor***	***0.1***	101.5	10
Substrate (% gravel and rubble(A/B/C))		0/1.0/0	Low	0.25		
Cover (%)		0	***None***	***0.1***		
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1029 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		0	***None***	***0.1***	750.0	75
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		60	***Poor***	***0.1***	750.0	75
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.4/0.6	***Poor***	***0.1***		
Cover (%)		0	***None***	***0.1***	750.0	75
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.4/0.6	***Poor***	***0.1***		
Cover (%)		0	***None***	***0.1***	750.0	75
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1030 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		1.3	***Poor***	***0.1***	1,566.0	157
Percent pools (%)		1.7	Moderate	0.5		
Vegetation index of riparian zone		134	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		12.9	***High***	***1***	1,566.0	1566
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.14/0.73/0.13	Moderate	0.5		
Cover (%)		1.3	***Poor***	***0.1***	1,566.0	157
Percent pools (%)		1.7	Moderate	0.5		
Vegetation index of riparian zone		134	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.14/0.73/0.13	Moderate	0.5		
Cover (%)		1.3	***Poor***	***0.1***	1,566.0	157
Percent pools (%)		1.7	Moderate	0.5		
Vegetation index of riparian zone		134	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1110 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		5	Moderate	0.5		
Cover (%)		0	***None***	***0.1***	656.3	66
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		5	***High***	***1***	656.3	656
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))	ISD	NA				
Cover (%)		0	***None***	***0.1***	656.3	66
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		5	High	1		
Substrate (% gravel and rubble(A/B/C))	ISD	NA				
Cover (%)		0	***None***	***0.1***	656.3	66
Percent pools (%)		0	***None***	***0.1***		
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1150 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3	High	1		
Cover (%)		14.9	***Moderate***	***0.5***	64.5	32
Percent pools (%)		5	***Moderate***	***0.5***		
Vegetation index of riparian zone		107	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		37.7	***Poor***	***0.1***	64.5	6
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.25/0.37/0.37	***Moderate***	***0.5***		
Cover (%)		14.9	***Moderate***	***0.5***	64.5	32
Percent pools (%)		5	***Moderate***	***0.5***		
Vegetation index of riparian zone		107	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.25/0.37/0.37	***Moderate***	***0.5***		
Cover (%)		14.9	***Moderate***	***0.5***	64.5	32
Percent pools (%)		5	***Moderate***	***0.5***		
Vegetation index of riparian zone		107	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1151 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	25.5	3
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		100	***Poor***	***0.1***	25.5	3
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	25.5	3
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	25.5	3
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1152 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	29.3	3
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		10	***High***	***1***	29.3	29
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.2	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	29.3	3
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.2	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	29.3	3
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1088

Watershed **South Teigen**

ILP **ILP 1088**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	40.0	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		100	***Poor***	***0.1***	40.0	4
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	40.0	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	40.0	4
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1090 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3	High	1		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	14.0	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		10	***High***	***1***	14.0	14
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (°C)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		30	***Poor***	***0.1***		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.1	Low	0.25		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	14.0	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		30	***Poor***	***0.1***		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.1	Low	0.25		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	14.0	1
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (°C)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

ILP ILP 1091 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		10	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	32.8	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		10	***High***	***1***	32.8	33
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		10	Low	0.25		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.1	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	32.8	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		10	Low	0.25		
Substrate (% gravel and rubble(A/B/C))		0/0.9/0.1	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	32.8	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

ST Tribs 1207

Watershed **South Teigen**

ILP **ILP 1207**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		30	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	30.0	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	30.0	30
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		30	***Poor***	***0.1***		
Substrate (% gravel and rubble(A/B/C))		0.8/0.2/1	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	30.0	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		30	***Poor***	***0.1***		
Substrate (% gravel and rubble(A/B/C))		0.8/0.2/1	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	30.0	3
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed North Treaty

ILP ILP 1051 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		4	High	1		
Cover (%)		8.4	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	124.7	12
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		40.5	***Poor***	***0.1***	124.7	12
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		4	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.6/0.4	Low	0.25		
Cover (%)		8.4	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	124.7	12
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		4	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.6/0.4	Low	0.25		
Cover (%)		8.4	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	124.7	12
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **North Treaty**

ILP **ILP 1052 - TMF Dam**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		13	Low	0.25		
Cover (%)		36.3	High	1		
Percent pools (%)		0	***Poor***	***0.1***	32.7	3
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		82.7	***Poor***	***0.1***	32.7	3
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		13	Low	0.25		
Substrate (% gravel and rubble(A/B/C))		0/0.17/0.83	Poor	0.1		
Cover (%)		36.3	High	1		
Percent pools (%)		0	***Poor***	***0.1***	32.7	3
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		13	Low	0.25		
Substrate (% gravel and rubble(A/B/C))		0/0.17/0.83	Poor	0.1		
Cover (%)		36.3	High	1		
Percent pools (%)		0	***Poor***	***0.1***	32.7	3
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **North Treaty**

ILP **ILP 1053 - TMF Dam**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	162.0	16
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		20	***Moderate***	***0.5***	162.0	81
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.8/0.2	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	162.0	16
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.8/0.2	Low	0.25		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	162.0	16
Vegetation index of riparian zone		200	High	1		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

NT Tribs 1072

Watershed **North Treaty**

ILP **ILP 1072**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	121.6	12
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		90	***Poor***	***0.1***	121.6	12
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	121.6	12
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	121.6	12
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

NT Tribs 1082

Watershed **North Treaty**

ILP **ILP 1082**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		8.5	Low	0.25		
Percent pools (%)		5	***Poor***	***0.1***	279.8	28
Vegetation index of riparian zone		126	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		51.3	***Poor***	***0.1***	279.8	28
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.5/0.5	Low	0.25		
Cover (%)		8.5	Low	0.25		
Percent pools (%)		5	***Poor***	***0.1***	279.8	28
Vegetation index of riparian zone		126	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.5/0.5	Low	0.25		
Cover (%)		8.5	Low	0.25		
Percent pools (%)		5	***Poor***	***0.1***	279.8	28
Vegetation index of riparian zone		126	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

NT Tribs 1059

Watershed **North Treaty**

ILP **ILP 1059**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		3.7	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	300.6	30
Vegetation index of riparian zone		115	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		74.2	***Poor***	***0.1***	300.6	30
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.25/0.75	***Poor***	***0.1***		
Cover (%)		3.7	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	300.6	30
Vegetation index of riparian zone		115	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0.25/0.75	***Poor***	***0.1***		
Cover (%)		3.7	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	300.6	30
Vegetation index of riparian zone		115	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

NT Tribs 1070

Watershed **North Treaty**

ILP **ILP 1070**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	20.3	2
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		100	***Poor***	***0.1***	20.3	2
Average flow (% of MAF)	ISD	NA				
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	20.3	2
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		50	High	1		
Percent pools (%)		0	***Poor***	***0.1***	20.3	2
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	ISD	NA				
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

Reach 8 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		6	Moderate	0.5		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	1600.0	160
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	1600.0	1600
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		6	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		1.0/0/0	High	1		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	1600.0	160
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		6	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		1.0/0/0	High	1		
Cover (%)		30	High	1		
Percent pools (%)		0	***Poor***	***0.1***	1600.0	160
Vegetation index of riparian zone		100	Moderate	0.5		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **South Teigen**

Reach **7 - TMF Dam**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		5	Moderate	0.5		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	1,566.0	157
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		100	***Poor***	***0.1***	1,566.0	157
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	1,566.0	157
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0/0/1.0	***Poor***	***0.1***		
Cover (%)		0	***Poor***	***0.1***		
Percent pools (%)		0	***Poor***	***0.1***	1,566.0	157
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

Reach 6 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		5	Moderate	0.5		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	2,277.0	228
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		52	***Poor***	***0.1***	2,277.0	228
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0/0.48/0.52	Low	0.25		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	2,277.0	228
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		5	Moderate	0.5		
Substrate (% gravel and rubble(A/B/C))		0/0.48/0.52	Low	0.25		
Cover (%)		5	Low	0.25		
Percent pools (%)		0	***Poor***	***0.1***	2,277.0	228
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

Reach 5 - Splitter Dam and Waste Pile

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		1	High	1		
Cover (%)		26.8	High	1		
Percent pools (%)		25	***Moderate***	***0.5***	9,202.1	4601
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		25.3	***Low***	***0.25***	9,202.1	2301
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0.11/0.63/0.25	***Moderate***	***0.5***		
Cover (%)		26.8	High	1		
Percent pools (%)		25	***Moderate***	***0.5***	9,202.1	4601
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		1	High	1		
Substrate (% gravel and rubble(A/B/C))		0.11/0.63/0.25	***Moderate***	***0.5***		
Cover (%)		26.8	High	1		
Percent pools (%)		25	***Moderate***	***0.5***	9,202.1	4601
Vegetation index of riparian zone		150	High	1		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

Reach 4 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3	High	1		
Cover (%)		16	***Moderate***	***0.5***		
Percent pools (%)		21	***Moderate***	***0.5***	8,275.9	4138
Vegetation index of riparian zone		123	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		7.9	***High***	***1***	8,275.9	8276
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.56/0.35/0.08	***Moderate***	***0.5***		
Cover (%)		16	***Moderate***	***0.5***		
Percent pools (%)		21	***Moderate***	***0.5***	8,275.9	4138
Vegetation index of riparian zone		123	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.56/0.35/0.08	***Moderate***	***0.5***		
Cover (%)		16	***Moderate***	***0.5***		
Percent pools (%)		21	***Moderate***	***0.5***	8,275.9	4138
Vegetation index of riparian zone		123	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

Reach 4 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3.5	High	1		
Cover (%)		38.2	High	1		
Percent pools (%)		22	***Moderate***	***0.5***	2,152.7	1076
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	2,152.7	2153
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		3.5	High	1		
Substrate (% gravel and rubble(A/B/C))		0.83/0.16/0	High	1		
Cover (%)		38.2	High	1		
Percent pools (%)		22	***Moderate***	***0.5***	2,152.7	1076
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		3.5	High	1		
Substrate (% gravel and rubble(A/B/C))		0.83/0.16/0	High	1		
Cover (%)		38.2	High	1		
Percent pools (%)		22	***Moderate***	***0.5***	2,152.7	1076
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **North Treaty**

Reach **2 - TMF Dam**

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		2	High	1		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	3,136.5	1,568
Vegetation index of riparian zone		144	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		13.8	***High***	***1***	3,136.5	3,136
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.18/0.67/0.14	***Moderate***	***0.5***		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	3,136.5	1,568
Vegetation index of riparian zone		144	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		2	High	1		
Substrate (% gravel and rubble(A/B/C))		0.18/0.67/0.14	***Moderate***	***0.5***		
Cover (%)		43.1	High	1		
Percent pools (%)		32.8	***Moderate***	***0.5***	3,136.5	1,568
Vegetation index of riparian zone		144	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed North Treaty

Reach 1 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3	High	1		
Cover (%)		31.4	High	1		
Percent pools (%)		40	High	1		
Vegetation index of riparian zone		131	***Moderate***	***0.5***	1,958.0	979
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		7.7	***High***	***1***	1,958.0	1958
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.37/0.55/0.07	***Moderate***	***0.5***		
Cover (%)		31.4	High	1		
Percent pools (%)		40	High	1		
Vegetation index of riparian zone		131	***Moderate***	***0.5***	1,958.0	979
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.37/0.55/0.07	***Moderate***	***0.5***		
Cover (%)		31.4	High	1		
Percent pools (%)		40	High	1		
Vegetation index of riparian zone		131	***Moderate***	***0.5***	1,958.0	979
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed North Treaty

Reach 1 - TMF Dam

Habitat Variable	Description of Habitat	Area 1				
		Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3	High	1		
Cover (%)		36.7	High	1		
Percent pools (%)		14	***Moderate***	***0.5***	746.6	373
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	746.6	747
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.70/0.30/0	High	1		
Cover (%)		36.7	High	1		
Percent pools (%)		14	***Moderate***	***0.5***	746.6	373
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.70/0.30/0	High	1		
Cover (%)		36.7	High	1		
Percent pools (%)		14	***Moderate***	***0.5***	746.6	373
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed South Teigen

Wetland STW2 - TMF Dam

Habitat Variable	Life Stage	Area 1			
		Rating	HSI Value	Area (m^2)	HU
	MIGRATION				
Habitat Quality		NA	NA	-	
	SPAWNING				
Habitat Quality		NA	NA	-	-
	REARING				
Habitat Quality		Low	0.1	314.0	31
	OVERWINTERING				
Habitat Quality		Low	0.1	314.0	31

NA = not applicable

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Coulter Creek**

ILP **2060 (Coulter Creek Side Channel) - Coulter Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Coho Salmon	**ADULT MIGRATION**						
	Max. temperature (˚C)	Assume optimal temperatures, < 10°C	-	***Excellent***	***1***	57.0	57
	Min. diss. oxygen (mg/L)	Assume optimal DO, > 6.5 mg/L	-	***Excellent***	***1***		
	SPAWNING/INCUBATION/EMERGENCE						
	Max. temperature (˚C)	Assume optimal temperatures, < 10°C	-	Excellent	1		
	Min. diss. oxygen (mg/L)	Assume optimal DO, > 6.5 mg/L	-	Excellent	1		
	Substrate (% gravel/cobble)		0	***Unsuitable***	***0.1***		
	Substrate (% fines)		100	***Unsuitable***	***0.1***	57.0	6
	REARING						
	Max. temperature (˚C)	Assume optimal temperatures, < 10°C	-	Excellent	1		
	Min. diss. oxygen (mg/L)	Assume optimal DO, > 6.5 mg/L	-	Excellent	1		
	Substrate (% gravel/cobble)		0	***Unsuitable***	***0.1***		
	Substrate (% fines)		100	***Unsuitable***	***0.1***	57.0	6
	Percent canopy		100	Average	0.5		
	Riparian zone index		100	Above Average	0.6		
	Percent pools		0	***Unsuitable***	***0.1***		
	Percent pools with canopy		0	Below Average	0.2		
	Cover (%)		18.2	Average	0.5		
	OVERWINTERING						
	Max. temperature (˚C)	Assume optimal temperatures, < 8°C	-	Excellent	1		
	Percent winter cover	Assume average conditions	-	***Average***	***0.5***	57.0	29

*Area: 30 m length *1.9 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Coulter Creek**

ILP **2061 (Coulter Creek) - Coulter Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Coho Salmon	**ADULT MIGRATION**						
	Max. temperature (°C)	Assume optimal temperatures, < 10°C	-	***Excellent***	***1***	60.0	60
	Min. diss. oxygen (mg/L)	Assume optimal DO, > 6.5 mg/L	-	***Excellent***	***1***		
	SPAWNING/INCUBATION/EMERGENCE						
	Max. temperature (°C)	Assume optimal temperatures, < 10°C	-	Excellent	1		
	Min. diss. oxygen (mg/L)	Assume optimal DO, > 6.5 mg/L	-	Excellent	1		
	Substrate (% gravel/cobble)		48	***Above Average***	***0.7***	60.0	42
	Substrate (% fines)		2	Excellent	1		
	REARING						
	Max. temperature (°C)	Assume optimal temperatures, < 10°C	-	Excellent	1		
	Min. diss. oxygen (mg/L)	Assume optimal DO, > 6.5 mg/L	-	Excellent	1		
	Substrate (% gravel/cobble)		48	Above Average	0.7		
	Substrate (% fines)		2	Excellent	1		
	Percent canopy		75	Excellent	1		
	Riparian zone index		100	Above Average	0.5		
	Percent pools (%)		9.5	***Unsuitable***	***0.1***	60.0	6
	Percent pools with canopy	Assume average conditions	-	Average	0.5		
	Cover (%)		18.2	Average	0.5		
	OVERWINTERING						
	Max. temperature (°C)	Assume optimal temperatures, < 8°C	-	Excellent	1		
	Percent winter cover	Assume average conditions	-	***Average***	***0.5***	60.0	30

*Area: 15 m length * 2 m wide * 2 sides*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Unuk River**

ILP **2063 - Coulter Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		3.5	High	1		
	Cover (%)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***	30	15
	Percent pools (%)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Vegetation index of riparian zone		100	***Moderate***	***0.5***		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		12	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***	30	15
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		12	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		
	FRY						
	Stream gradient (%)		3.5	High	1		
	Substrate (% gravel and rubble(A/B/C))	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Cover (%)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***	30	15
	Percent pools (%)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Vegetation index of riparian zone		100	***Moderate***	***0.5***		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		12	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		
	PARR						
	Stream gradient (%)		3.5	High	1		
	Substrate (% gravel and rubble(A/B/C))	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Cover (%)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***	30	15
	Percent pools (%)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Vegetation index of riparian zone		100	***Moderate***	***0.5***		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		12	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		

*Area: 15 m length * 2 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Unuk River**

ILP **1025 (Unuk River) - Coulter Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		1	High	1		
	Cover (%)		33.6	High	1		
	Percent pools (%)		7	***Moderate***	***0.5***	220	110
	Vegetation index of riparian zone		100	***Moderate***	***0.5***		
	Average flow (% of MAF)		>50	High	1		
	Average temperature (ºC)		6	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		
	EMBRYO						
	Substrate (% fines)		8	High	1		
	Average flow (% of MAF)		>50	***Moderate***	***0.5***	220	110
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		6	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		
	FRY						
	Stream gradient (%)		1	High	1		
	Substrate (% gravel and rubble(A/B/C))		0.6/0.2/0.(	High	1		
	Cover (%)		33.6	High	1		
	Percent pools (%)		7	***Moderate***	***0.5***	220	110
	Vegetation index of riparian zone		100	***Moderate***	***0.5***		
	Average flow (% of MAF)		>50	High	1		
	Average temperature (ºC)		6	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		
	PARR						
	Stream gradient (%)		1	High	1		
	Substrate (% gravel and rubble(A/B/C))		0.6/0.2/0.(	High	1		
	Cover (%)		33.6	High	1		
	Percent pools (%)		7	***Moderate***	***0.5***	220	110
	Vegetation index of riparian zone		100	***Moderate***	***0.5***		
	Average flow (% of MAF)		>50	High	1		
	Average temperature (ºC)		6	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		

*Area Post: 7 m wide * 10 m length * 2 posts*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Unuk River**

ILP **5008 - Coulter Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		5	Moderate	0.5		
	Cover (%)		0	***Poor***	***0.1***	16	2
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		100	Moderate	0.5		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		7	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8	High	1		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***	16	8
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		7	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8	High	1		
	FRY						
	Stream gradient (%)		5	Moderate	0.5		
	Substrate (% gravel and rubble(A/B/C))	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Cover (%)		0	***Poor***	***0.1***	16	2
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		100	Moderate	0.5		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		7	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8	High	1		
	PARR						
	Stream gradient (%)		5	Moderate	0.5		
	Substrate (% gravel and rubble(A/B/C))	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Cover (%)		0	***Poor***	***0.1***	16	2
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		100	Moderate	0.5		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		7	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8	High	1		

*Area: 20 m length *0.8 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Treaty Creek**

ILP **100 - Treaty Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		19	***Poor***	***0.1***	150	15
	Cover (%)		17	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		100	Moderate	0.5		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		5	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.5	High	1		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	15	***Moderate***	***0.5***	150	75
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		5	***Moderate***	***0.5***		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		7.5	High	1		
	FRY						
	Stream gradient (%)		19	***Poor***	***0.1***	150	15
	Substrate (% gravel and rubble(A/B/C))		0.7/1.0/0.	Moderate	0.5		
	Cover (%)		17	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		100	Moderate	0.5		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		5	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.5	High	1		
	PARR						
	Stream gradient (%)		19	***Poor***	***0.1***	150	15
	Substrate (% gravel and rubble(A/B/C))		0.7/1.0/0.	Moderate	0.5		
	Cover (%)		17	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		100	Moderate	0.5		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		5	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.5	High	1		

*Area: 15 m length *5 m wide* 2 sides*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Treaty Creek**

ILP **108 - Treaty Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		24	***Poor***	***0.1***	40	4
	Cover (%)		31	High	1		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		8	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.4	High	1		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	2	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***	40	20
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		8	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		7.4	High	1		
	FRY						
	Stream gradient (%)		24	***Poor***	***0.1***	40	4
	Substrate (% gravel and rubble(A/B/C))		0.7/1.0/0.	Moderate	0.5		
	Cover (%)		31	High	1		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		8	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.4	High	1		
	PARR						
	Stream gradient (%)		24	***Poor***	***0.1***	40	4
	Substrate (% gravel and rubble(A/B/C))		0.7/1.0/0.	Moderate	0.5		
	Cover (%)		31	High	1		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		8	High	1		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.4	High	1		

*Area: 20 m length *2.0 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Treaty Creek**

ILP **204 - Treaty Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		20	***Poor***	***0.1***	6	1
	Cover (%)		12	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.9	Low	0.25		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	15	Moderate	0.5		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.9	***Low***	***0.25***	6	2
	FRY						
	Stream gradient (%)		20	***Poor***	***0.1***	6	1
	Substrate (% gravel and rubble(A/B/C))		0.8/1.0/0.	Moderate	0.5		
	Cover (%)		12	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.9	Low	0.25		
	PARR						
	Stream gradient (%)		20	***Poor***	***0.1***	6	1
	Substrate (% gravel and rubble(A/B/C))		0.8/1.0/0.	Moderate	0.5		
	Cover (%)		12	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.9	Low	0.25		

*Area: 20 m length *0.3 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Treaty Creek**

ILP **205 - Treaty Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		15	***Poor***	***0.1***	8	1
	Cover (%)		30	High	1		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.4	Moderate	0.5		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	15	***Moderate***	***0.5***	8	4
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		6	***Moderate***	***0.5***		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8.4	***Moderate***	***0.5***		
	FRY						
	Stream gradient (%)		15	***Poor***	***0.1***	8	1
	Substrate (% gravel and rubble(A/B/C))		0.8/1.0/0.	Moderate	0.5		
	Cover (%)		30	High	1		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.4	Moderate	0.5		
	PARR						
	Stream gradient (%)		15	***Poor***	***0.1***	8	1
	Substrate (% gravel and rubble(A/B/C))		0.8/1.0/0.	Moderate	0.5		
	Cover (%)		30	High	1		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.4	Moderate	0.5		

*Area: 20 m length *0.4 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Treaty Creek**

ILP **209 - Treaty Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		9	Moderate	0.5		
	Cover (%)		40	High	1		
	Percent pools (%)		0	***Poor***	***0.1***	18	2
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.6	Low	0.25		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	15	Moderate	0.5		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.6	***Low***	***0.25***	18	5
	FRY						
	Stream gradient (%)		9	Moderate	0.5		
	Substrate (% gravel and rubble(A/B/C))		0.9/1.0/0.	Moderate	0.5		
	Cover (%)		40	High	1		
	Percent pools (%)		0	***Poor***	***0.1***	18	2
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.6	Low	0.25		
	PARR						
	Stream gradient (%)		9	Moderate	0.5		
	Substrate (% gravel and rubble(A/B/C))		0.9/1.0/0.	Moderate	0.5		
	Cover (%)		40	High	1		
	Percent pools (%)		0	***Poor***	***0.1***	18	2
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		8.6	Low	0.25		

*Area: 20 m length *0.9 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Treaty Creek**

ILP **210 - Treaty Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		16	***Poor***	***0.1***	45	5
	Cover (%)		10	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.5	High	1		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	10	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***	45	23
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		6	***Moderate***	***0.5***		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		7.5	High	1		
	FRY						
	Stream gradient (%)		16	***Poor***	***0.1***	45	5
	Substrate (% gravel and rubble(A/B/C))		0.6/1.0/0.	Moderate	0.5		
	Cover (%)		10	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.5	High	1		
	PARR						
	Stream gradient (%)		16	***Poor***	***0.1***	45	5
	Substrate (% gravel and rubble(A/B/C))		0.6/1.0/0.	Moderate	0.5		
	Cover (%)		10	Moderate	0.5		
	Percent pools (%)		0	***Poor***	***0.1***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average temperature (ºC)		6	Moderate	0.5		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	Moderate	0.5		
	Average pH		7.5	High	1		

*Area: 15 m length *3 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **North Treaty Creek**

ILP **4011 (North Treaty Creek) - Treaty Creek Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Dolly Varden	**ADULT**						
	Stream gradient (%)		3	High	1		
	Cover (%)		34	High	1		
	Percent pools (%)		10	***Moderate***	***0.5***	210	105
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		6	***Moderate***	***0.5***		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8.5	***Moderate***	***0.5***		
	EMBRYO						
	Substrate (% fines)	ISD, Assume moderate/average conditions	10	***Moderate***	***0.5***	210	105
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average velocity (cm/s)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		6	***Moderate***	***0.5***		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8.5	***Moderate***	***0.5***		
	FRY						
	Stream gradient (%)		3	High	1		
	Substrate (% gravel and rubble(A/B/C))		0.6/1.0/0.	***Moderate***	***0.5***	210	105
	Cover (%)		34	High	1		
	Percent pools (%)		10	***Moderate***	***0.5***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		6	***Moderate***	***0.5***		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8.5	***Moderate***	***0.5***		
	PARR						
	Stream gradient (%)		3	High	1		
	Substrate (% gravel and rubble(A/B/C))		0.6/1.0/0.	***Moderate***	***0.5***	210	105
	Cover (%)		34	High	1		
	Percent pools (%)		10	***Moderate***	***0.5***		
	Vegetation index of riparian zone		150	High	1		
	Average flow (% of MAF)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average temperature (ºC)		6	***Moderate***	***0.5***		
	Average dissolved oxygen (mg/L)	ISD, Assume moderate/average conditions	-	***Moderate***	***0.5***		
	Average pH		8.5	***Moderate***	***0.5***		

*Area: 15 m length *3 m wide* 3 banks + 15 m length*5 m wide*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Bell Irving River**

ILP **4004 (Bell Irving River) - Treaty Access Road**

Species	Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Chinook Salmon	**ADULT**						
	Average max. or min. pH		7.4	Excellent	1		
	Max. temperature (˚C)	Assume optimal temperature	-	Excellent	1		
	Min. diss. oxygen (mg/L)	Assume optimal DO	-	Excellent	1		
	Percent pools		10	***Average***	***0.4***	248	99
	Pool class rating (A/B/C)		1.0/0/0	Excellent	1		
	SPAWNING/INCUBATION/EMERGENCE						
	Min. diss. oxygen (mg/L)	Assume optimal DO	-	Excellent	1		
	Max. or min. temperature (˚C)	Assume optimal temperature	-	Excellent	1		
	Average gravel size (cm)	Assume average conditions	-	***Average***	***0.5***	248	124
	Average water velocity (cm/s)		-	Excellent	1		
	Percent fines		5	Excellent	1		
	Base flow as % of MAF		>50	Excellent	1		
	Peak flow as % of MAF	Assume average conditions	-	***Average***	***0.5***		
	JUVENILE REARING						
	Average max. or min. pH		7.4	Excellent	1		
	Max. temperature (˚C)	Assume optimal temperature	-	Excellent	1		
	Min. diss. oxygen (mg/L)	Assume optimal DO	-	Excellent	1		
	Percent pools		10	***Average***	***0.4***	248	99
	Pool class rating (A/B/C)		1.0/0/0	Excellent	1		
	Base flow as % of MAF		>50	Excellent	1		
	Peak flow as % of MAF	Assume average conditions	-	Average	0.5		
	Substrate class	Assume average conditions	-	Average	0.5		
	Percent riffle fines		5	Excellent	1		
	Percent cover		20	Excellent	0.8		
	Substrate cover	Assume average conditions	-	Average	0.5		
	Average water velocity (cm/s)	Assume optimal velocity	-	Excellent	1		

*Area: 15 m length * 5 m wide * 2 sides*

*Footing Area: 7 m *7 m * 2 posts*

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **Treaty Creek**
ILP **108 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Coniferous trees	0.2	900	180

Watershed **Treaty Creek**
ILP **114 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Mixed trees	0.2	900	180

Watershed **Treaty Creek**
ILP **151 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Coniferous trees	0.2	900	180

Watershed **Treaty Creek**
ILP **204 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Mixed trees	0.2	900	180

Watershed **Treaty Creek**
ILP **205 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Mixed trees	0.2	900	180

Watershed **Treaty Creek**
ILP **209 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Mixed trees	0.2	900	180

Watershed **Treaty Creek**
ILP **243 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Coniferous trees	0.2	900	180

Watershed **Treaty Creek**
ILP **244 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Coniferous trees	0.2	900	180

Watershed **Treaty Creek**
ILP **210 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Mixed trees	0.2	900	180

Watershed **North Treaty Creek**
ILP **4011 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Deciduous trees	0.2	900	180

Watershed **Bell Irving River**
ILP **4005 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Mixed trees	0.2	900	180

Watershed **Bell Irving River**
ILP **4006 - Transmission Line**

Habitat Variable	Description of Habitat	HSI Value	Area (m^2)	HU
Riparian	Deciduous trees	0.2	900	180

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **North Treaty**

Reach **0 - Water Quantity**

Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3	High	1		
Cover (%)		17	***Moderate***	***0.5***		
Percent pools (%)		6	***Moderate***	***0.5***	1056.6	528
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		5	***High***	***1***	1056.6	1057
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.70/0.30/0	High	1		
Cover (%)		15	***Moderate***	***0.5***		
Percent pools (%)		6	***Moderate***	***0.5***	1056.6	528
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.70/0.30/0	High	1		
Cover (%)		15	***Moderate***	***0.5***		
Percent pools (%)		6	***Moderate***	***0.5***	1056.6	528
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **North Treaty**

Reach **1 - Water Quantity**

Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3	High	1		
Cover (%)		36.7	High	1		
Percent pools (%)		14	***Moderate***	***0.5***	158.0	79
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
EMBRYO						
Substrate (% fines)		0	***High***	***1***	158.0	158
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
FRY						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.70/0.30/0	High	1		
Cover (%)		36.7	High	1		
Percent pools (%)		14	***Moderate***	***0.5***	158.0	79
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		
PARR						
Stream gradient (%)		3	High	1		
Substrate (% gravel and rubble(A/B/C))		0.70/0.30/0	High	1		
Cover (%)		36.7	High	1		
Percent pools (%)		14	***Moderate***	***0.5***	158.0	79
Vegetation index of riparian zone		131	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7.5	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **South Teigen**

Reach **1 - Water Quantity**

Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3.5	High	1		
Cover (%)		30	High	1		
Percent pools (%)		5	***Moderate***	***0.5***	1,970.5	985
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7	High	1		
EMBRYO						
Substrate (% fines)		10	***High***	***1***	1,970.5	1971
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7	High	1		
FRY						
Stream gradient (%)		3.5	High	1		
Substrate (% gravel and rubble(A/B/C))		0.83/0.16/0	High	1		
Cover (%)		30	High	1		
Percent pools (%)		5	***Moderate***	***0.5***	1,970.5	985
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7	High	1		
PARR						
Stream gradient (%)		3.5	High	1		
Substrate (% gravel and rubble(A/B/C))		0.83/0.16/0	High	1		
Cover (%)		30	High	1		
Percent pools (%)		5	***Moderate***	***0.5***	1,970.5	985
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 4.3-1. HSI Ratings and Values for Impacted Watercourses (HADD)

Watershed **South Teigen**

Reach **2 - Water Quantity**

Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
ADULT						
Stream gradient (%)		3.5	High	1		
Cover (%)		30	High	1		
Percent pools (%)		15	***Moderate***	***0.5***	1221.4	611
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7	High	1		
EMBRYO						
Substrate (% fines)		10	***High***	***1***	1221.4	1221
Average flow (% of MAF)	Fall	>50	High			
Average velocity (cm/s)	ISD	NA				
Average temperature (ºC)	Summer Temperature	8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7	High	1		
FRY						
Stream gradient (%)		3.5	High	1		
Substrate (% gravel and rubble(A/B/C))		0.83/0.16/0	High	1		
Cover (%)		30	High	1		
Percent pools (%)		15	***Moderate***	***0.5***	1221.4	611
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7	High	1		
PARR						
Stream gradient (%)		3.5	High	1		
Substrate (% gravel and rubble(A/B/C))		0.83/0.16/0	High	1		
Cover (%)		30	High	1		
Percent pools (%)		15	***Moderate***	***0.5***	1221.4	611
Vegetation index of riparian zone		141	***Moderate***	***0.5***		
Average flow (% of MAF)	Late Summer	>50	High	1		
Average temperature (ºC)		8	High	1		
Average dissolved oxygen (mg/L)	ISD	NA				
Average pH		7	High	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold and italics for 'Rating' and 'HSI Value' indicated which ratings and values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 6.3-1

HSI Ratings and Values for Compensation Sites (HADD)

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Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (HADD)

Watershed: Teigen

Site: 1

Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m^2)	HU
Coho Salmon						
Adult Migration						
Max. temperature (˚C)	Assume optimal conditions	-	Excellent	**0.75**	3,779	2,834
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	1		
Spawning/Incubation/Emergence						
Max. temperature (˚C)	Assume optimal conditions	-	Excellent	**0.75**	3,779	2,834
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	1		
Substrate (% gravel/cobble)		>50	Excellent	1		
Substrate (% fines)		<15	Excellent	1		
Rearing						
Max. temperature (˚C)	Assume optimal conditions	-	Excellent	**0.75**	3,779	2,834
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	1		
Substrate (% gravel/cobble)		>50	Excellent	1		
Substrate (% fines)		<15	Excellent	1		
Percent canopy		35 to 85	Excellent	1		
Riparian zone index		>150	Excellent	1		
Percent pools		40	Excellent	1		
Percent pools with canopy		>60	Excellent	1		
Percent cover		>30	Excellent	1		
Overwintering						
Max. temperature (˚C)	Assume optimal conditions	-	Excellent	**0.75**	3,779	2,834
Percent winter cover		30	Excellent	1		

NA = not applicable.

MAF = mean annual flow.

Substrate Rating: A = cobble or boulder or small vegetation; B = silt, gravel, cobble and boulders (equal amounts); and C = fines, boulders, and bedrock dominate.

Bold for "HSI Value' indicated which values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (HADD)

Watershed: Teigen

Site: 1

Habitat Variable	Rating	HSI Value	Area (m²)	HU
All Ponds				
Migration				
Habitat Quality	NA	NA	-	-
Spawning				
Habitat Quality	NA	NA	-	-
Rearing				
Habitat Quality	Above Average	1	145,462	145,462
Overwintering				
Habitat Quality	Above Average	0.75	145,462	109,097

NA = not applicable.

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (HADD)

Watershed: Teigen

Existing Site: 2 - Existing Pond

Habitat Variable	Rating	HSI Value	Area (m²)	HU
Pond 1				
Migration				
Habitat Quality	NA	NA	-	-
Spawning				
Habitat Quality	NA	NA	-	-
Rearing				
Habitat Quality	Moderate	0.5	2,880	1,440
Overwintering				
Habitat Quality	Poor	0.1	2,880	288
Pond 2				
Migration				
Habitat Quality	NA	NA	-	-
Spawning				
Habitat Quality	NA	NA	-	-
Rearing				
Habitat Quality	Poor	0.1	100	10
Overwintering				
Habitat Quality	Poor	0.1	100	10
Pond 3				
Migration				
Habitat Quality	NA	NA	-	-
Spawning				
Habitat Quality	NA	NA	-	-
Rearing				
Habitat Quality	Poor	0.1	152	15
Overwintering				
Habitat Quality	Poor	0.1	152	15
Pond 4				
Migration				
Habitat Quality	NA	NA	-	-
Spawning				
Habitat Quality	NA	NA	-	-
Rearing				
Habitat Quality	Poor	0.1	100	10
Overwintering				
Habitat Quality	Poor	0.1	100	10
Pond 5				
Migration				
Habitat Quality	NA	NA	-	-
Spawning				
Habitat Quality	NA	NA	-	-
Rearing				
Habitat Quality	Moderate	0.5	840	420
Overwintering				
Habitat Quality	Above Average	0.75	840	630

NA = not applicable

Appendix 6.3-1. HSI Ratings and Values for Compensation Sites (HADD)

Watershed: Teigen

Existing Site: 2 - Stream

Habitat Variable	Description of Habitat	Value	Rating	HSI Value	Area (m²)	HU
<u>Coho Salmon</u>						
Adult Migration						
Max. temperature (˚C)	Assume optimal conditions	-	Excellent	**1**	55	55
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	1		
Spawning/Incubation/Emergence						
Max. temperature (˚C)	Assume optimal conditions	-	Excellent	1		
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	1		
Substrate (% gravel/cobble)	ISD, Assume moderate/average conditions	-	Moderate	**0.5**	55	28
Substrate (% fines)	ISD, Assume moderate/average conditions	-	Moderate	**0.5**		
Rearing						
Max. temperature (˚C)	Assume optimal conditions	-	Excellent	1		
Min. diss. oxygen (mg/L)	Assume optimal conditions	-	Excellent	1		
Substrate (% gravel/cobble)	ISD, Assume moderate/average conditions	-	Moderate	**0.5**	55	28
Substrate (% fines)	ISD, Assume moderate/average conditions	-	Moderate	**0.5**		
Percent canopy	ISD, Assume moderate/average conditions	-	Moderate	**0.5**		
Riparian zone index		>150	Excellent	1		
Percent pools	ISD, Assume moderate/average conditions	-	Moderate	**0.5**		
Percent pools with canopy	ISD, Assume moderate/average conditions	-	Moderate	**0.5**		
Percent cover	ISD, Assume moderate/average conditions	-	Moderate	**0.5**		
Overwintering						
Max. temperature (˚C)	Assume optimal conditions	-	Excellent	**1**	55	55
Percent winter cover		30	Excellent	1		

NA = not applicable

ISD - insufficient data

MAF = mean annual flow

Substrate Rating: A = cobble or boulder or small vegetation, B = silt, gravel, cobble and boulders (equal amounts), and C = fines, boulders, and bedrock dominate

Bold for "HSI Value' indicated which values were selected for HU calculation

Selection is based upon lowest HSI value in life stage

Appendix 6.3-2

Technically Feasible Design Memo – Teigen Creek Site 1 (HADD)

Rescan™
Engineers and Scientists

Draft Memorandum

DATE: December 2012 Refer to File No.: B.1_Teigen Creek Report.docx

SUBJECT: Teigen Creek: Feasibility Assessment of the Proposed Fish Habitat Compensation Area

1. Introduction

This report provides the results from the feasibility assessment for the proposed Fish Habitat Compensation Area within the lower Teigen Creek drainage basin. The work has been focussed on the engineering planning and development of a new off-channel habitat system that will be established north of Teigen Creek.

The proposed Fish Habitat Compensation Area (the Project) is located along the north side of the Teigen valley, immediately upstream of the confluence with south Teigen Creek. Teigen Creek flows northeast into the Bell-Irving River. The proposed Project is located on provincial Crown Land.

This report includes a description of the methodologies that were used in the feasibility assessment work. A results and observations section follows that describes the findings from the investigative work as well as identified risks to the development of the Project. Based on the completed technical feasibility assessment, conclusions and recommendations are provided for the development of the Project.

All figures and drawings are provided in appendices of this report.

2. Methodology

Field investigations were conducted during field trips in 2011 and 2012. Extensive ground and helicopter-based aerial observations were conducted during all field visits. The work in 2011 was focused on site assessments for locating the new off-channel drainage network, as well as obtaining local topographic survey-based information at key locations along the route. Investigations in 2011 and 2012 were associated with developing an understanding of the hydrologic characteristics of the drainage basin, the geomorphology of Teigen Creek, subsurface materials, groundwater within the Project area and the physical layout with respect to the existing ground surface.

A range of survey techniques were employed to collect local topographic data at locations across the proposed habitat compensation area. Differential GPS (DGPS) equipment was used to collect mapping grade topographic data and to collect feature data at proposed intake locations. Compass and chain surveys were also used to collect additional topographic data across noted terrain features, and to further refine the DGPS data where necessary. Total station surveys were conducted at potential intake locations. In addition, field observations and aerial reconnaissance were conducted during all field visits.

Light Detection and Ranging (LiDAR) data was provided for the proposed fish habitat compensation area. The LiDAR data was utilized to develop a digital terrain model (DTM) for the area. The model also provided the basis for the engineering layout and development of the channel and pond system.

In 2011 and 2012, geomorphological assessments of the Project Area were carried out by completing a series of site investigations of local geologic terrain and channel conditions. In addition, the process also included an examination of historic aerial photographs and satellite imagery for Teigen Creek.

Surface water monitoring along Teigen Creek has been ongoing since 2008. A hydrometric station (TGN-H1) has been continuously recording water levels throughout the year. The station is positioned immediately upstream of the confluence with South Teigen Creek. Flow discharge measurements and hydrometric levelling surveys have been completed in accordance with the *Manual of Hydrometric Standards in British Columbia* (RISC 2009).

Groundwater discharge zones were identified during local ground inspections in 2011 and in 2012. A series of small standing water bodies are present along the base of the hillslopes. The larger water bodies are associated with beaver activities are connected by a channel that generally follows the toe of the slope. The upstream extent of the Project area shows less evidence of groundwater along the valley floor.

3. Results and Observations

The results of the field investigations, office-based data review, and feasibility assessment are provided below. This information was used in the development of the preliminary designs (Appendix B).

3.1 Basin Description

Teigen Creek flows northeast out of the Boundary Range of the Coast Mountains and is a large tributary of the Bell-Irving River. The basin drainage area is approximately 154 km^2. The Project is positioned along the northwest side of the valley and extends northwest along a portion of the floodplain. This floodplain is over 2,000 m long and is over 500 m wide at its widest. Landforms across the floodplain range from elevated terraces, remnant floodplain and cut-off channels to levee deposits along the margins of active channel sections.

A mixed floodplain forest is present, with shrub, sedge and willow meadows present along the margins of active channel and open water areas. Surficial sediments are coarse grained and appear fluvial in origin. Deposits of colluvium are present in places and extend out from the base of adjacent hillslopes. Fine grain silts and clays were observed in and around the existing pond areas, as well as in places where the groundwater presence was noted at surface.

3.2 Channel Geomorphology

Lower Teigen Creek is characterized as a gravel bed stream that has an average channel gradient of 1%. The channel morphology within the Project reach varies from meander to braided. Channel bank full widths range from 15 m along the straighter stream sections to over 50 m where large gravel bar deposits are present. Sediment transport processes are bedload driven, with in-channel depositional features including gravel bar deposits to elongated mid-channel gravel bars within the stream. Jams of large woody debris are also present along the channel edges or stranded on gravel bars in places.

The Project is located on a terrace 3 m or more in elevation above the main channel. The Project area is what was once seasonally occupied floodplain but shows no sign of occupation within the last 50 years.

3.3 Hydrology

The hydrology of Teigen Creek is associated with a mountainous watershed that has a broad valley floor that is bordered by steep gradient hillslopes and headwater drainage basins. With a total drainage area

of 154 km^2, surface water flows are generated from hillslope-related runoff from precipitation events, as well as snow melt.

Hydrometric data for Teigen Creek was collected at station TGN-H1 which has been in operation during the open water season since 2008. The mean annual discharge (MAD) for Teigen Creek was estimated from the 2008 - 2011 discharge hydrograph (Appendix A, Figure 4). From this, the MAD for Teigen Creek was estimated to be 6.8 m^3/s. The water withdrawal rate for the Project was based on the 10% MAD value of 0.68 m^3/s.

For Teigen Creek, the estimated annual hydrograph is characterized by spring meltwater flows that begin in mid-April. Freshet-induced peak flows occur late May or early June. Surface water flows decline throughout the summer months as contributions from snowpack and hillslope-related runoff decrease. During the fall period, the annual hydrograph features peak discharge events that occur in response to intense rainfall-runoff events. Winter low flow conditions tend to develop by late November and continue until spring freshet (Figure 4).

Given a potential withdrawal rate of 10% of daily discharge, there would be sufficient flow in Teigen Creek during low flow seasons to support a habitat compensation project on surface water alone. Groundwater can be used to augment surface water supply during the open water season. Habitat areas in ponds and channels will be scaled such that no greater than 10% MAD would be diverted to support them.

3.4 Engineering Planning

The preliminary planning and design of the proposed fish habitat compensation area consists of a series of 11 ponds and interconnecting channels providing 149,241 m^2, fed primarily by groundwater. The purpose of the channels and ponds is to provide off-channel rearing, refuge and overwintering habitat. The Project is to be located on the north side of the valley parallel to Teigen Creek and will be positioned along the base of the adjacent hillslopes. The outlet for the system discharges into an existing side channel of Teigen Creek that currently provides seasonal fish access and will serve as the primary fish access point (Appendix B, Drawing KSM-TEC-019-025).

The ponds and channels presented in the preliminary design drawings (Appendix B) represent generic shapes that will be further developed during the detailed design phase. During the next phase, additional complexity and specific habitat features will be prescribed and incorporated into the design of the channel and ponds. This will include pool-riffle morphology, shoals-islands-deepwater complexing in ponds, and low-bank wetland features and placement of large woody debris (Appendix B, Drawing KSM-TYP-012-026).

The following is a summary of the results from the completed engineering planning and assessment work that were used in the preliminary design phase:

- The design of the Project is based on the concept that open channels and ponds will be excavated below the existing ground surface to intercept groundwater flow and seasonal surface water runoff from the adjacent terrain;
- The channel patterns and the configuration of the ponds were based on the existing ground contours and were designed to integrate the ponds into the surrounding landscape to minimize earthworks volumes;
- The trapezoidal shape and dimensions of the open channel sections were sized to convey ground waters and surface waters along the channel sections. The channel base width is 2 m, with 2H:1V sideslopes excavated to depths up to 3.0 m below the existing ground surface;

- The surface water supply rate available for the Project was based on the 10% MAD value of 0.68 m^3/s. An average design flow of 0.1 m^3/s was used for planning purposes with the minimum water depth along the channel sections to be 0.3 m. This will result in an average stream velocity of 0.12 m/s^2.
- The planned drainage outlet for the Project will be located downstream along the left bank of lower Teigen Creek. The outlet will also serve as the access for fish entering the Project
- A proposed surface water intake location was identified along left bank of the upstream channel bend. The purpose of the water intake is to allow for surface waters to be withdrawn and supplied to the fish habitat compensation system if insufficient groundwater flows exist.
- The design criterion for the depth of the ponds was determined by the need for ice-free overwintering habitat. The maximum winter ice thickness as determined by winter ice core sampling in lakes in the area was 1.0 m. 50% of the area of each pond will be >2 m deep as measured from the outlet channel invert.
- Deeper water sections 3 to 4 m deep will be present within each pond. The depths of these sections will be determined, in part, by the minimum elevation of the local water table at each location.
- An access road and protection dyke will be constructed along the western extent of the Project. This embankment structure will be sized to withstand a 25 year flood event and will provide access during the construction of the Project. The structure will be constructed from materials excavated during the construction of the ponds and channels.

3.5 Risk Assessment

As part of the feasibility assessment for the proposed Project, a risk assessment was undertaken to identify information gaps and to quantify potential risk. The assessment was based on the available information and included an assessment of the water supply potential, channel stability, earthworks, layout of the proposed system, and related maintenance requirements.

During the risk assessment all available information was reviewed, significant information gaps were identified, and hazards associated with known information or with gaps were reviewed. Possible consequences associated with the information or information gaps were then identified and a risk rating relative to the feasibility of the project was assigned. Finally, possible mitigation for associated risks then identified.

The following is a summary of the risk assessment:

3.5.1 Water Supply

- Based on the evidence of groundwater presence along the proposed route, it is expected that sufficient groundwater sources will be available.
- Hydrometric data indicates that winter flows in Teigen Creek are sufficient to support flow in the Project through the winter. A surface water intake may be used to augment groundwater.
- Length and depth of groundwater collection channel to be determined to provide flow rates for channel design.

3.5.2 Channel Stability

- Flood risk along lower Teigen Creek is considered low due to protection provided by bedrock at the proposed intake location.

- The lower portion of the Project is located on a bench that has not been part of the active floodplain for greater than 50 years, based on the age of the current stand of trees.
- The access road/protection dyke will be sized to protect the Project from a 25 year event.

3.5.3 Earthworks

- Terrain mapping and floodplain location indicates suitable well-graded coarse grained materials will be present for construction.
- Some fine-grained soils are present and may be used to create impermeable banks along pond margins.

3.5.4 Project Layout

- The Project layout incorporated bedrock and steep terrain at the upstream extent to provide protection from flooding and stability for the intake structure. The hillslope will also provide lateral stability along the Projects northern extent.
- Channel sections were maintained at 1 to 3 % gradients to provide suitable habitat for target species and be within the gradient range for pool-riffle and forced pool-riffle morphologies.
- Ponds were laid out along contours and within other landscape features to minimize earthworks.
- Design of the water intake will require protection against local aggradation and degradation. It will be designed to exclude most sediment and the first pond in the system will act as a grit pond for removing suspended sediment.

3.5.5 Maintenance Requirements

- Maintenance needs were evaluated to be at a moderate risk for beaver-related impacts, low risk for sediment buildup at water intake and outlet areas, as well as for any physical repairs to pond and channel sections
- Active wildlife management will likely be required to mitigate the potential effects of beaver activities within the compensation area
- Outlet locations will be properly positioned and maintained to ensure continuation of fish access.
- Proximity to the proposed access road allows for good access for maintenance.

4. Conclusions and Recommendations

The results from the completed feasibility assessment for the proposed Fish Habitat Compensation Area along lower Teigen Creek have been presented. Site investigation and engineering planning has been completed to confirm that the development of the Project area is technically feasible at the location. The low gradient terrain indicates that conventional excavation and construction techniques for the channels and ponds will be appropriate.

Teigen Creek can provide sufficient surface water volumes to the Project area. The presence of groundwater along the proposed alignment indicates a high potential for groundwater to be the primary water supply source for the Project. The existing terrain provides suitable low gradient ground surfaces for the construction of the channels and ponds. The layout of the compensation area is well positioned relative to the location of the active channel sections along lower Teigen Creek.

The designs presented in Appendix B show potential habitat area that is feasible to construct. The actual areas that will be constructed will be less than these potential areas and will be determined based on the habitat area required for sufficient compensation. The larger potential number is presented as optional area available as a risk mitigation measure.

The Project was chosen based on many biological and geophysical criteria. However, operationally, the proximity to existing or planned road infrastructure and the area available in the Teigen watershed made this site suitable. Preference was given to building fewer larger projects as opposed to many small projects in order to more efficiently use resources and to focus maintenance activities.

Wetland habitat compensation is an additional component of the larger KSM habitat compensation program. Wetland habitat will be developed within the Project and wetland scientists have participated in the design of the Project to ensure both habitat types are included in the design. The combination of both fish and wetland habitat development is a natural corollary and will ensure an inclusive ecosystem approach to the development of the Project. The typical pond detail in Appendix B shows some examples of ecosystem complexing that will be implemented.

The Projects represent relatively large-scale construction activities and may require multiple years to make fully operational. As such, a staged approach to the construction of these Projects is recommended. This approach would allow for seasonal settling and stabilization, integration of regulator and stakeholder participation, design changes as required by site conditions, and sufficient flexibility to incorporate the Projects into the surrounding landscape while minimizing impacts to the existing ecosystems.

The following recommendations are put forward for consideration in the future development of the Project.

1. The established surface water and groundwater monitoring programs should be continued so that the water sources are properly characterized for use in detailed design.
2. Detailed engineering surveys should be completed along the proposed alignment.
3. Based on the completed surveys, detailed design work is required to determine the final configuration of the channels, ponds, and access road/protection dyke.
4. Hydraulic modeling should be completed to assess the functioning of the systems and the effect of habitat complexing on flow velocity distributions and water quality conditions across representative channel sections and ponds. In addition, detailed hydraulic scour analyses and channel bank protection requirements should be conducted with respect to Treaty Creek.
5. A hazard analysis should be completed based on the existing flood frequency analysis to determine the design flood levels across the Project and where additional embankment protection is required.
6. The construction-related earthwork volumes should be determined as well as a cost estimate for the construction of the Project.
7. A Construction Management Plan should be completed that will include road access details, borrow and spoil areas, material handling, construction sequencing, and an Environmental Management Plan for the Project area.

References

Knighton, A.D. 1998. Fluvial Forms and Processes: A New Perspective. Routledge, New York.

BC Ministry of Forests. 1998. Fish Stream Identification Guidebook.

Resources Information Standards Committee, Ministry of Environment (RISC). 2009. Manual of British Columbia Hydrometric Standards.

- Appendix A -

Figures

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PROJECT # 868-020-04-02 GIS No. KSM-10-169d November 7, 2012

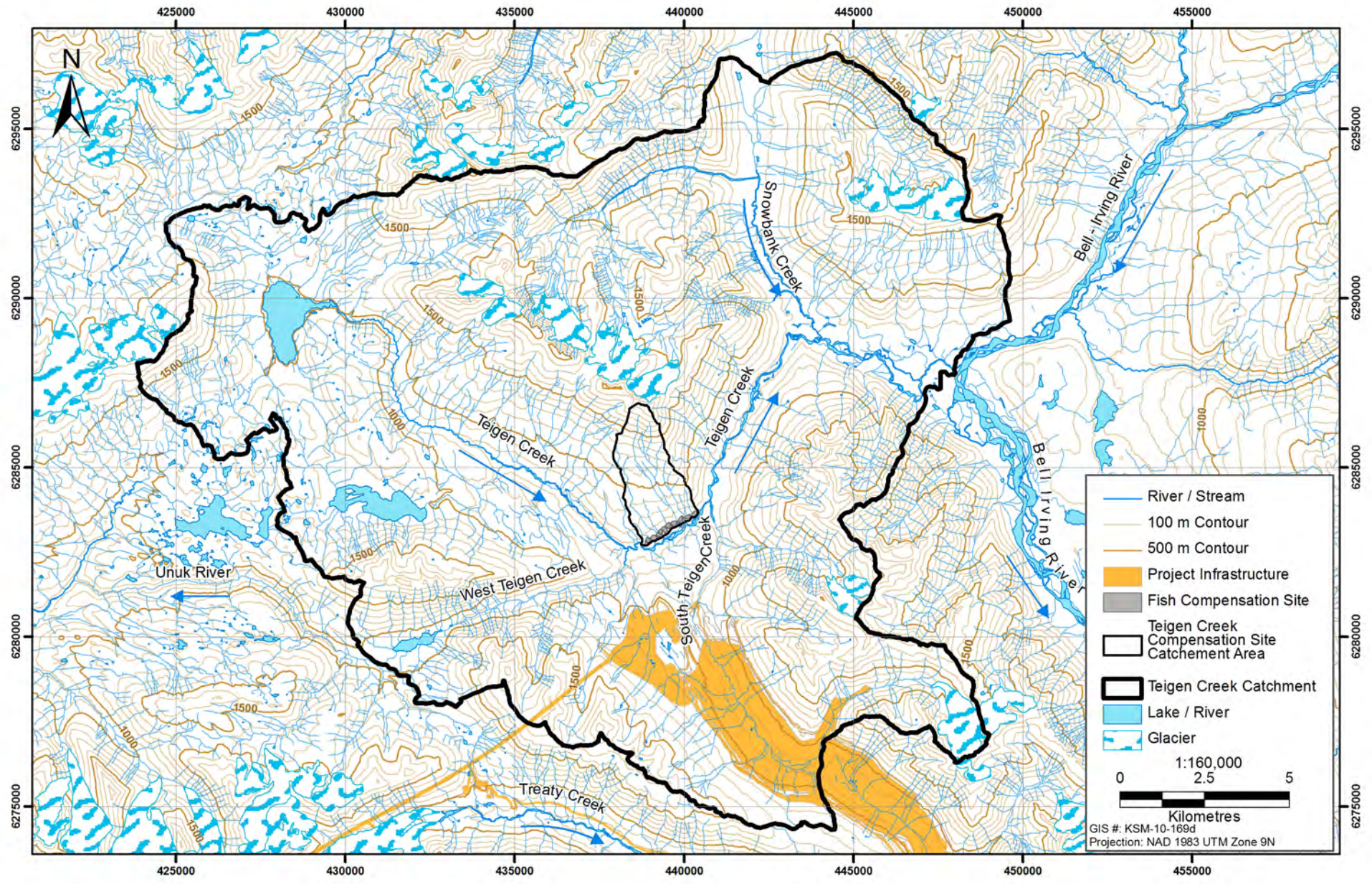


Figure 1

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Drainage Area for Teigen Creek Watershed

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Figure 1

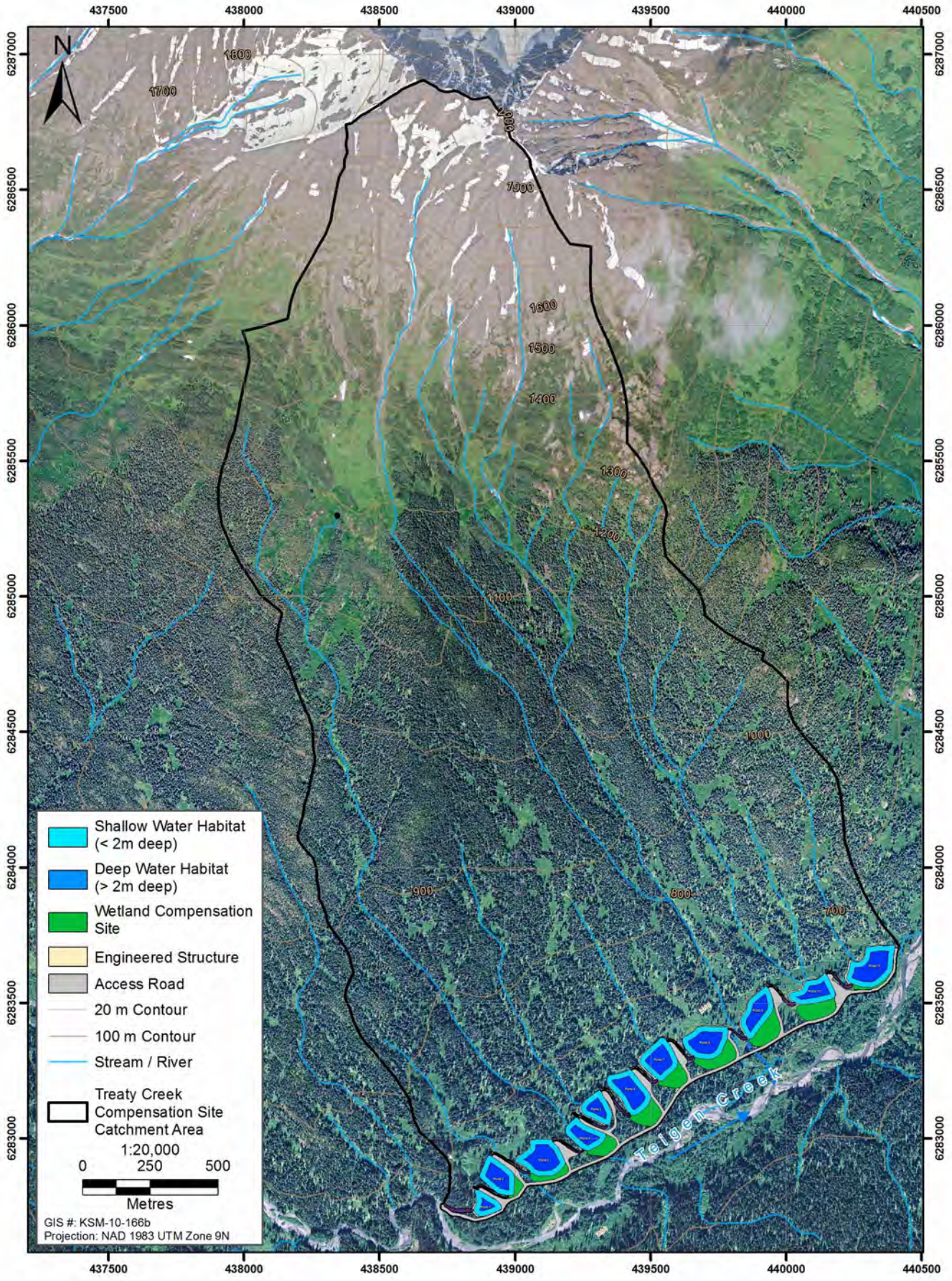


Figure 2

Drainage Area for the Proposed Teigen Creek Fish Habitat Compensation Area

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Figure 3

Teigen Creek Fish Habitat Compensation Area Overview

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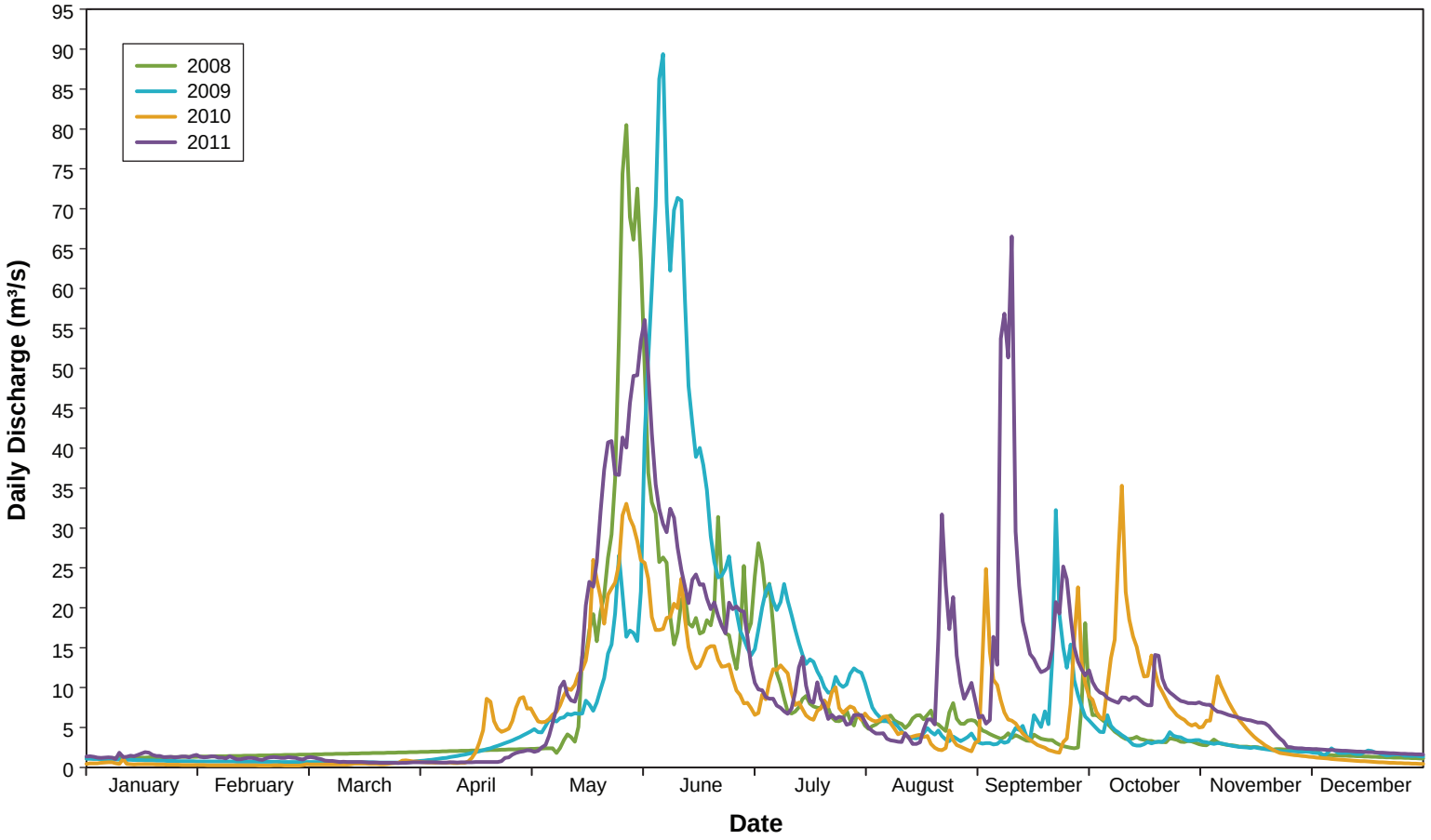


Figure 4

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Annual Hydrograph at Hydrometric Station TGN-H1, Teigen Creek, 2008 to 2011

Figure 4

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- Appendix B -

Drawings

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NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

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PROJECT

KSM Fish Habitat Compensation Project

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SCALE: as shown

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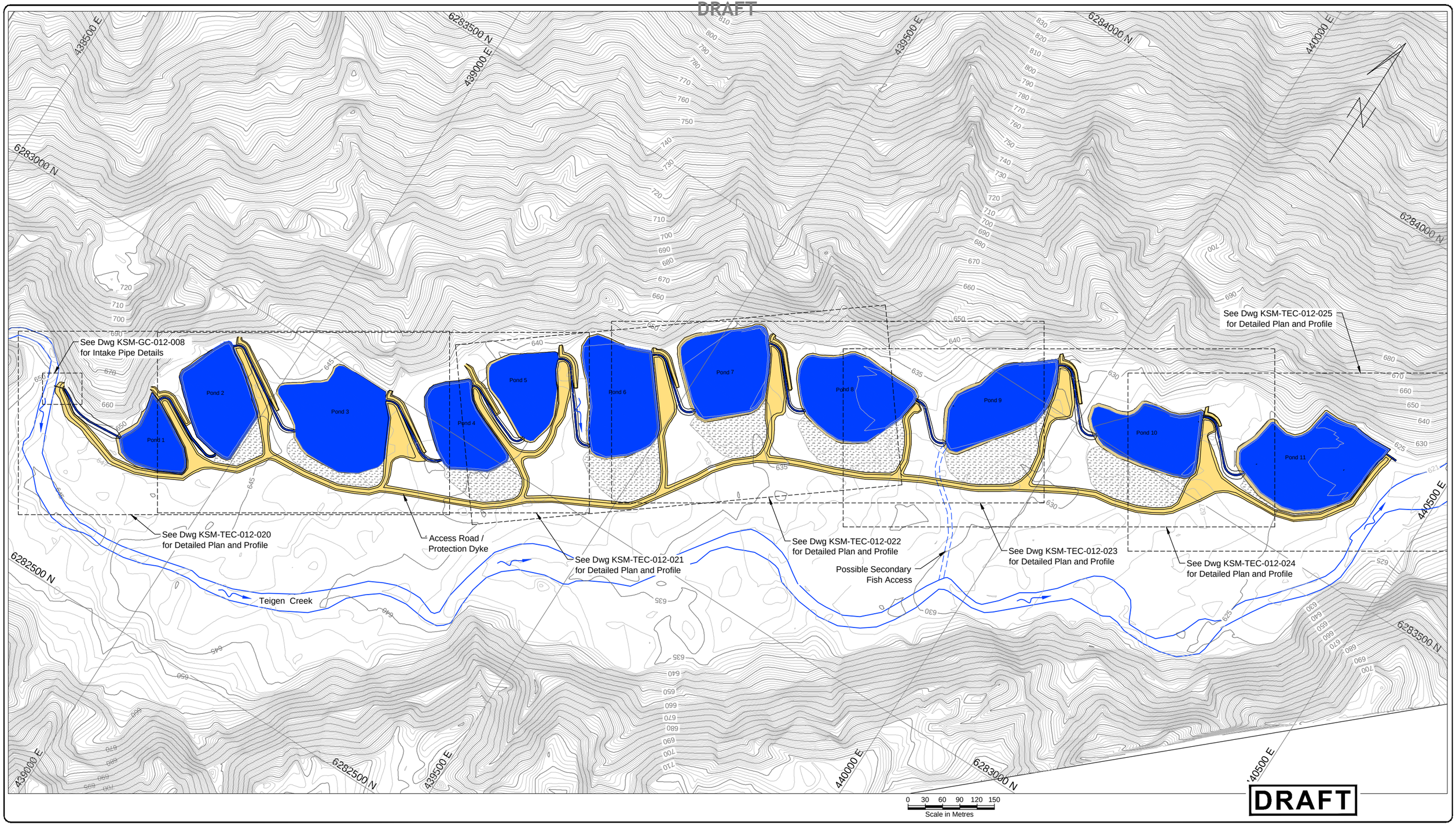
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Teigen Creek Overview

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A	Issued for Discussion	DG	BA	10Aug12

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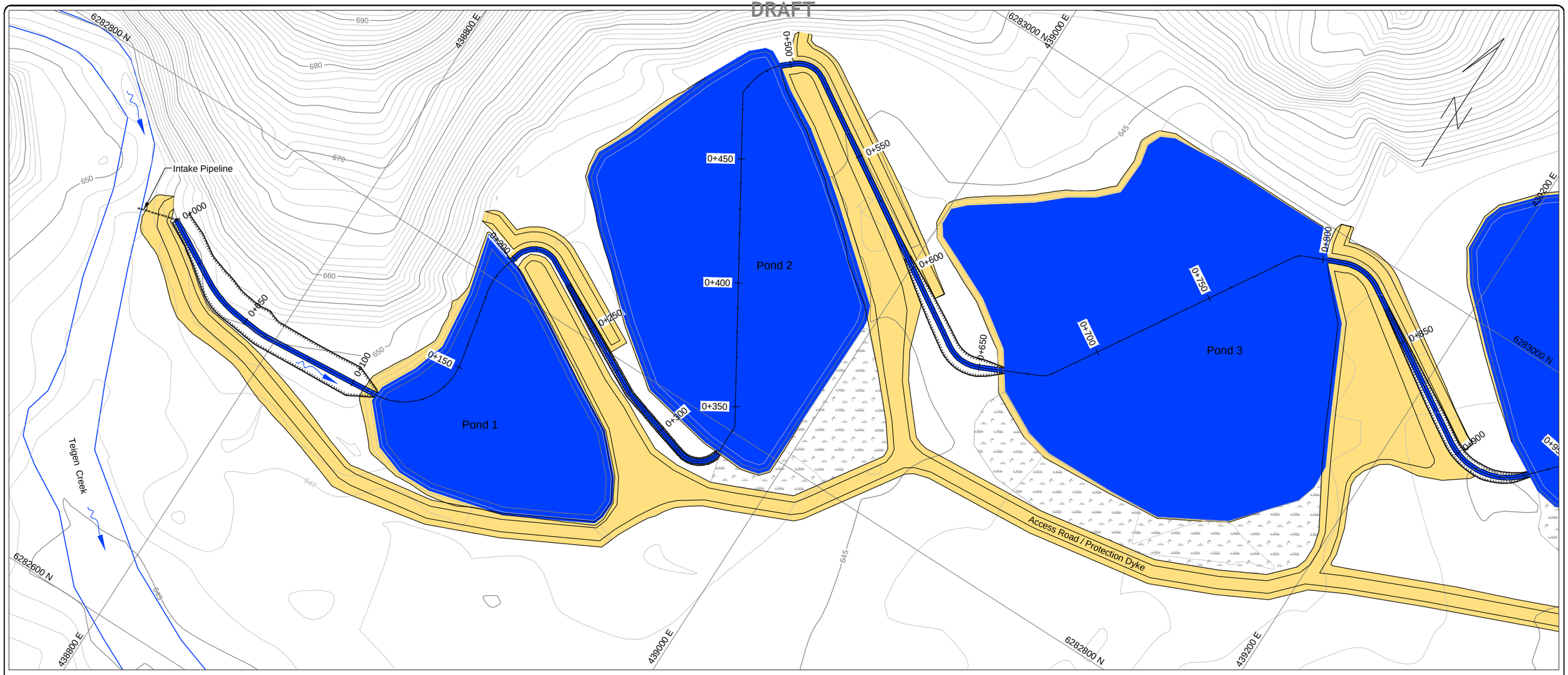
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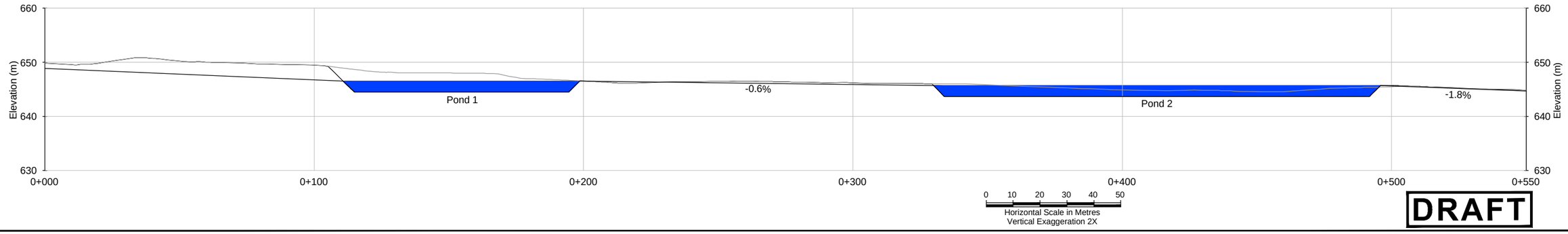
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A	Issued for Discussion	DG	BA	10Aug12

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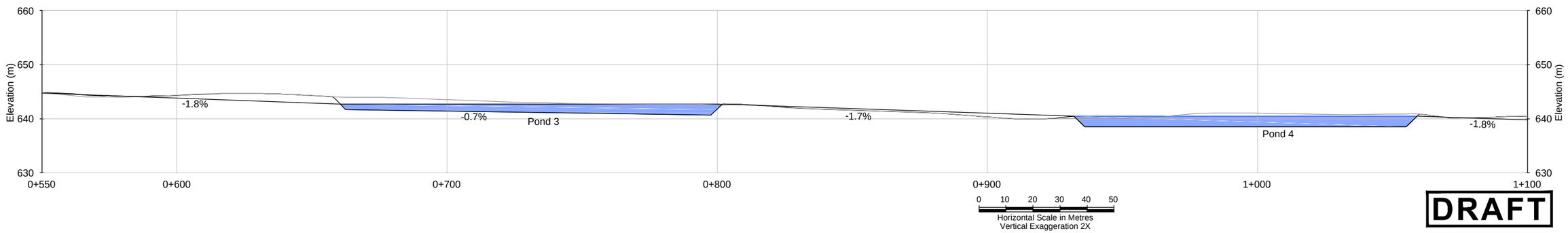
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B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

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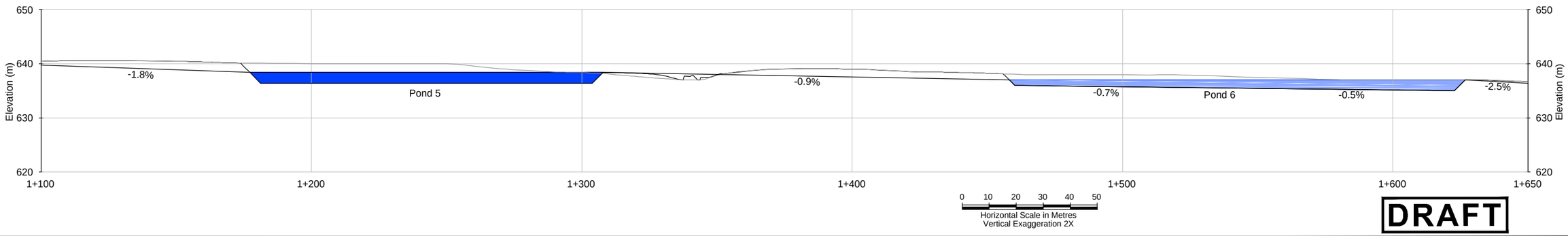
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NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

REVISIONS

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PROJECT

KSM Fish Habitat Compensation Project

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SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

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DATE: Sept. 28, 2012

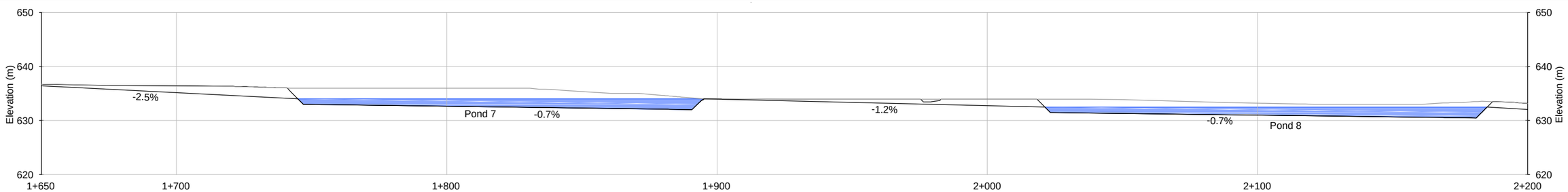
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Teigen Creek Plan and Profile Station 1+100 to 1+650

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NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

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PROJECT

KSM Fish Habitat Compensation Project

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RESCAN JOB NO.: 0868-020-04-01

CAD/GIS No: KSM-TEC-012-023

DATE: Sept. 28, 2012

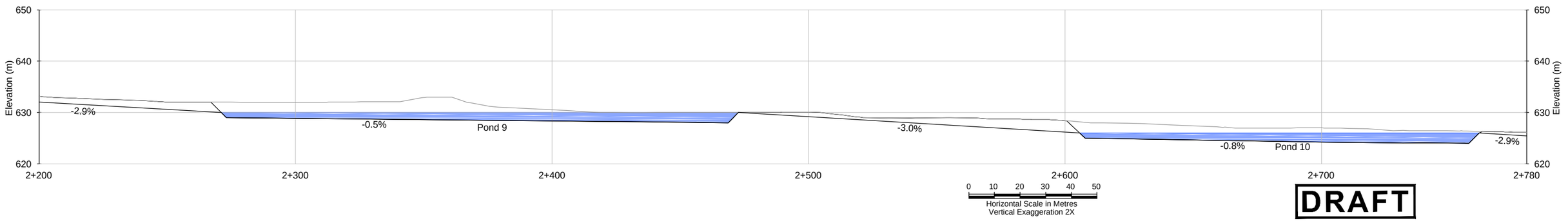
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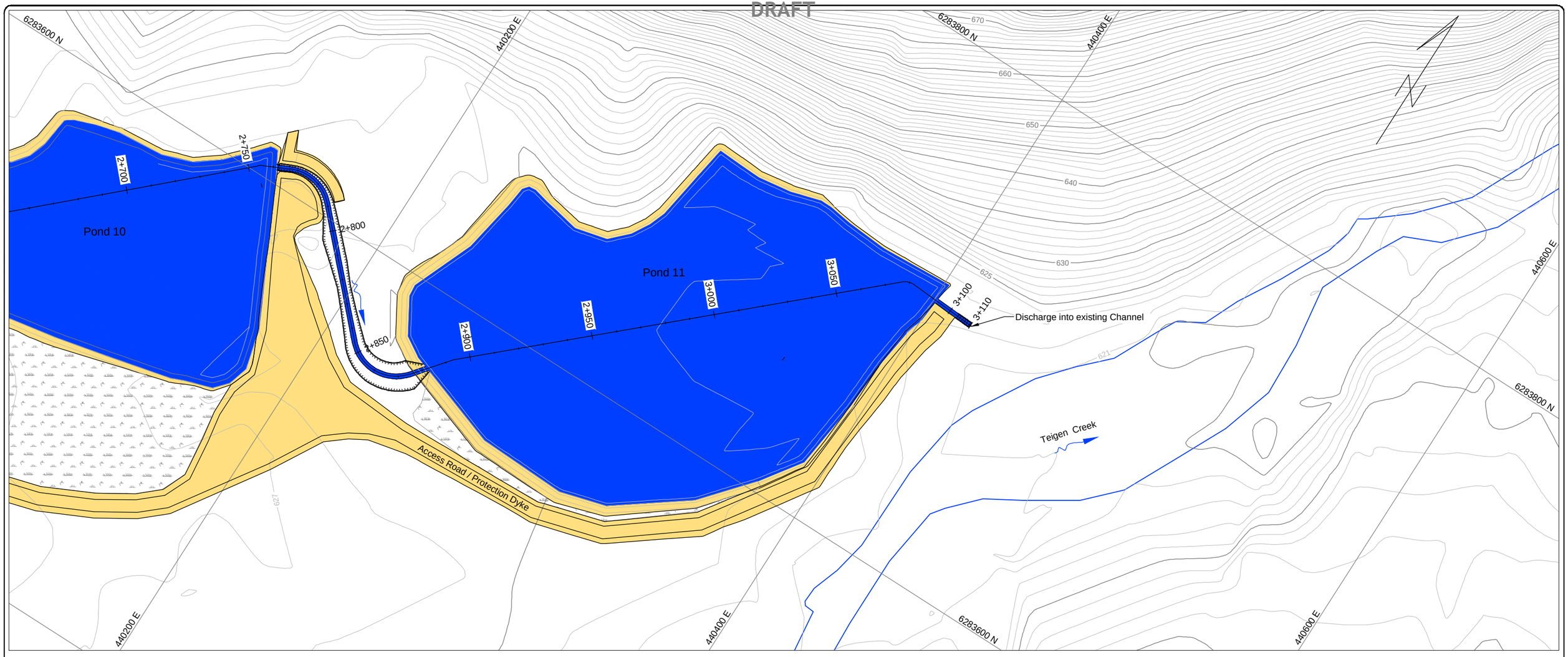
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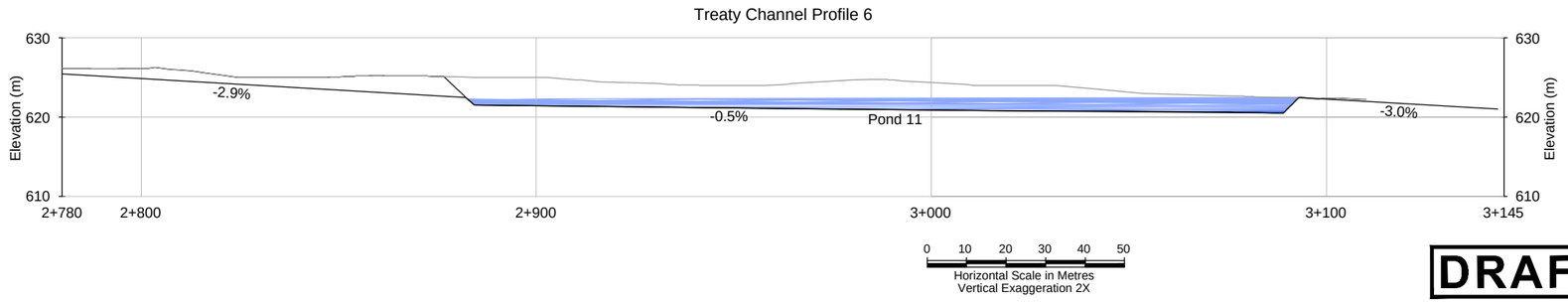
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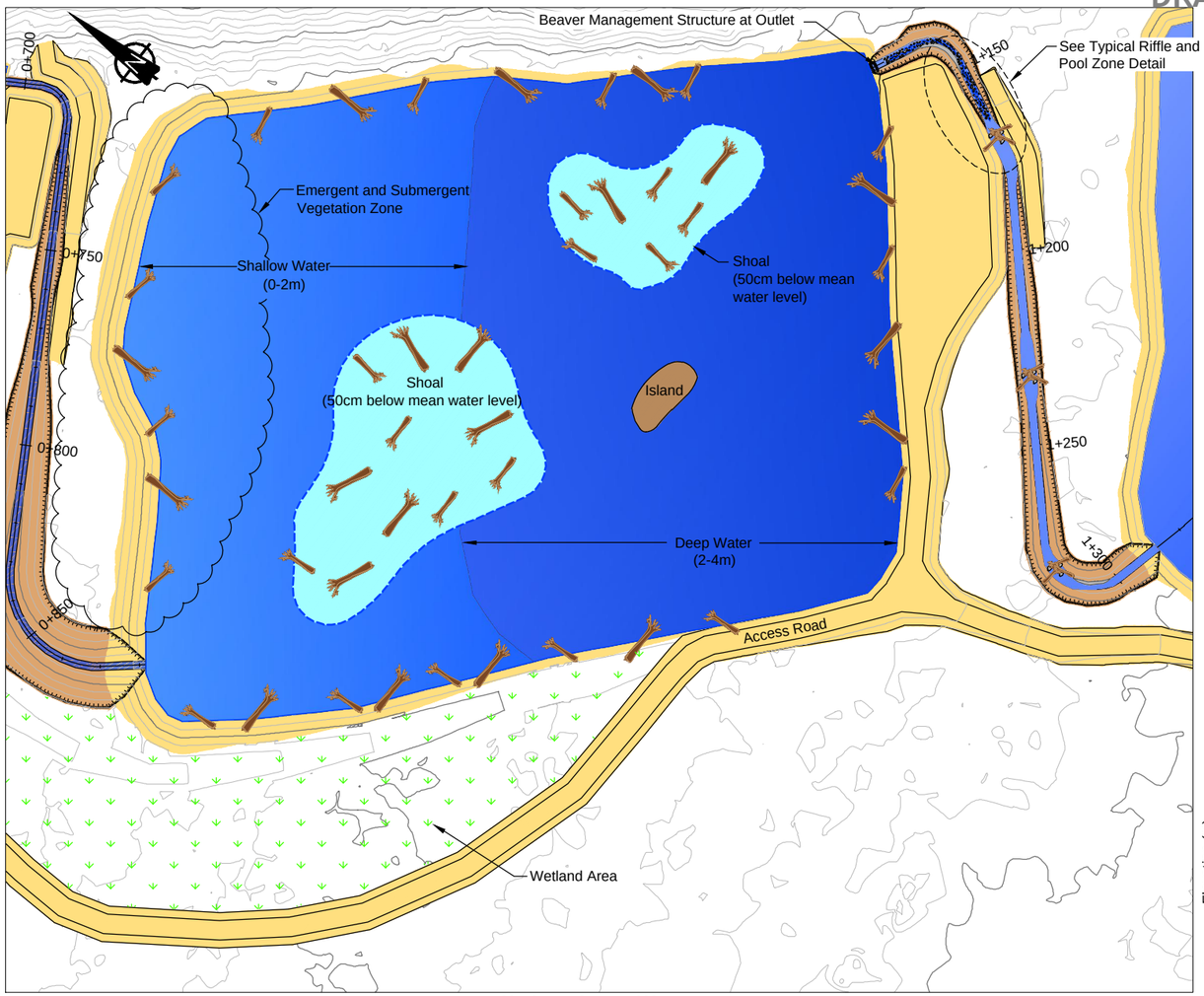
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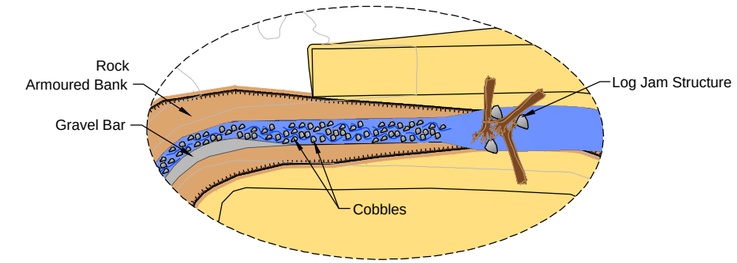
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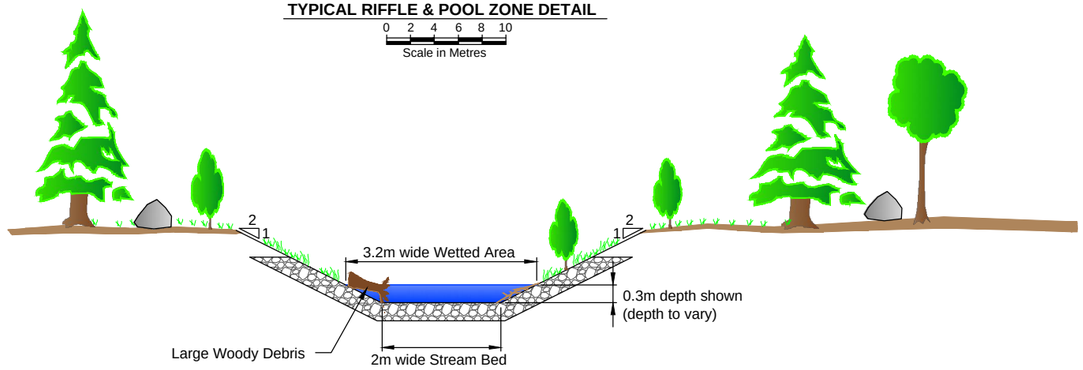
TYPICAL POND LAYOUT

0 5 10 15 20 25
Scale in Metres



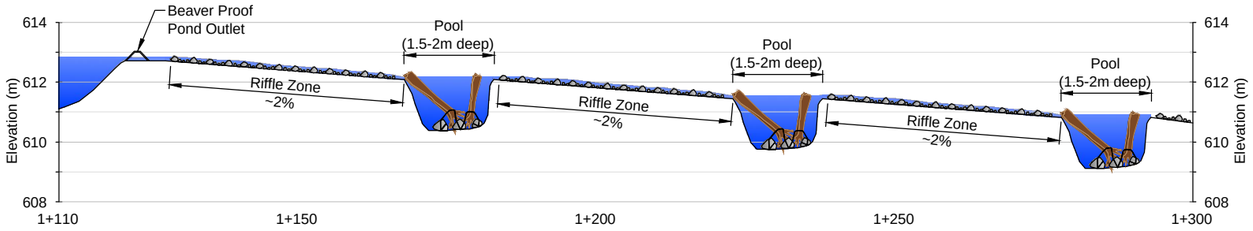
TYPICAL RIFFLE & POOL ZONE DETAIL

0 2 4 6 8 10
Scale in Metres



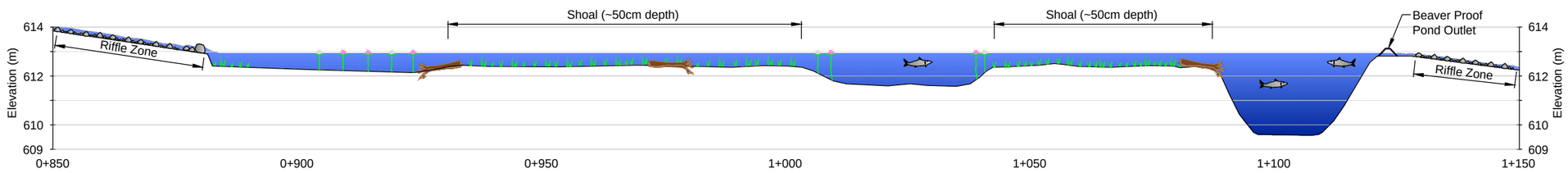
TYPICAL RUN ZONE CHANNEL SECTION

0 0.5 1 1.5 2 2.5
Scale in Metres



TYPICAL CHANNEL PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X



TYPICAL POND PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X

NO.	DESCRIPTION	CHK'D	APP'D	DATE
A	Issued for Discussion	DG	BA	8Aug12

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PROJECT

KSM Fish Habitat Compensation

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SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

CAD/GIS No: KSM-TYP-012-026

DATE: Oct. 18, 12

TITLE:

Pond and Channel Typical Plan and Sections

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- Appendix C -

Photographs



Plate 1. Aerial view of Teigen Creek and floodplain where the Project is located, on the left bank. Arrow denotes flow direction, star denotes intake location in near bedrock control.



Plate 2. Aerial view of Teigen Creek and the downstream extent floodplain where the Project is located, on the left bank. Arrow denotes flow direction, star is located near outlet location.



Plate 3. Aerial view of Teigen Creek at the outlet location, on the left bank. Arrow denotes flow direction, star denotes intake location.



Plate 4. Creek level view of Teigen Creek looking upstream at intake location.

- Appendix D -

Risk Analysis

Risk Analysis: Teigen Creek

Criteria		Proven	Inferred	TBD	Suitable for Project	Possible Consequences	Likelihood of Consequence Occuring	Mitigation	Risk to Project	Consequence/Comments
Water Supply	Surface Waters	Hydrometric monitoring ongoing since 2008 in Teigen			Yes	Intake maintenance	moderate	Design intake to limit maintenance requirements	low	Intake design will account for aggredation and degradation and may be located on bedrock.
	Ground Waters		Assessed by geomorphologist		TBD in 2013 by standpipes	Groundwater insufficient	low	Rely on surface water intake	low	Groundwater based open water is observable throughout the year.
	Total Water	Yes, from hydrometric station			Yes	Water supply difficult to maintain	low	Robust intake design and interception of surface water	low	Existing data suggests that either surface water or groundwater alone may be sufficient so the combination of the two will provide sufficient water supply.
Channel Stability	Flood Risk	Assessed by geomorphologist			Yes	Flood Damage to Project	low	Construct project to withstand a 25 yr event	low	Overall, existing flood risk to compensation area exists as assessed by geomorphologist & professional engineer can be mitigated by engineered design and will be evaluated by modelling during design phase.
	Avulsion Event	Assessed by geomorphologist			Yes	Impact Damage to Project	moderate	Layout project outside of debris torrent or terrain hazard pathway	low	Project components are downstream of hillslope and bedrock control.
Earthworks	Suitable Building Materials		Terrain mapping and ground inspections		TBD	Unsuitable materials for earthworks construction	low	Find local borrow source or engineered alternative	low	Proximity to earthworks improves feasibility of endhaul and borrow operations.
	Excavation Volumes		LiDAR based terrain model		TBD	Excess spoil generated	low	Endhaul excess materials and store at a safe area	low	Depth to groundwater level will determine the final elevation of channels and ponds.
Project Layout	Location and Gradient	Yes, by LiDAR and Survey data			Yes	Habitat requirements necessitate a realignment to improve gradient	low	Realignment of channels & ponds to improve habitat suitability.	low	Current layouts are based on LiDAR data and some local total station surveys.
	Intake Structures	Stable location associated with proposed bridge			Yes	Detailed analysis finds that intake location is not suitable	low	Find a suitable intake location. Rely on groundwater	low	If surface water intake not possible, then will need to rely on groundwater as primary water source for compensation area and size ponds and channels accordingly.
	Outlets/Fish Access	Yes, multiple options exist			Yes	Access is effected	moderate	Provide adequate protection at outlet area to maintain access. Provide secondary access where possible.	low	Evaluate secondary fish access points.
	Embankments	Embankments & protection dyke will be provided for construction access and flood protection needs	Assessed by professional engineer		Yes	Embankment failure	low	Conduct flood and scour analyses and size embankments accordingly	low	Materials observed during field visits and by hand-dug test pits ~1 m indicate suitable materials exist for embankment construction.

Notes:
***Proven** - Detailed data has been collected that can quantify or otherwise confirm the resource.*
***Inferred** - No extensive data set exists to prove the resource but ground investigations, review of other related data, and professional judgement have been used to infer the resource.*
***TBD** - Not enough information exists to make a determination at this point.*
***Sufficient for Project** - The proven or inferred resource will be sufficient for the design of the project or does not pose a threat to the design (e.g. no threat from flood would be a "Yes" in sufficient for project column).*
***Possible Consequences** - What are the consequences associated with a resource being insufficient (e.g. not enough surface water - consequence reliance on groundwater).*
***Likelihood** - What is the likelihood of occurrence associated with the possible issue/deficiency with the resource based on the information available.*
***Mitigation** - Method of mitigating risk (e.g. flood risk - build larger dyke).*
***Risk to Project** - Given the consequence and the likelihood, what is the risk to the project (e.g. high consequence * low likelihood = moderate risk).*

Risk Analysis: Teigen Creek

Criteria		Proven	Inferred	TBD	Suitable for Project	Possible Consequences	Likelihood of Consequence Occuring	Mitigation	Risk to Project	Consequence/Comments
Maintenance	Beaver	Beaver already present in existing ponds			Yes	Beaver activities affect pond function	moderate	Active wildlife management will be required	low	Management strategies will be developed in conjunction with a wildlife biologist.
	Sediment		low		Yes	Sediment is deposited in ponds	moderate	Maintenance required to remove sediment and maintain pond depths	low	Intake structures will be designed and located to exclude sediment. Reliance on groundwater will minimize sedimentation.
	Repair		low		Yes	Damage to pond, channel or embankment structures	moderate	Maintenance required to repair damage to system	low	System components will be designed to withstand a 25 yr event.

Notes:
***Proven** - Detailed data has been collected that can quantify or otherwise confirm the resource.*
***Inferred** - No extensive data set exists to prove the resource but ground investigations, review of other related data, and professional judgement have been used to infer the resource.*
***TBD** - Not enough information exists to make a determination at this point.*
***Sufficient for Project** - The proven or inferred resource will be sufficient for the design of the project or does not pose a threat to the design (e.g. no threat from flood would be a "Yes" in sufficient for project column).*
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***Mitigation** - Method of mitigating risk (e.g. flood risk - build larger dyke).*
***Risk to Project** - Given the consequence and the likelihood, what is the risk to the project (e.g. high consequence * low likelihood = moderate risk).*

Appendix 6.3-3

Technically Feasible Design Memo – Glacier Creek Site 1 (HADD)

Rescan™
Engineers and Scientists

Draft Memorandum

DATE: December 2012 Refer to File No.: B.1_Glacier Creek Report.docx

SUBJECT: Glacier Creek: Feasibility Assessment of the Proposed Fish Habitat Compensation Area

1. Introduction

This report provides the results from the feasibility assessment for the proposed Fish Habitat Compensation Area within the lower Glacier Creek Watershed. The work has been focussed on the engineering planning and development of a new off-channel habitat system that is proposed east of Glacier Creek.

The proposed Glacier Creek Fish Habitat Compensation Area (the Project) is located approximately 20 km south of Bell 2 Lodge along BC Highway 37. Glacier Creek flows southwest under the highway through a large diameter (5,000 mm) culvert and flows into the Bell Irving River. The proposed Project is located on provincial Crown Land.

This report includes a description of the methodologies that were used in the feasibility assessment work. A results and observations section follows that describes the findings from the investigative work as well as identified risks to the development of the Project. Based on the completed technical feasibility assessment, conclusions and recommendations are provided for the development of the Project.

All figures and drawings are provided in appendices of this report.

2. Methodology

Field investigations were conducted during field trips in 2011 and 2012. Extensive ground and helicopter-based aerial observations were conducted during all field visits. The work in 2011 focused on site assessments for locating potential off-channel sites, as well as obtaining local topographic survey-based information at key locations along the route. Additional investigations in 2011 and 2012 focussed on developing an understanding of the hydrologic characteristics of the drainage basin, the geomorphology of Glacier Creek, subsurface materials, groundwater within the Project area and the physical layout with respect to the existing ground surface.

A range of survey techniques were employed to collect local topographic data at locations across the proposed habitat compensation area. Differential GPS (DGPS) equipment was used to collect mapping grade topographic data and to collect feature data at specific locations such as existing topographic features or proposed intake locations. Compass and chain surveys were also used to collect additional topographic data across noted terrain features and to further refine the DGPS data where necessary. Total Station survey was completed at potential intake locations as well as around the Highway 37 right-of-way (ROW).

Light Detection and Ranging (LiDAR) data was obtained for the Project area. The LiDAR data was utilized to develop a digital terrain model (DTM) for the area. The model also provided the basis for the engineering layout and development of the channel and pond system.

In 2011 and 2012, geomorphological assessments of the Project Area were carried out by completing a series of site investigations of local geologic terrain and channel conditions. This process also included an examination of historic aerial photographs and satellite imagery for Glacier Creek.

A hydrometric station (GLC-H1) was installed in May 2012 approximately 20 m upstream of the culvert. Flow discharge measurements and hydrometric levelling surveys at the station have been completed monthly in accordance with the *Manual of Hydrometric Standards in British Columbia* (RISC 2009).

In September of 2012 twelve test pits were excavated along the proposed alignment with standpipes installed in seven of the pits for ongoing groundwater monitoring. At each pit, soil and subsurface materials at depth were recorded, with representative samples obtained for laboratory testing. Pressure transducers were installed in 2 of the 4 standpipes in order to continuously record local groundwater levels throughout the year. Standpipes were developed using Waterra tubing and water quality samples were collected. Water levels were measured using a water level meter and pressure transducers were installed in 2 of the standpipe to collect continuous water level data.

3. Results and Observations

The results of the field investigations, office-based data review, and feasibility assessment are provided below. These results were used to develop the proposed systems presented as preliminary designs (see Appendix B).

3.1 Basin Description

Glacier Creek is positioned along the Skeena Mountain Range that forms the eastern divide of the Bell-Irving Watershed. The drainage basin is orientated in southwest direction and features a confined and steep area, 25% of the basin is glaciated. The difference in elevation from the basin's height-of-land to its drainage outlet (at approximately 478 m asl) along the Bell Irving River is 1,200 m.

Glacier Creek has a drainage area of 16.6 km^2, with an overall channel length of approximately 7,000 m from the base of the glacier (Figures 1 and 2). The lower 1,500 m of Glacier Creek, the focus of the investigation, is associated with a relatively large alluvial fan complex that extends to the Bell-Irving River. The fan is confined by the adjacent hillslopes along the river valley. In places, Glacier Creek has downcut through portions of the alluvial fan deposit. This has exposed glaciofluvial sediments along the stream banks.

The proposed Project area features a mixed forest that extends across glaciofluvial terraces and slope breaks. These remnant features extend back from the present day channel and out towards the contact with the adjacent valley hillslopes. The soils are well drained and coarse-grained with high percentages of sub-rounded cobbles and boulders (Appendix C, Plate 4).

Recently completed site excavations along the proposed Project alignment indicate that subsurface materials at depths up to 5 m below ground surface consist of a mixture of glaciofluvial and alluvial sediments. Across the alluvial fan, coarse sands and gravels with cobble to boulder size clasts are present and are normally consolidated and well drained. Between Highway 37 and the Bell-Irving River, the alluvial sediments are underlain by glacial till. The till formed an impermeable layer that allowed a build-up of groundwater to occur along the lower slopes.

3.2 Channel Geomorphology

Glacier Creek is characterized as a moderate-to-steep gravel bed stream, and has an average slope of 3%. The channel varies between step-pool and cascade morphologies. Steps are more frequently

associated with large woody debris (LWD) as opposed to large cobbles or boulders. The channel substrate varies from coarse sands and gravels to cobble and boulder size clasts.

Lower Glacier Creek emerges from a bedrock canyon into a narrow mountainous valley that expands from less than 10 m (upstream of the alluvial fan) to over 500 m wide with distance downstream. Channel pattern varies from relatively short straight reaches, where lateral movement is restricted by valley walls or the channel has incised into sediment wedges, to quasi braided reaches, where in-channel sedimentation and LWD cause the channel to wander over the active channel margins. Average bankfull width is approximately 9 m, but can range from 6 m to 25 m.

Glacier Creek has a high sediment supply. At the apex of the fan, where the channel emerges from the bedrock canyon, channel elevation can vary by as much as 6 m related to in-channel depositional features. Sediment transport processes are bedload driven, with in-channel depositional features such as lateral and point gravel bar deposits along channel perimeters and bends. In addition, a prominent and repeating depositional feature along Glacier Creek is the presence of relatively large mid-channel accumulations of coarse grained sediments intermixed with large woody debris. These features form obstructions that lead to instabilities associated with excessive sediment accumulations, extended stream bends, channel shifting and breaching in places, as well as the presence of intensive bank erosion in places.

3.3 Hydrology

Surface water flows of Glacier Creek are generated from hillslope-related runoff from precipitation events, as well as snow and glacier melt waters. The surface water hydrology of Glacier Creek was estimated from the hydrometric monitoring network that has been established within the KSM Project area. Based on drainage area, a synthetic daily discharge hydrograph was constructed for flow characterization.

For Glacier Creek, the estimated annual hydrograph is characterized by spring meltwater flows that begin in mid-April. Freshet-induced peak flows occur towards the end of May. Surface water flows decline throughout the summer months as contributions from snowpack and hillslope-related runoff decrease. During the fall period, the annual hydrograph features peak discharge events that occur in response to intense rainfall-runoff events. Winter low flow conditions tend to develop by mid-November and continue until spring freshet (Figure 4).

The mean annual discharge (MAD) for Glacier Creek was estimated from the synthetic discharge hydrograph based on regional data. From this the range in MAD was estimated to vary from 0.75 m^3/s to 1.1 m^3/s between dry and wet hydrologic years (Figure 4).

Given a potential withdrawal rate of 10% of daily discharge, there would be insufficient flow during low flow seasons to support a habitat compensation project on surface water alone. Surface water can be used to augment groundwater supply during the open water season. Habitat areas in ponds and channels will be scaled such that no greater than 10% MAD would be diverted to support them. To improve future MAD estimates, a hydrometric monitoring station was installed May of 2012 along lower Glacier Creek.

3.4 Engineering Planning

The preliminary planning and design of the Project consists of a series of 4 ponds and interconnecting channel providing 20,580 m^2 of wetted area, fed primarily by groundwater. The Project is to be located east of Glacier Creek and will follow existing depressions and abandoned channels that are present along the lower extent of the alluvial fan. The 4 ponds connected by 5 channel sections will be positioned downslope of the highway and will be extended east and parallel to the Bell-Irving River. The drainage outlet for the system will be connected to an existing unnamed tributary that flows into the Bell-Irving River, just south of Glacier Creek. The outlet will serve as an access point for fish to

access the Project (Appendix B, Drawing KSM-GC-012-001). An additional access point may be constructed immediately downstream of the Highway 37 culvert for Glacier Creek. This access may be used as a surface water intake from the downstream end of the Glacier Creek culvert if necessary.

The ponds and channels in the preliminary design drawings represent generic shapes that will be further developed during the detailed design phase. During the detailed design phase additional complexity and specific habitat features will be prescribed such as spacing of riffle-pool morphology, LWD placement frequency and orientation, shoals-islands-deepwater complexing in ponds, and riparian prescriptions including low-bank wetland vegetation (Appendix B, Drawing KSM-TYP-012-026).

The following is a summary of the results from the completed engineering planning and assessment work that were used in the preliminary design phase:

- The design of the Project is based on the concept that open channels and ponds will be excavated to depths below the existing ground surface to intercept subsurface groundwater flows and seasonal surface water runoff from the adjacent ground surface.
- The channel patterns and the configuration of the ponds were based on the existing ground contours and were designed to integrate the ponds into the surrounding landscape to minimize earthworks volumes.
- The trapezoidal shape and size of the open channels will be sized to convey surface and groundwater that will be intercepted by the channel sections. The channel base width is 2 m with 2H:1V sideslopes excavated to depths up to 2.5 m.
- An average design flow of 0.1 m^3/s was used for planning purposes with the minimum water depth along the channel sections to be 0.3 m. This will result in an average stream velocity of 0.12 m/s^2.
- Average depth below ground surface to the groundwater table as encountered during test pitting was approximately 2.5 m. Excavation depths could be on average 2 m below the water table;
- The design criterion for the depth of the ponds was determined by the need for ice-free overwintering habitat. The maximum winter ice thickness as determined by winter ice core sampling in lakes in the area was 1.0 m. 50% of the area of each pond will be >2 m deep as measured from the outlet channel invert.
- Deeper water sections 3 to 4 m deep will be present within each pond. The depths of these sections will be determined, in part, by the minimum elevation of the local water table at each location.
- An access road and protection dyke will be constructed along the western extent of the Project. This embankment structure will be sized to withstand a 25 year flood event and will provide access during the construction of the Project. The structure will be constructed from materials excavated during the construction of the ponds and channels.

3.5 Risk Assessment

As part of the feasibility assessment for the proposed Project, a risk assessment was undertaken to identify information gaps and to quantify potential risk. The assessment was based on the available information and included an assessment of the water supply potential, channel stability, earthworks, layout of the proposed system, and related maintenance requirements.

During the risk assessment all available information was reviewed, significant information gaps were identified, and hazards associated with known information or with gaps were reviewed. Possible consequences associated with the information or information gaps were then identified and a risk

rating relative to the feasibility of the project was assigned. Finally, possible mitigation for associated risks then identified.

The risk assessment results can be found in Appendix D. The following is a summary of the risk assessment:

3.5.1 Water Supply

- Hydrometric data indicates that winter flows in Glacier Creek are not sufficient to support flow in the Project through the winter. A surface water intake may be used to augment groundwater.
- Standpipes have been installed to monitor groundwater elevation. Based on the groundwater levels encountered at the time of installation sufficient groundwater is present to support year round flow in the proposed system.
- Length and depth of groundwater collection channel to be determined to provide flow rates for channel design.

3.5.2 Channel Stability

- Flood risk along lower Glacier Creek will have a minimal effect on the Project water supply is groundwater based (i.e. no intake structure is required).
- Flood risk related to the Bell-Irving River is low. The lower portion of the Project is located on a bench that has not been part of the active floodplain for greater than 50 years, based on the age of the current stand of trees.
- The access road/protection dyke will be sized to protect the Project from a 25 year event.

3.5.3 Earthworks Construction

- There is an abundance of well-graded coarse-grained materials which appear to be suitable for construction materials.
- There is a limited supply of fine-grained materials however given the intention to construct a groundwater based system, there is expected to be little need for the construction of impermeable layers.

3.5.4 Drainage System Layout

- Layout of the Project allows for the hydraulic gradient to drive the system.
- Channel sections were maintained within 1 to 3 % gradients to provide suitable habitat for target species.
- Ponds were laid out along contours and within other landscape features to minimize earthworks.
- Large pond areas may exfiltrate along margins. Fine grained materials may be required for larger ponds.

3.5.5 Maintenance Requirements

- No beavers are currently present in the area. However, beaver activities will be managed to limit impact to the functioning of the Project.
- Periodic maintenance will be required to remove accumulated sediment and to conduct minor repairs, however, the reliance on groundwater should significantly reduce both sediment movement into the system and impacts to the ponds or channels that require maintenance.

4. Conclusions and Recommendations

The results from the feasibility assessment for the proposed Fish Habitat Compensation Area along Glacier Creek have been described. Site investigation and engineering planning has been completed to confirm that the development of the Project is technically feasible at the proposed location. The low gradient terrain indicates that conventional excavation and construction techniques for the channels and ponds will be appropriate across the lower alluvial fan.

The presence of groundwater along the proposed alignment indicates a high potential for groundwater to be the primary water supply source for the compensation network. The layout of the compensation area will take advantage of the gently sloping terrain and groundwater resources found on the lower fan at the confluence of Glacier Creek and Bell-Irving River.

The designs presented in Appendix B show potential habitat area that is feasible to construct. The actual areas that will be constructed will be less than these potential areas and will be determined based on the habitat area required for sufficient compensation. The larger potential number is presented as optional area available as a risk mitigation measure.

The Project was chosen based on many biological and geophysical criteria. However, operationally, the proximity to existing or planned road infrastructure and the area available in the Glacier watershed made this site suitable. The proximity to Highway 37 provides a greater level of certainty with regards to the stability of the local area relative to channel activity found in Glacier Creek. As well, the highway provides excellent access for construction, monitoring and maintenance. Preference was given to building fewer larger projects as opposed to many small projects in order to more efficiently use resources and to focus maintenance activities.

Wetland habitat compensation is an additional component of the larger KSM habitat compensation program. Wetland habitat will be developed within the Project and wetland scientists have participated in the design of the Project to ensure both habitat types are included in the design. The combination of both fish and wetland habitat development is a natural corollary and will ensure an inclusive ecosystem approach to the development of the Project. The typical pond detail in Appendix B shows some examples of ecosystem complexing that will be implemented.

The Projects represent relatively large-scale construction activities and may require multiple years to make fully operational. As such, a staged approach to the construction of these Projects is recommended. This approach would allow for seasonal settling and stabilization, integration of regulator and stakeholder participation, design changes as required by site conditions, and sufficient flexibility to incorporate the Projects into the surrounding landscape while minimizing impacts to the existing ecosystems.

The following are recommendations for consideration in the future development of the Project:

1. The established surface water and groundwater monitoring programs should be continued so that the water sources are properly characterized for use in detailed design.
2. Detailed engineering surveys should be completed along the proposed alignment.
3. Based on the completed topographic surveys, detailed design work is required to determine the final configuration of the channels, ponds, and road access/protection dyke.
4. Hydraulic modeling analyses should be completed to assess the functioning of the systems and the effect of habitat complexing on flow velocity distributions and water quality conditions

across representative channel sections and ponds. In addition, detailed hydraulic scour analyses and channel bank protection requirements are required.

5. A flood frequency and hazard analysis should be completed to determine the design flood levels across the alluvial fan, and where additional embankment protection should be provided across the compensation area.
6. The construction-related earthwork volumes will need to be determined in conjunction with related cost estimate for constructing the Project.
7. A Construction Management Plan should be completed that will include road access details, the location of soil and spoil stockpile areas, as well as an Environmental Management Plan for the Project.
8. Development of a rehabilitation plan to re-establish vegetated ecosystems within the Project footprint should be developed.

- Appendix A -

Figures

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PROJECT # 868-020-04-02 GIS No. KSM-10-169c November 7, 2012

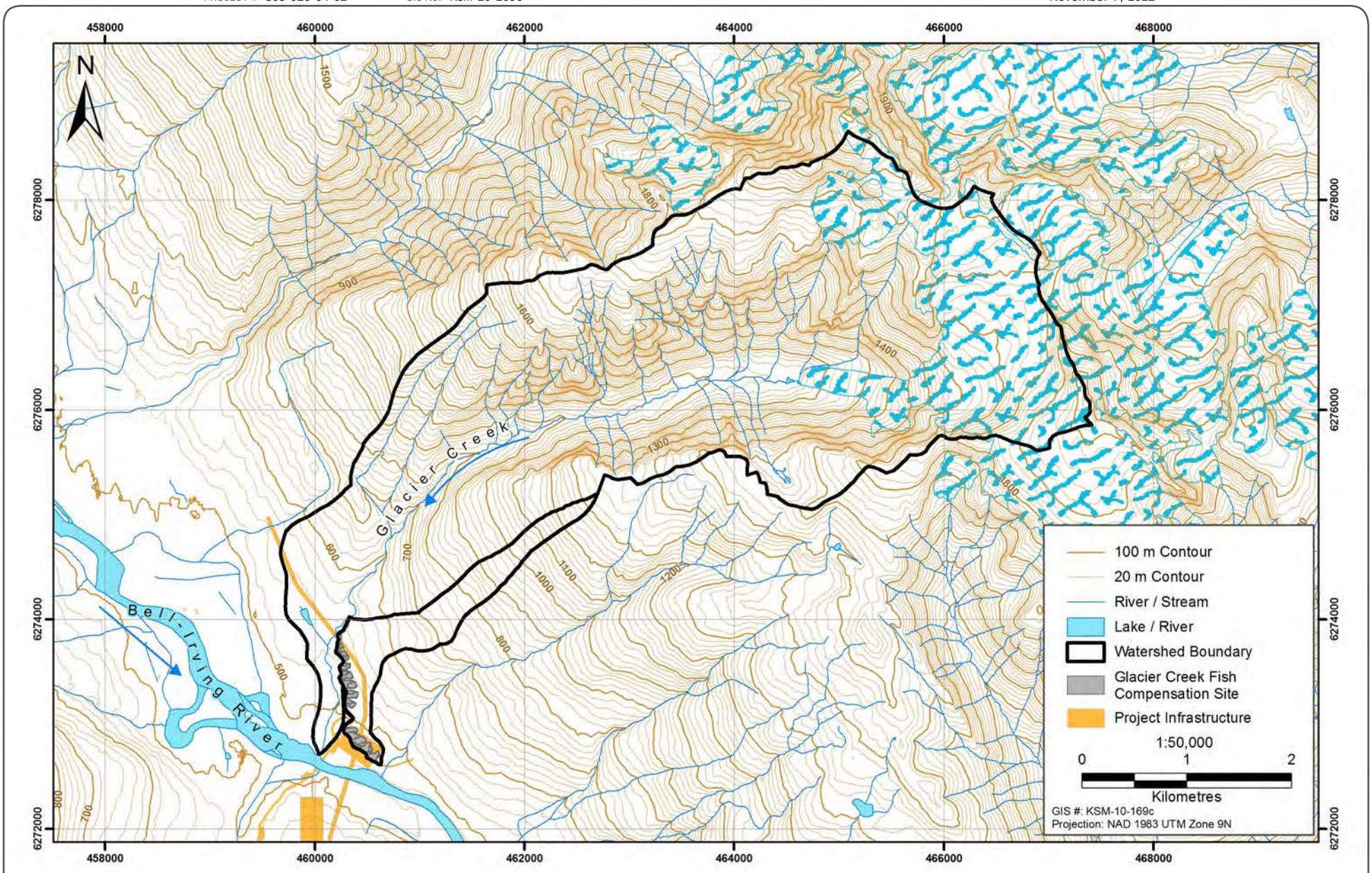


Figure 1

SEABRIDGE GOLD
KSM PROJECT

Drainage Area for Glacier Creek Watershed

Rescan
Engineers & Scientists

Figure 1

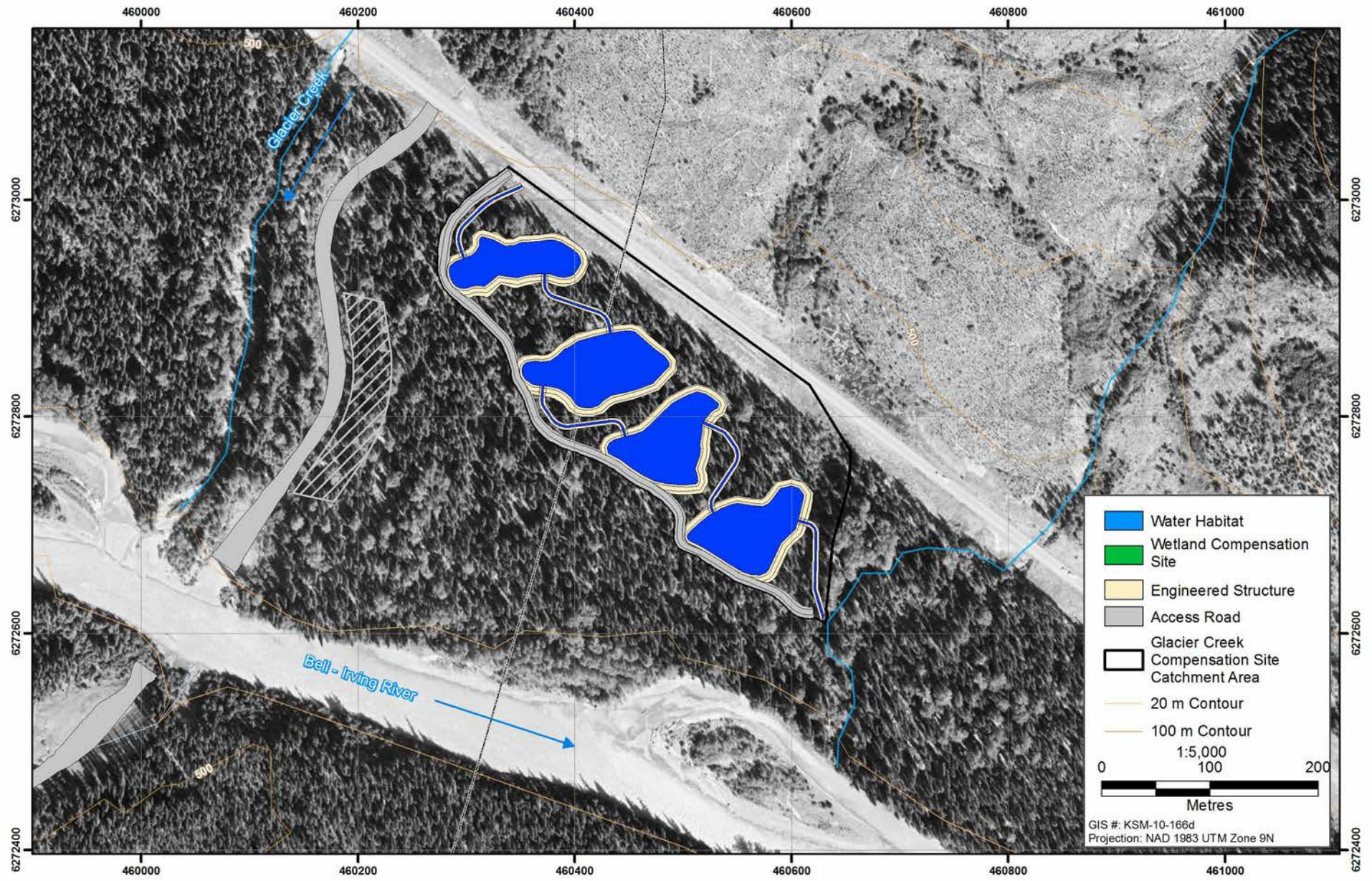


Figure 2

SEABRIDGE GOLD
KSM PROJECT

Drainage Area for the Proposed Glacier Creek Fish Habitat Compensation Area

Figure 2

Rescan
Engineers & Scientists



Figure 3

Glacier Creek Fish Habitat Compensation Area Overview

SEABRIDGE GOLD
KSM PROJECT

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Engineers & Scientists

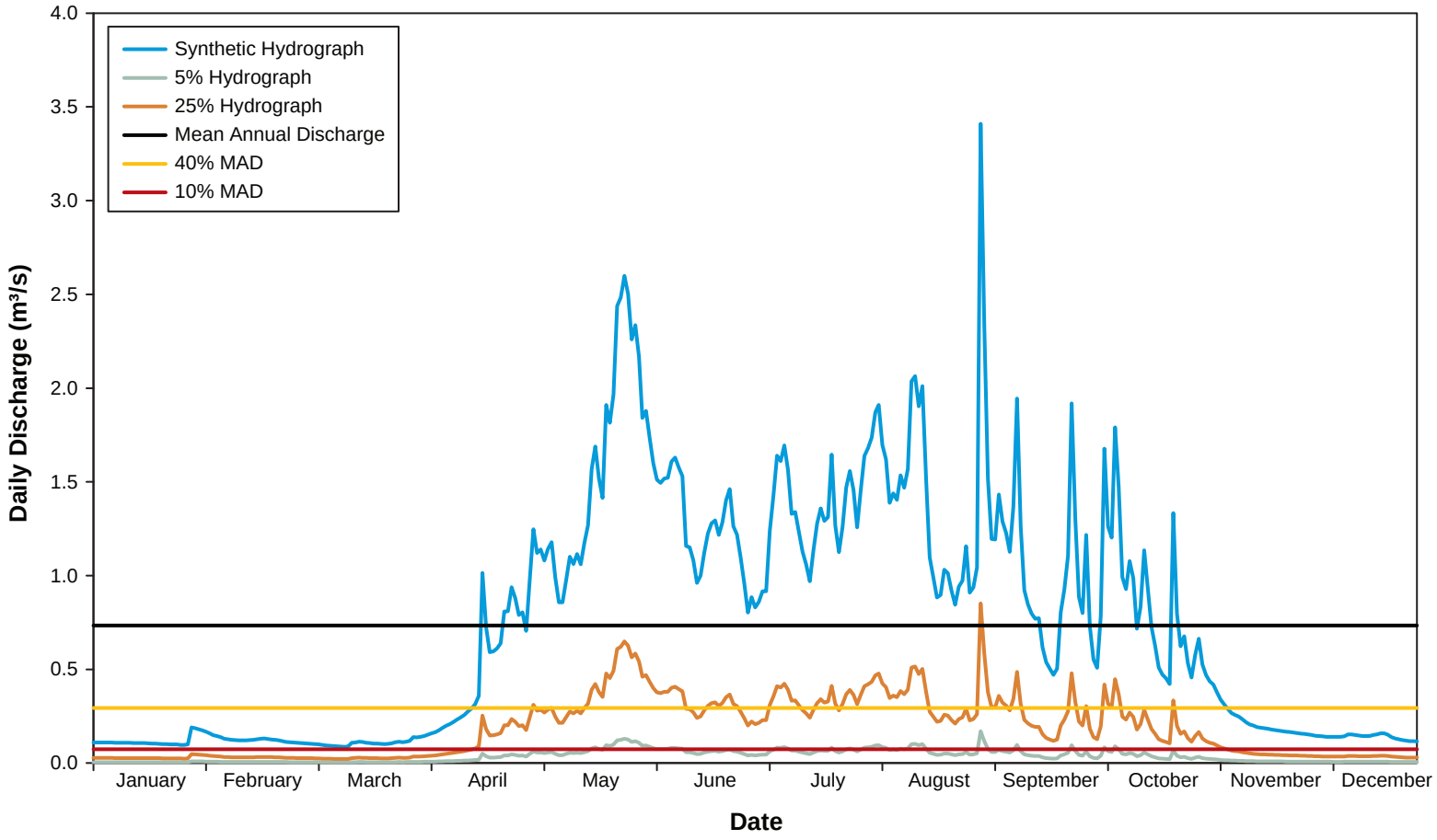


Figure 4

SEABRIDGE GOLD
KSM PROJECT

Annual Synthetic Hydrograph
Glacier Creek, Regional Analysis

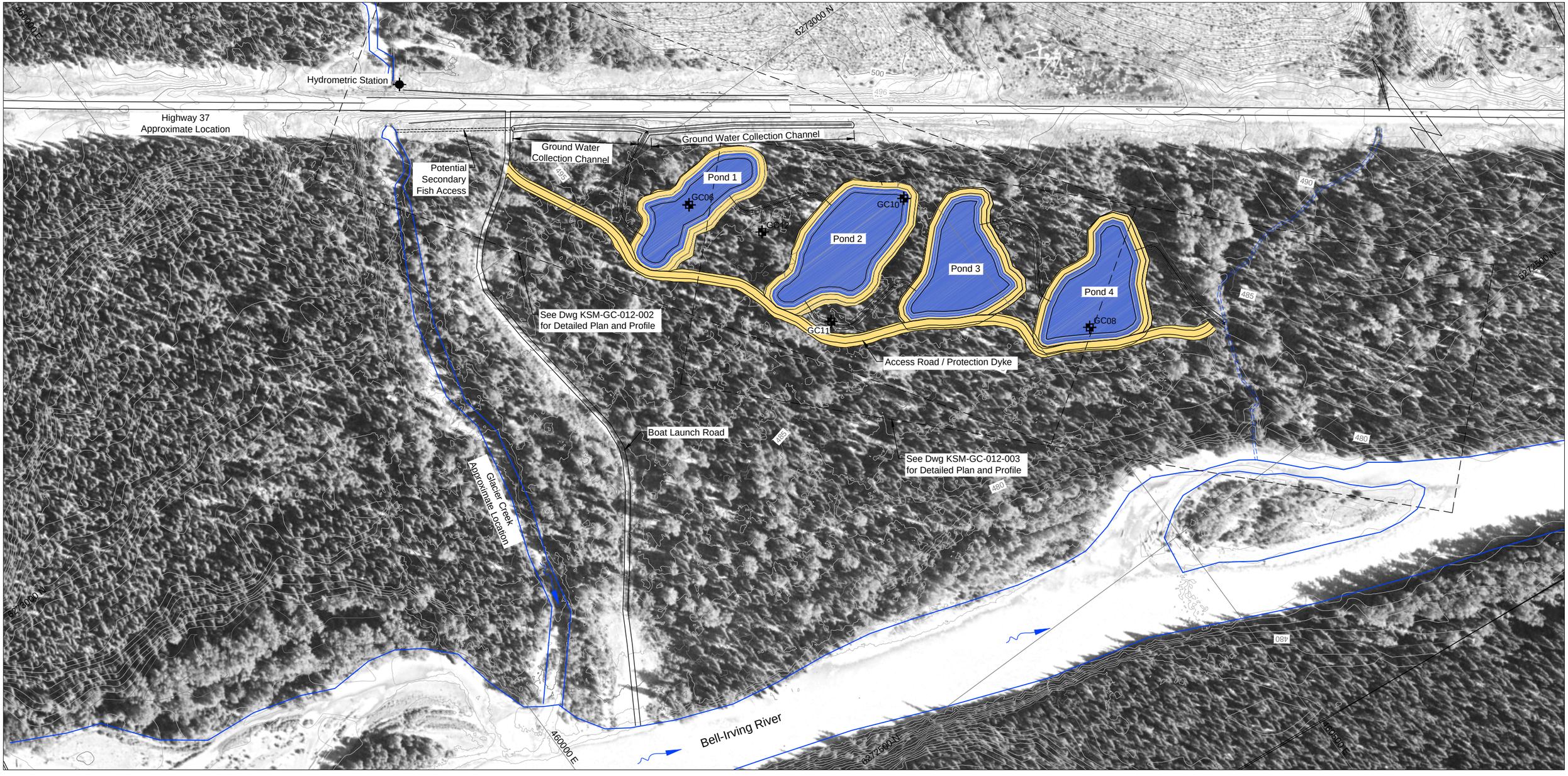
Figure 4

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Engineers & Scientists

- Appendix B -

Drawings

DRAFT



LEGEND

- Stand Pipe Locations

0 20 40 60 80 100
Scale in Metres

DRAFT

NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

REVISIONS

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SEABRIDGE GOLD

Professional Engineers Stamp

PROJECT
KSM Fish Habitat Compensation Project

This drawing is for planning purposes only. Not responsible for any design and construction completed by others

SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

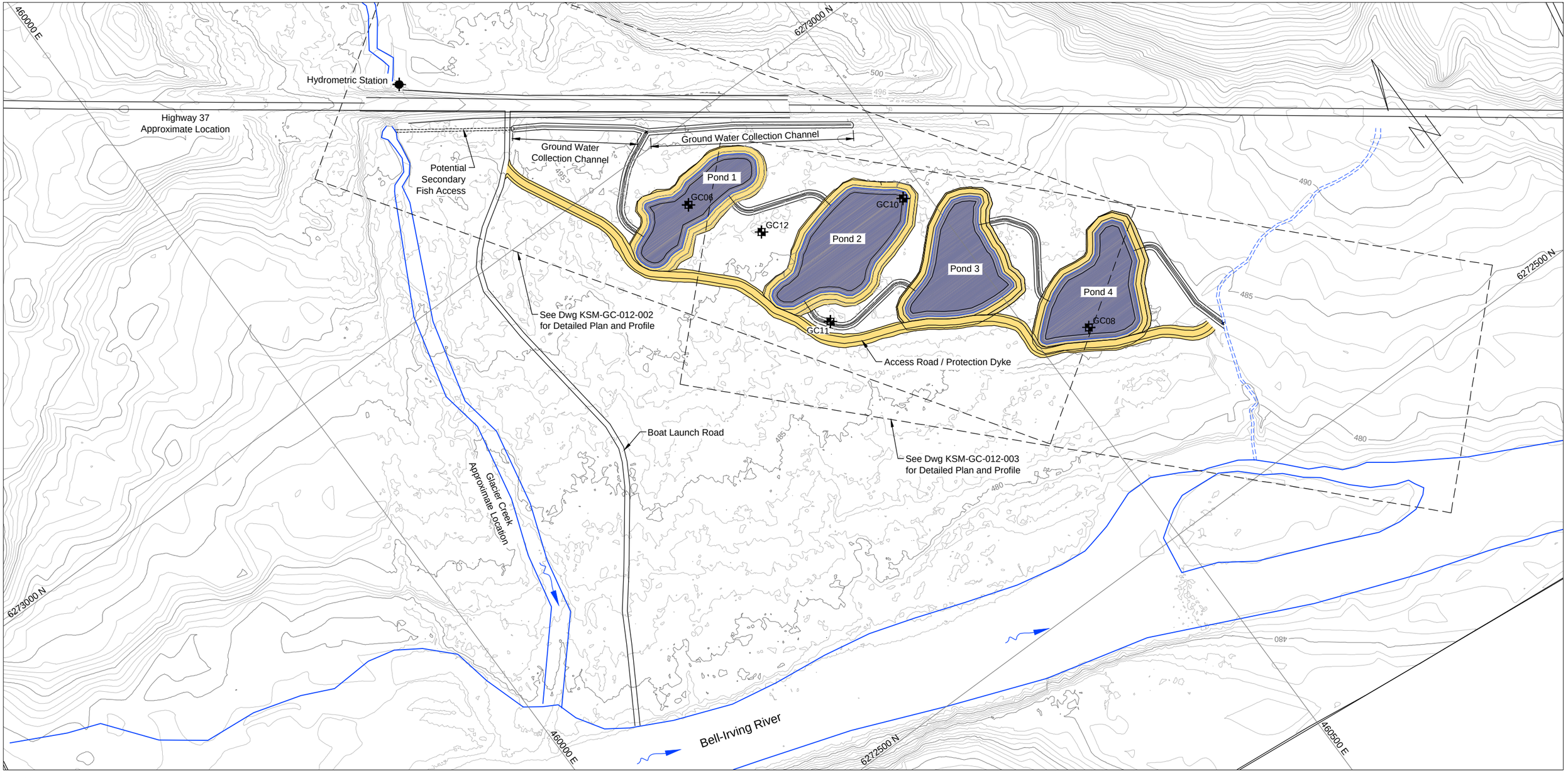
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DATE: Oct. 18, 2012

TITLE:
Glacier Creek Overview

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DRAFT



LEGEND

- Stand Pipe Locations

0 20 40 60 80 100
Scale in Metres

DRAFT

NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

REVISIONS

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PROJECT
KSM Fish Habitat Compensation Project

This drawing is for planning purposes only. Not responsible for any design and construction completed by others

SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

CAD/GIS No: KSM-GC-012-001

DATE: Oct. 18, 2012

TITLE: Glacier Creek Overview

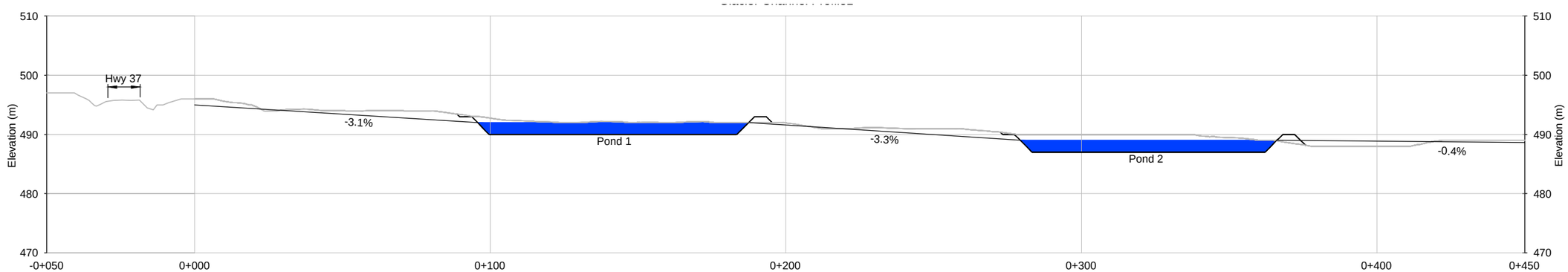
C:\02_Rescan\KSM\Glacier 1_RevB.dwg

DRAFT



LEGEND

- Stand Pipe Locations



0 10 20 30 40 50
Horizontal Scale in Metres
Vertical Exaggeration 2X

DRAFT

NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

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PROJECT
KSM Fish Habitat Compensation Project

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SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

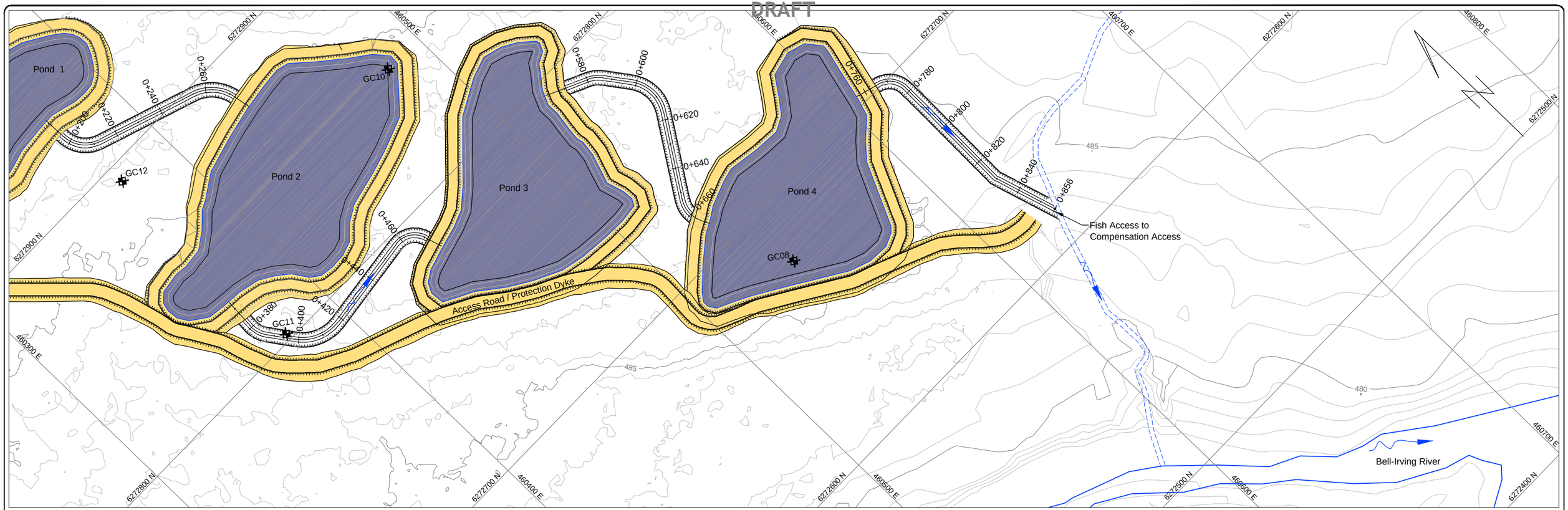
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DATE: Oct. 18, 2012

TITLE:
Glacier Creek Plan and Profile
Station 0+000 to 0+450

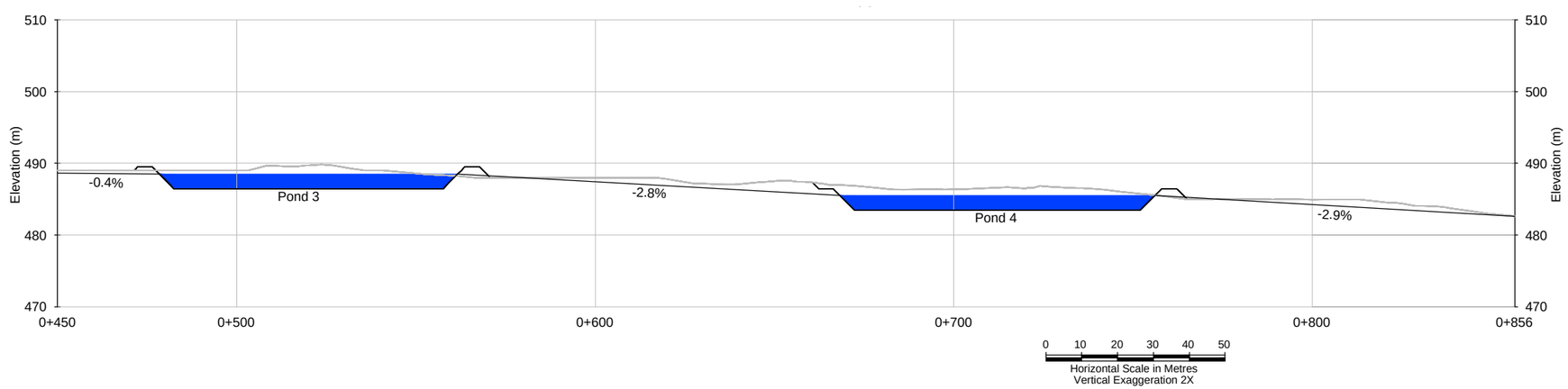
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DRAFT



LEGEND

- Stand Pipe Locations



DRAFT

NO.	DESCRIPTION	CHK'D	APP'D	DATE
B	Issued for Review	DG	BA	28Sep12
A	Issued for Discussion	DG	BA	10Aug12

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KSM Fish Habitat Compensation Project

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SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

CAD/GIS No: KSM-GC-012-003

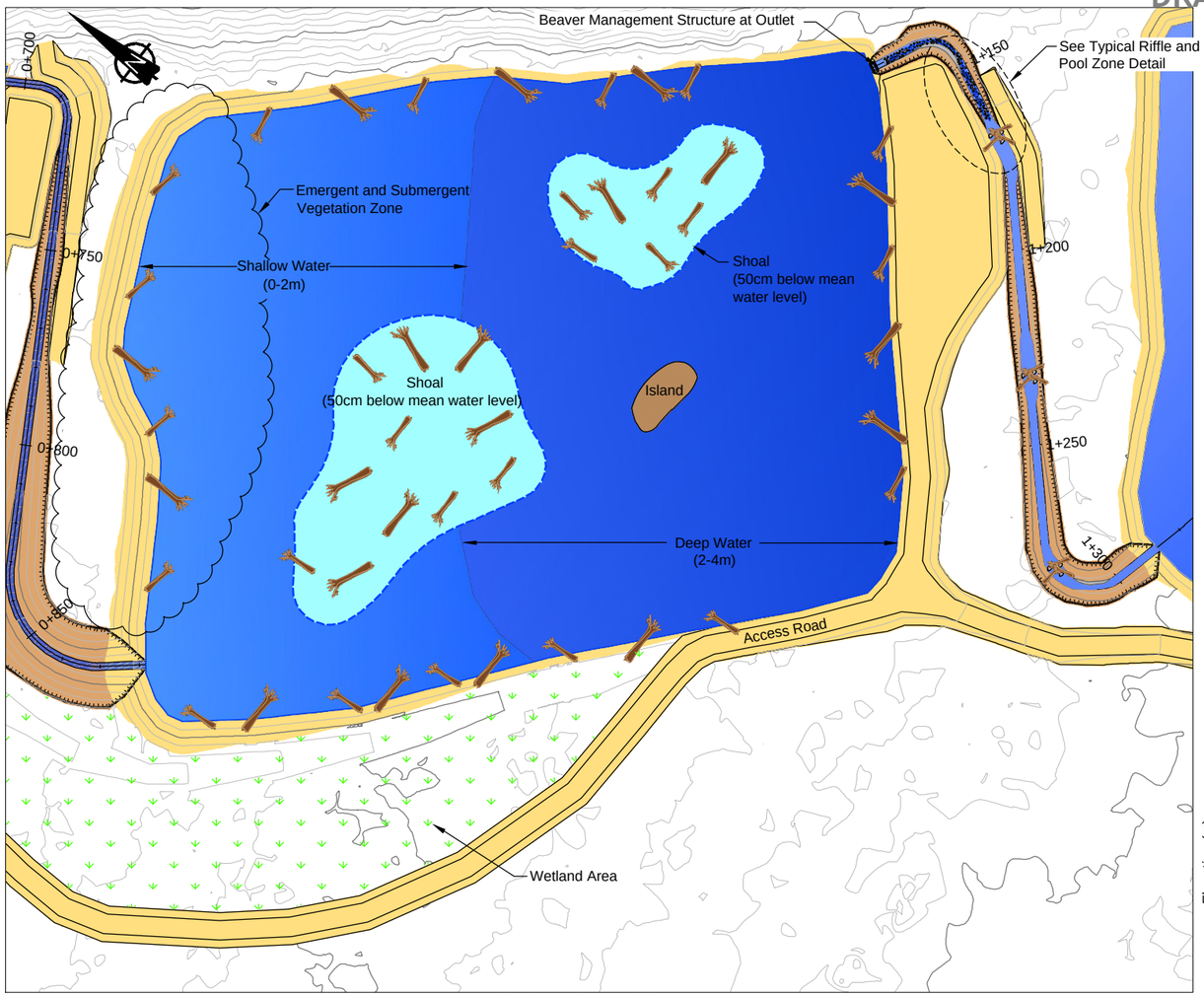
DATE: Oct. 18, 2012

TITLE:

Glacier Creek Plan and Profile Station 0+450 to 0+856

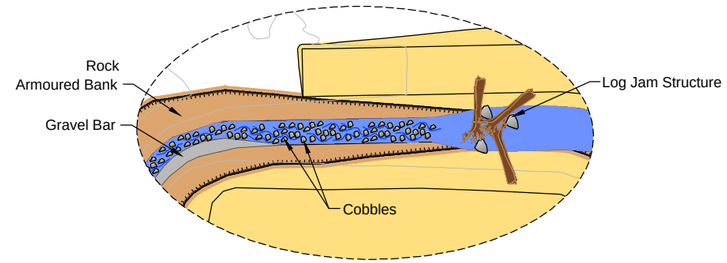
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DRAFT



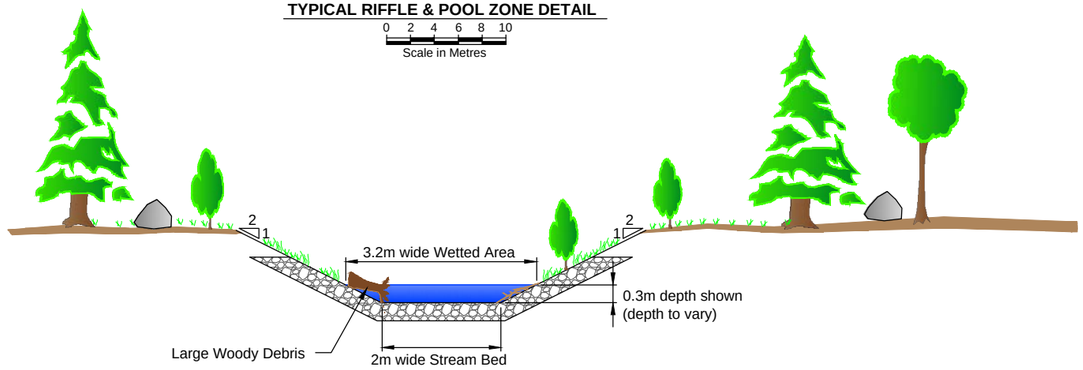
TYPICAL POND LAYOUT

0 5 10 15 20 25
Scale in Metres



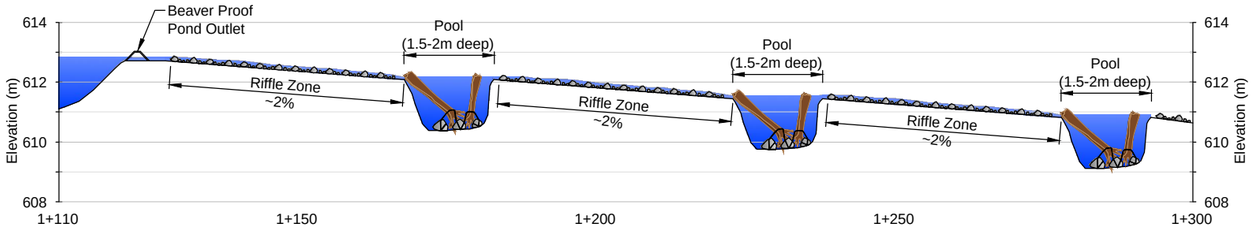
TYPICAL RIFFLE & POOL ZONE DETAIL

0 2 4 6 8 10
Scale in Metres



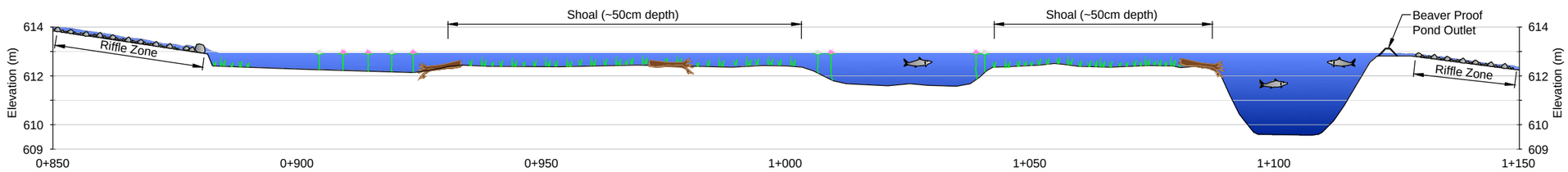
TYPICAL RUN ZONE CHANNEL SECTION

0 0.5 1 1.5 2 2.5
Scale in Metres



TYPICAL CHANNEL PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X



TYPICAL POND PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 5X

NO.	DESCRIPTION	CHK'D	APP'D	DATE
A	Issued for Discussion	DG	BA	8Aug12

REVISIONS

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SEABRIDGE GOLD

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PROJECT

KSM Fish Habitat Compensation

This drawing is for planning purposes only. Not responsible for any design and construction completed by others

SCALE: as shown

RESCAN JOB NO.: 0868-020-04-01

CAD/GIS No: KSM-TYP-012-026

DATE: Oct. 18, 12

TITLE:

Pond and Channel Typical Plan and Sections

C:\02_Rescan\KSM\Treaty_Typicals_RevA.dwg

- Appendix C -

Photographs



Plate 1. High angle photograph looking north towards the Bell-Irving River/Glacier Creek confluence and the Project Area.



Plate 2. Downstream outlet of the Glacier Creek 5,000 mm culvert and outlet pool.



Plate 3. Aerial view of the Project Area and outlet location.



Plate 4. Example of materials found in test pitting at Glacier Creek.



Plate 5. Installing standpipe in test pit at Glacier Creek.



Plate 6. Preparing standpipe for installation. Filter sock placed over the screened interval.



Plate 7. Backfilling during standpipe installation.



Plate 8. Well Development, water level measurement and water sampling following standpipe installation.



Plate 9. Reseeding after completion of test pit.

- Appendix D -

Risk Analysis