APPENDIX H

Fish Passage Assessment

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APPENDIX H
FISH PASSAGE ASSESSMENT

1.0 FISH USE

Streams and rivers within the study area dry up or freeze solid during winter, hence fish must overwinter in lakes, or possibly large pools within large rivers, where they exist. Based on literature and fisheries data collected at the Project site, North/South Consultants Inc. (NSC) note that juvenile and young-of-year char move upstream into the smaller tributaries to access rearing and foraging habitat in spring. Spring movements typically begin as streams begin to flow and water temperatures reach approximately 5-7°C. Typically, the number of Arctic Char moving upstream will increase until water temperatures reach about 15°C. Although the general pattern is upstream movement during spring, juveniles may also return to lakes, likely in response to changes in flow or reductions in water temperature. Juvenile Arctic Char are thought to move into these tributaries for early access to warmer water and foraging habitat and to avoid predators. Figure H.1 presents daily catch rates for Arctic char captured in hoop nets set in Sheardown Lake Tributary 1 in the spring of 2008 (NSC, pers. comm.). Two hoop nets were set near the mouth of the stream with the objective of evaluating the timing of fish movements and stream utilization. One faced upstream (US Catch) and one downstream (DS Catch) to look at the direction of fish movements.

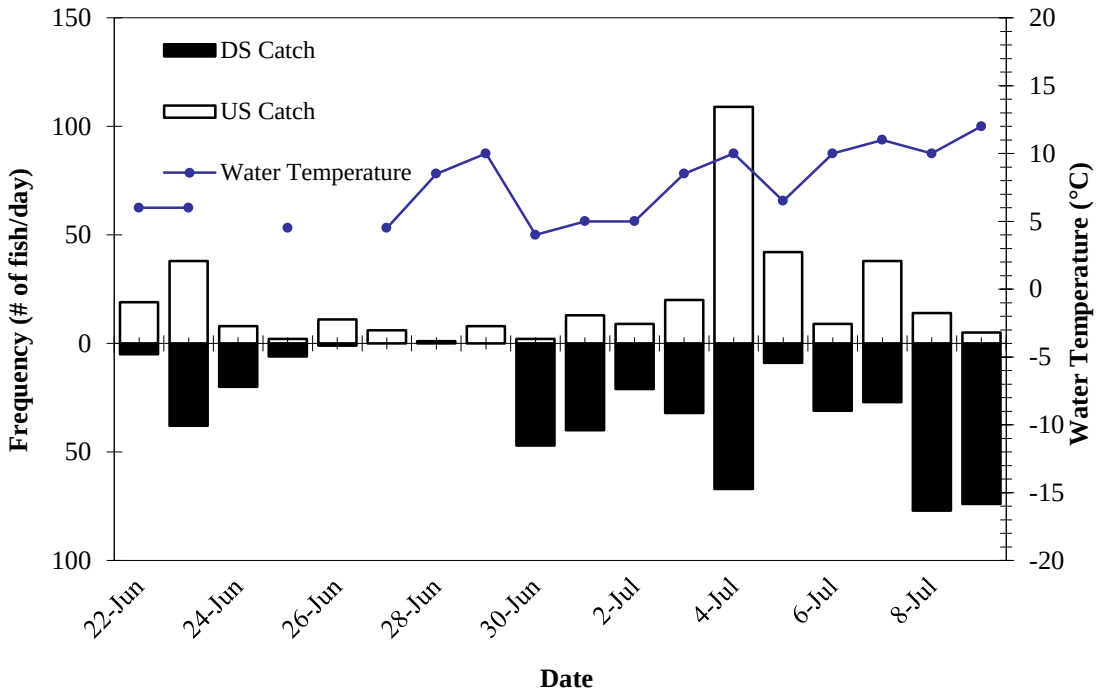

Figure H.1 Hoop Net Catch Rates of Arctic Char, Sheardown Lake Tributary 1, Spring 2008

During fall, juvenile Arctic Char typically initiate return movements to overwintering habitat as water temperature decreases to about 7°C. Peak fall movements occur as temperatures in tributaries decrease from 7° to 2°C after which few fish remain in the streams (Figure H.2; NSC, pers. comm.).

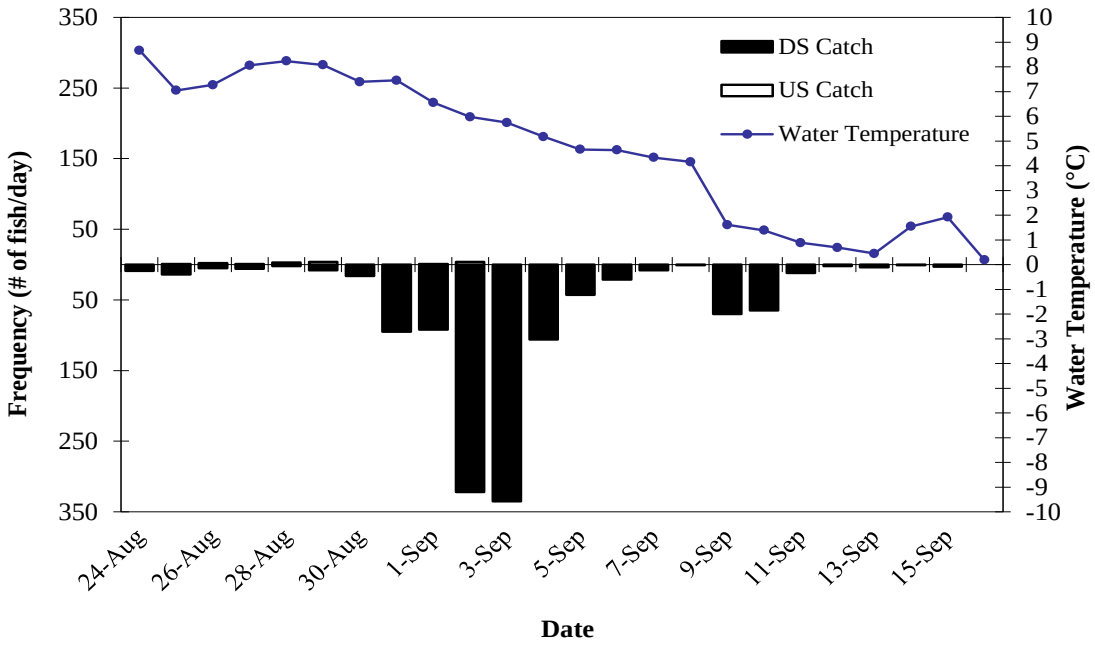

Figure H.2 Hoop Net Catch Rates of Arctic Char, Sheardown Lake Tributary 1, Fall 2007

2.0 HYDROLOGIC ESTIMATES

2.1 HYDROLOGIC FLOW PATTERNS

Within the Steensby Railway area, flows are typically close to 0 m^3/s in early June and rise through June to peak in July during freshet. Average flows then fall through August and return to 0 m^3/s in September or October as air temperature drops below zero. Rainfall may cause short duration high flows in July, August and September. As discussed in Section 1.0, fish within the vicinity of the Mary River Project overwinter in lakes and large bodies of water that do not freeze completely during winter. As water temperatures increase in late June and July, fish initiate migration to upstream tributaries to access rearing habitat. The fish out migrate in late August and early September before stream flows cease and freeze over. Upstream migration in July and August are considered the critical period for fish passage at culverts and as such these two months were used for the fish passage flows. The velocity criteria were assessed using the July flow as this represents the higher flow period where fish are migrating upstream.

2.2 CLIMATE CHANGE FACTOR

As part of the hydrologic assessment, a climate change literature review was completed to discuss the potential effects of climate change on the hydrology within the Steensby Railway area. Through the literature review completed it was assumed that a 20% increase in July and August streamflow is reasonable. The 20% increase is in line with the recommendation for climate change factors in the legislated flood assessments in a changing climate in BC document (EGBC, 2018). July and August will still be the months used for the assessment as significant portions of June data has not been collected at the hydrometric stations.

2.3 MEAN MONTHLY FLOW ESTIMATION

A hydrologic analysis has been completed to determine mean monthly flows during July and August at the confirmed and potentially fish-bearing Steensby Railway water crossings.

Flow data was available from 2008 at 17 of the 18 stations and were reviewed and used to determine mean monthly unit runoff for the months of July and August in l/s/km^2. One station (H11) did not have flow data during 2008 and was omitted as part of the assessment. Additionally, stations three other stations (H3, H8 and H9) had only five years of flow data from 2006-2011 and were thus omitted as part of this assessment. Only 7 of the stations were along the Steensby Railway alignment with only 1 to 3 years of record (common year of 2008). To account for this, the monthly mean unit runoff (l/s/km^2) was calculated for each of the 14 stations considered, for the common year of 2008. The mean monthly unit runoffs were compared among each station to evaluate if any trends are present related to spatial location (e.g., coastal versus interior, low elevation versus high elevation) and catchment area size. It was determined that there is no significant trend between the unit discharge and these factors.

The mean monthly unit runoffs for July and August for the total period of record for the on-site stations were also calculated (2006-2021). A scaling factor was calculated by comparing the total record for the stations to the 2008 monthly mean unit runoffs (Total/2008). The average scaling factor for July and August was used to estimate the long-term mean monthly flow at the 7 stations along the Steensby Railway alignment. The average July scaled mean monthly unit runoff and August scaled monthly mean unit runoff was determined from the 7 stations along the Steensby Railway alignment and a 20% climate change uplift was added to the average values.

Table H.1 Steensby Railway Alignment Scaled Monthly Mean Unit Runoffs

Location	July Scaled	August Scaled
Mary River	50.11	23.32
BR11	69.97	23.96
BR25	59.56	23.86
Ravn River	51.23	25.95
BR96-2	28.60	30.23
Rowley River	50.23	20.66
BR137	27.87	32.07
Standard Deviation	14.2	3.8
Average	44.0	25.7
Average Plus Climate Change	**52.8**	**30.9**

3.0 BASELINE VELOCITIES

The baseline velocities within the existing channels where the proposed culverts will be installed were calculated using Manning's open channel flow. The channel geometry was obtained from the detailed topographic and drone LiDAR survey provided by Kitikmeot Challenger in August 2023 (Kitikmeot Challenger, 2023). The baseline flow velocity calculations are intended to be used as a tool to discuss the potential impacts of the proposed culvert installation on the velocities within each stream. These are simple calculations that provide an order-of-magnitude estimate of average velocities in the existing stream for comparison to modelled velocities within the future culverts.

It is noted that not all water crossing locations were completed for two reasons including no survey data collected at the proposed culvert location, and/or no defined channel within the stream. Without survey information the channel geometry is unknown and without a defined channel the Manning's open channel flow result would be meaningless.

The resulting baseline velocities can be seen in Table H.2.

4.0 CULVERT DEPTH AND VELOCITES

The water depth and velocity within the proposed culverts at each crossing was determined using Manning's equation for open channel flow in a pipe. A Microsoft Excel model was developed to determine the resulting depth and velocity in all the culverts from given flows, pipe sizes and pipe slopes. Using the average July and August mean monthly unit discharges calculated as part of section 2.3 (52.8 l/s/km^2 for July and 30.9 l/s/km^2 for August, respectively), the mean monthly discharges were calculated for each water crossing location. The model determines cross section average velocity and maximum depth at each crossing.

TABLE H.2

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MARY RIVER PROJECT

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Systra Culvert ID	NSC Baseline Report Site ID	Bankfull Width Est.[2]	Proposed Culvert(s)[6]					Modelled Baseline Flow Velocities	Fish Swim Distance Modelling				Physical Characteristics and Flow Regime[7]	Biological Characteristics	Mitigation Measure (see Report for descriptions)
			Catchment Area	Length	Slope	July Avg Velocity	Aug Avg Velocity		Maximum Swim Distance						
									July Size Class	July Swim Distance	Aug Size Class	August Swim Distance			
		Range (m)	(km^2)	(m)	(%)	(m/s)	(m/s)	m/s	mm	m	mm	m			
MCV-0-2	CV-000-0a-Y	1.7 - 19.7	0.26	35.0	4.2%	0.29	0.24	Note 4	110	140	85	130	This is an unnamed stream on a small catchment (0.26 km^2). The stream is split into two branches with the left receiving the most flow and the right branch being frequently dry. There are also numerous discontinuous subsurface flow barriers downstream. At the crossing the mean wetted width ranged from 0.73 to 36.2 m (NSC, 2024). Water depths rarely exceed 0.2 m.	No fish have been observed or captured in this stream, however as there are no permanent downstream barriers, there is potential feeding/rearing use of habitat in the rail alignment area during periods of high water. No overwintering habitat. The fish size classes adopted for the fish passage assessment are from nearby SCV-001 (CV-000-0a-Y) of 110 mm in July and 85 mm in summer/fall.	Treatment 1
SCV-0-1	CV-000-1a-Y	5 - 32.3	0.15	21.8	0.5%	0.10	0.09	0.09	110	150	85	130	This is an unnamed stream with a small catchment (0.15 km2). There are no permanent downstream barriers between the rail crossing and the Mary River. However, there is an intermittent barrier downstream where during periods of low water (such as August 2022), the stream becomes a series of unconnected pools and short stretches of flowing surface water between patches of subsurface flow with no access from downstream waterbodies.	Rearing habitat for juvenile Arctic Char and potential feeding and spawning habitat for Ninespine Stickleback. Low numbers of fish captured. Commonly captured downstream from rail centerline. Arctic Char size range is from 106 to 160 mm in spring and a minimum size of 83 mm in summer/fall.	Treatment 1
SCV-0-3	CV-000-2-Y	18.4 - 52.7	0.03	22.5	2.9%	0.09	0.08	Note 4	110	150	85	130	This stream is part of the same watershed as the stream crossed by the rail at CV-000-1a-Y and is connected through an intermittent channel approximately 100 m upstream of the CV-000-2-Y centreline. The two streams were connected in 2021 but not in 2022. The stream provides only intermittent habitat likely requiring significant snowmelt or periods of rain to sustain connectivity with larger downstream waterbodies and with habitat at the CV-000-1a-Y crossing. When wetted, habitat was largely unconfined marshy, shallow habitat with some riffle/run over fines and patches of gravel/cobble. Mean measured depths and velocities were low in 2021. In 2022, the stream was reduced to a series of unconnected pools with no fish access from downstream or upstream areas. There are no permanent downstream barriers between the rail crossing and the Mary River. However, during periods of low water, the stream becomes a series of unconnected pools interspersed with short stretches of flowing surface water between patches of subsurface flow with no access from downstream. There is a permanent barrier approximately 430 m upstream from the centreline.	Juvenile Arctic Char and Ninespine Stickleback were not observed or captured during any of the survey periods at the CV-000-2-Y crossing area. However, both species were captured in the CV-000-1a-Y stream to which CV-000-2-Y is intermittently connected, including in the vicinity of where the two were connected during spring 2022. When there is sufficient flow/water and connectivity to other waterbodies in the area, the CV-000-2-Y stream would provide rearing habitat for juvenile Arctic Char, particularly farther downstream from the crossing. This stream can also provide feeding and potential spawning habitat for Ninespine Stickleback. The stream does not provide overwintering habitat for either species or spawning habitat for char. No fish observed or captured, however Arctic Char and Ninespine Stickleback were captured in CV-000-1a-Y of which CV-000-2-Y is intermittently connected to. This stream can provide feeding and potential spawning for Ninespine Stickleback and rearing habitat for juvenile Arctic Char. Not an overwintering habitat for either species or spawning for Arctic Char. Because of the intermittent connection to CV-000-1a-Y, the same fish size classes were adopted for the fish passage assessment.	Treatment 1
SCV-0-4	CV-000-3a-Y	9.3 - 38.5	0.25	21.1	0.6%	0.15	0.12	Note 4	105	150	90	130	This crossing is on an unnamed stream a small catchment (0.25 km^2) that drains 220 m southwest to a larger stream and then another 1 km before draining into the Mary River. This stream has two branches, the left hand of which is very shallow. The stream has standing water in some areas, with wetted widths ranging from 1.1 to 17.1 m. There is a permanent barrier 500 m upstream, and two intermittent barriers downstream, where during periods of lower water, the stream develops short stretches of flowing surface water between stretches of subsurface flow with no access from downstream overwintering habitat.	Ninespine Stickleback and Arctic Char have been captured. When there is sufficient flow/water, the stream can provide rearing habitat for juvenile Arctic Char and feeding and potential spawning habitat for Ninespine Stickleback. Both fish species were captured in August 2021 (ARCH: 45 to 135 mm) and spring 2022 (55 to 173 mm) in the electrofished area approximately 50 m downstream of the current centerline. In August 2022, no electrofishing was conducted due to the presence of an intermittent downstream barrier preventing passage from the overwintering habitat. In August 2023, electrofishing was conducted immediately upstream of the current centerline, and two juvenile Arctic Char (89 and 96 mm) were captured. The selected size class for fish passage modelling for July is the mean size class for all streams (105 mm), and for August the minimum size class caught at the crossing (90 mm).	Treatment 1
SCV-0-5	CV-000-3b-Y	42.9 - 51	0.63	29.9	2.5%	0.35	0.29	Note 4	105	150	90	130	This stream is the righthand branch, the lefthand branch being CV-000-3a-Y. These two branches merge both upstream and downstream from the centreline. Most of the water in this system flows from the righthand branch upstream before crossing over to the lefthand branch immediately upstream from the centreline. In addition, this righthand branch (CV-000-3b-Y) is further divided into several branches farther upstream. The stream is narrow throughout the surveyed reach and was shallow during all site visits. Due to barriers, the stream provides only intermittent habitat that was largely shallow pools and run with substrate composed primarily of fines with some patches of larger coarse material throughout. There are no permanent downstream barriers between the rail crossing and the Mary River. However, during periods of low water the stream develops short stretches of flowing surface water interspersed with patches of subsurface flow and no access from downstream overwintering habitat. There are also permanent subsurface flow barriers on each of the three upstream branches (660-920 m upstream).	Ninespine Stickleback and Arctic Char have been captured. The stream can provide a rearing habitat for juvenile Arctic Char and feeding and potential spawning for Ninespine Stickleback. No overwintering habitat for either species or spawning for Arctic Char. This crossing shares the same fish catch data as CV-000-3a-Y.	Treatment 1
SCV-0-6	CV-0-6-N	3.7 - 52.7	0.46	23.1	3.0%	0.28	0.23	Note 4	105	130	85	130	This is an unnamed stream with a small catchment (0.45 km^2) that drains 240 m southwest to a larger stream and then another 1 km before draining into the Mary River. The current centreline is at a braided section of the stream. A second culvert is located on the lefthand branch at this location 30 m to the northwest (see the assessment for CV-000-2-Y). This righthand branch is a very short, ephemerally wetted area. It is intermittently connected to the stream system at CV-000-1a-Y via the CV-000-2-Y branch, approximately 100 m upstream from the centreline. This area may be accessible under high flows from the stream crossed by CV-000-2-Y; the two stream branches merge approximately 35 m downstream from the centreline. Under very high-water conditions (i.e., peak freshet), there may be a small amount (40 m) of usable habitat upstream from the centreline at the rail crossing at CV-0-6-N. The stream is largely unconfined marshy, shallow habitat. There are no permanent downstream barriers between the rail crossing and the Mary River. However, during periods of low water, the stream becomes a series of unconnected pools interspersed with short stretches of flowing surface water between patches of subsurface flow with no access from downstream. The right branch likely carries even less water. On the left branch, there is a permanent barrier approximately 430 m upstream from the centreline.	Fish were not captured in this stream, but were caught in the adjacent system (CV-000-1-Y). There is no overwintering for either species and no Arctic Char spawning. Ninespine stickleback spawning is possible but unlikely. Arctic char sizes are 106-160 mm (July) and minimum of 83 mm (August).	Treatment 1
SCV-1-1	CV-001-2-Y	8 - 15	1.18	35.0	4.2%	0.47	0.38	Note 4	105	28	90	36	This is a small, unnamed stream with a small catchment (1.18 km^2) that drains 25 m south to a small lake. The stream had average wetted widths along the surveyed reach ranging from 0.70-15.0 m in August 2022 and 0.71-13.60 m in August 2023. Measured water depths were low to moderate (typically <0.50 m). Measured point velocities were generally <0.50 m/s but occasionally exceeded 1.00 m/s in some riffles. Stream morphology was mostly riffle/pool/run and substrates were a mixture of fines, cobble, and boulder. There is an intermittent high gradient/shallow water combination barrier located 50 m upstream from the centreline. When water levels are sufficient, larger juvenile char can ascend the step-pool habitat in this reach. Fish were captured upstream of this stretch in August 2022 and 2023 indicating it is only intermittent and highly dependent on water levels. There is also an intermittent vertical drop barrier 230 m upstream from the centreline. The height of the drop is reduced during higher spring water levels and large juveniles can access habitat farther upstream. No permanent barriers have been identified.	Juvenile Arctic Char primarily use habitat downstream of the lowermost intermittent barrier, near the confluence with the downstream lake. However, under higher flows, some larger juveniles (>100 mm) can access habitat upstream of this reach for rearing. There is some risk of natural stranding if water levels decrease sufficiently after the fish have ascended the step-pool habitat. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback have not been captured or observed in this stream. It is unknown if the species is present in the watershed, though the steeper habitat is likely unsuitable for the species. No fish were captured in spring, so a fish size of 105 mm (average of all stream sites) was used with July flows to assess fish passage. August fish sizes ranged from 89 to 187 mm, so a size class of 90 mm was adopted to assess fish passage.	Treatment 3
SCV-3-1	CV-003-1	2.3 - 36	1.04	29.0	15.1%	0.67	0.54	0.86	N/A	N/A	N/A	N/A	This is a braided stream system, and the smaller channels branching off may be intermittently dry or develop intermittent barriers under lower flows.	See Note 1.	None
SCV-4-2	CV-004-2	11.3 - 14.72	0.07	35.0	10.5%	0.20	0.18	0.21	N/A	N/A	N/A	N/A	Unconnected - permanent barriers exist here.	See Note 1.	None
SCV-6-4	CV-006-1a	6.82 - 17.7	0.02	22.7	8.0%	0.12	0.10	0.20	105	150	105	150	This is an unnamed stream with a very small catchment (0.017 km^2) that drains 1.2 km west to a small lake, which appears to be at the head of a larger watershed that flows to the southeast for approximately 11.2 km towards the north end of Angijurjuk Lake. This stream is highly braided with three distinct channels crossed at the rail alignment and additional braiding within 100 m downstream of the centreline. Bridges are planned for the other two channels. There are intermittent downstream subsurface flow barriers, and a vertical drop 60 m upstream from the rail centreline. Very low flows (average July discharge of 0.001 m^3/s). This stream morphology is highly braided with 3 distinct channels and multiple flow barriers. Wetted widths typically range from <0.5 - 1.0m, measured water depths and point velocities of <0.1 - 0.2 and <0.1 - 0.3 m/s, respectively.	Fish were not captured in spring of 2023, however the site is a intermittent habitat for Arctic Char due to its connectively to the CV-006-1 channel. The stream does not provide overwintering habitats for either species, but provides a seasonal rearing habitat for juvenile Arctic Char and could provide feeding and potential spawning for Ninespine Stickleback, although there is no evidence to support the use of Ninespine Stickleback using this habitat. Fish use is likely limited to periods of high flows. Th average size for all streams (105 mm) was selected for the fish passage assessment.	Treatment 1
SCV-7-1	CV-007-1	0.9 - 3.1	1.17	35.0	5.6%	0.50	0.46	0.79	135	44	75	13	This is an unnamed stream with a small catchment (1.17 km^2) that drains 700 m southwest to a larger watershed that then flows to the southeast for approximately 9.5 km towards the north end of Angijurjuk Lake. Mean wetted width along the surveyed reach of the stream was consistently 2.0-2.3 m across all survey periods. Measured mean depths (0.24 m) and velocities (0.87 m/s) in spring 2022 were approximately twice those measured in August 2021 and 2022. There are no downstream barriers between the rail crossing and the larger downstream watershed. There is a permanent barrier consisting of a series of vertical drops (>0.5 m) immediately downstream of an area with subsurface flow and very high (21°) gradient, located 700 m upstream from the rail centreline.	Arctic Char have been captured and observed here while Ninespine Stickleback have not. The stream provides seasonal rearing habitat for juvenile Arctic Char and could provide feeding and potential spawning habitat for Ninespine Stickleback. No overwintering habitat. Arctic Char catches in July ranged from 134 to 200 mm, and August catches ranged from 75 to 160 mm.	Treatment 3
SCV-9-2	CV-009-1	2.5 - 8.4	0.66	35.0	14.9%	0.61	0.50	Note 4	N/A	N/A	N/A	N/A	Discontinuous - one permanent and one intermittent upstream barriers and one intermittent downstream barrier.	See Note 2.	None
SCV-12-4	CV-012-2	1.8 - 3.4	0.48	35.0	8.4%	0.44	0.35	0.60	N/A	N/A	N/A	N/A	Discontinuous - intermittent subsurface flow barrier downstream and one permanent upstream barrier (steep gradient 11°).	See Note 2.	None
SCV-13-1	CV-013-1	0.8 - 1.3	0.54	33.2	14.6%	0.56	0.46	0.90	N/A	N/A	N/A	N/A	Discontinuous - two intermittent subsurface flow barriers downstream. During summer/fall surveys, there were additional downstream reaches where a combination of small vertical drops and shallow water prevented most upstream fish movement.	See Note 1.	None
SCV-14-2	CV-014-2	0.6 - 0.8	0.24	34.0	2.9%	0.32	0.26	0.63	105	79	105	150	The Steensby rail alignment crosses a small, unnamed stream with a small catchment (0.23 km^2) that drains 280 m south to a larger watershed that flows another 13.5 km generally southwards before draining into the north end of Angijurjuk Lake. The stream was not assessed in spring of 2021 because of snow and ice and was dry in August in all survey years (2021-2023). A full survey was only conducted in spring 2022. There is a permanent barrier upstream. The average wetted width was 1.41 m along the surveyed reach, with measured depths typically <0.2 m and one case of a depth exceedance of 0.5 m.	No fish have been captured or observed here. There is no spawning or overwintering habitat for Arctic Char. Ninespine Stickleback have not been observed in this stream, but one was observed in a pond downstream. The streams habitat is suitable for rearing and adult feeding. The mean Arctic Char size class of 105 mm was used to assess fish passage.	Treatment 1
SCV-16-1	CV-016-1-Y	0.5 - 4.4	0.13	35.0	0.5%	0.10	0.09	0.11	105	150	85	130	This is an unnamed stream with a small catchment (0.13 km^2) that drains 510 m south to a larger watershed that flows another 5.4 km generally southwards before draining into the north end of Angijurjuk Lake. There are no downstream barriers. Upstream from the centreline, the stream splits in two which each having several upstream permanent barriers.	Juvenile Arctic Char use the habitat for rearing with no habitat for spawning or overwintering in this stream. Ninespine Stickleback have not been captured or observed, it is therefore unknown if the species are present here, but the habitat is very suitable for the species. No fish have been captured in spring, so the mean fish size of 105 mm was adopted to assess fish passage in July. Arctic Char captured in August ranged in size from 85 to	Treatment 1
SCV-16-3	CV-016-2a-R	1.25 - 23.1	0.02	31.5	5.1%	0.10	0.08	Note 4	N/A	N/A	N/A	N/A	There is a permanent flow barrier located at the centerline. Upstream from this barrier, surface water is very shallow and only persists during peak spring melt. There is also an intermittent barrier downstream where the channel disappears, dispersing the flow over terrestrial vegetation often becoming subsurface during summer/fall.	See Note 1	None
SCV-16-4	CV-016-4-R	0.37 - 30	0.09	30.5	0.5%	0.13	0.10	0.12	105	150	100	150	This is an unnamed stream with a very small catchment (0.09 km^2) that flows into and out of the pond that will be infilled by the rail at site NEWCULV-2 to the southeast. From the pond, the stream flows approximately 6 km generally to the southeast before draining into the north end of Angijurjuk Lake. There is an intermittent subsurface flow barrier 130 m downstream of the crossing preventing fish passage to/from any larger downstream watersheds during periods of low water conditions. There are permanent barriers 60 m and 90 m upstream of the crossing, where the stream becomes subsurface flow on a steep slope with a vertical drop of 0.6 m upstream. The mean wetted width ranges from 2.6 m (fall 2022) to 12.5 m (spring 2022). The measured depths were generally shallow (<0.2 m, rarely exceeding 0.5 m).	Juvenile Arctic Char use the habitat for rearing, with no spawning or overwintering habitat in this stream. Ninespine Stickleback have not been captured or observed in this stream. Arctic Char captured in summer ranged from 100 to 150 mm. The mean size of 105 mm was used to assess fish passage in July, and 100 mm was used to assess passage in August.	Treatment 1
SCV-16-7	NEWCULV-2	No data available	0.03	35.0	0.5%	0.06	0.05	Note 4	105	150	100	150	The Steensby railway centreline crosses this watershed where an inflowing stream (CV-016-4) meets with the pond at site NEWCULV-2. The footprint will affect both stream habitat and nearshore pond habitat (see CV-016-4 habitat assessment sheet for stream information). The inflow is a small, seasonal stream with a permanent subsurface flow/gradient barrier 65 m upstream of the pond. Although habitat quantity is limited, the inflow stream is accessible from the downstream pond and can provide rearing habitat for both species. The outflow is a small, seasonal stream with an intermittent subsurface flow barrier 120 m downstream of the pond.	Arctic Char were observed/captured in the pond during the open-water season until low water conditions in late summer and fall prevented access from larger downstream watersheds. No stranded fish were observed at the time of the August surveys. Juvenile char use the pond for rearing when water levels are sufficient. Depths are never sufficient to support Arctic Char spawning or overwintering. Although their presence in the watershed has not yet been confirmed, Ninespine Stickleback may potentially use the pond for rearing/feeding and the habitat is also suitable for spawning, but depths are insufficient for overwintering. Arctic char captured in August ranged in size from 100 to 150 mm. The mean fish size (105 mm) was used to assess fish passage in July.	Treatment 1
SCV-17-1	LE-017-1-R	3.3 - 65.2	1.63	33.5	1.1%	0.35	0.29	0.36	N/A	N/A	N/A	N/A	Inflow is a small, braided, intermittent stream that has permanent subsurface flow barriers upstream of the pond, one is within the rail embankment	See Note 1.	None

TABLE H.2

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Systra Culvert ID	NSC Baseline Report Site ID	Bankfull Width Est.[2]	Proposed Culvert(s)[6]					Modelled Baseline Flow Velocities	Fish Swim Distance Modelling				Physical Characteristics and Flow Regime[7]	Biological Characteristics	Mitigation Measure (see Report for descriptions)
			Catchment Area	Length	Slope	July Avg Velocity	Aug Avg Velocity		Maximum Swim Distance						
									July Size Class	July Swim Distance	Aug Size Class	August Swim Distance			
		Range (m)	(km^2)	(m)	(%)	(m/s)	(m/s)	m/s	mm	m	mm	m			
SCV-17-3	CV-017-1-Y	18.9 - 23.3	0.04	23.7	4.0%	0.12	0.09	0.18	N/A	N/A	N/A	N/A	This is a small, unnamed stream that has two downstream branches. One branch drains 350 m west into an unnamed pond (pond that will be encroached by the rail at LE-017-1-R) which is known to have both Arctic Char and Ninespine Stickleback present. The other branch drains 270 m south to a larger river, which then flows another 9 km west and then 7 km south into the north end of Angijurjuk Lake. The crossing is accessible to fish during spring, however lower water levels and lack of stream connectivity in the fall prevent fish access to the crossing. The upper limits of surface water in this watershed are within the rail footprint. There is no aquatic habitat upstream from the crossing.	See Note 1.	None
SCV-18-1	CV-018-1-R	0.6 - 7.4	2.19	16.6	0.5%	0.34	0.28	0.56	110	84	110	150	This is a small, unnamed stream with a small catchment (2.19 km^2) that drains 330 m south to a larger watershed that flows another 8 km generally to the southeast before draining into the north end of Angijurjuk Lake. The stream is relatively narrow with average wetted width along the surveyed reach ranging from 2.1-6.6 m across all sampling seasons. Measured depths were moderate and typically 0.2-0.3 m. Measured velocities were relatively high, frequently exceeding 1.0 m/s, with some areas measuring >2.0 m/s in spring 2022. Stream morphology was mostly riffle/run in the spring and riffle/run/pool in the fall. Substrates were predominantly gravel/cobble with some patches of fines, particularly downstream from the centreline. There are no permanent downstream barriers between the rail crossing and larger downstream watersheds. There is a permanent barrier 400 m upstream from the rail crossing where subsurface flow under boulders and a 0.8 m vertical drop block fish passage farther upstream. The mean wetted width ranges from 2.1 m to 6.6 m. Measured depths were typically 0.2 to 0.3 m.	Juvenile Arctic Char use the habitat for rearing, but the depth is not sufficient for spawning or overwintering. Ninespine Stickleback have not bee captured or observed in this stream. Arctic Char captured in August ranged in size from 110 to 170 mm. No fish were captured in spring. The minimum size of 110 mm was used to assess fish passage in July and August.	Treatment 1
SCV-27-2	CV-027-2	2 - 16.5	1.75	33.0	2.6%	0.54	0.43	0.88	110	18	110	42	This is a small, unnamed stream with a small catchment (1.75 km^2) that drains 680 m south to a larger watershed, which then flows another 8 km generally southwards before draining into the north end of Angijurjuk Lake. There is an intermittent subsurface flow barrier between the crossing and larger downstream watersheds that is present under low water levels, particularly those observed late in the open-water season of an especially dry summer in 2022. Conversely, there is an intermittent high velocity barrier immediately upstream of the crossing that is present during periods of particularly high water levels. There is also a permanent barrier ~650 m upstream where the water flow is subsurface in a boulder-filled channel with vertical drops. The mean wetted width ranged from 1.3 m (fall 2021) to 4.8 m (spring 2022). Measured depths were typically <0.3 m, never exceeding 0.7 m.	Juvenile Arctic Char can use habitat in the vicinity of the rail crossing for rearing when water levels are sufficient to provide connectivity with the downstream watershed; char were observed downstream of the intermittent barrier during one survey. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback use habitat in the vicinity of the rail crossing for rearing, adult feeding, and potentially for spawning. No fish were captured during any of the surveys. The fish sizes from a similar crossing nearby with a similar catchment size (CV-18-1-R) was used to assess fish passage (110 mm for both July and August).	Treatment 2
SCV-27-4	CV-R06	15 - 40	0.37	35.0	1.5%	0.24	0.20	0.28	105	150	105	150	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-R06 that drains 300 m south to a large pond. From the large pond, water flows another 6 km generally southwards before draining into the northeast end of Angijurjuk Lake. There are two intermittent downstream barriers between the railway crossing and larger downstream watersheds. Stream flows were either subsurface or too shallow for fish passage within a 50 m reach downstream of the rail centreline under low water conditions in August of each year (i.e., 2021-2023). There are permanent barriers present throughout the open-water season immediately upstream of the crossing where the stream flows become subsurface in a rocky channel which extends for several hundred meters upstream.	Juvenile Arctic Char have not been captured or observed in this stream during surveys. It is unknown if the species is present in the watershed. Any char use of the habitat in the crossing area would be restricted to juvenile rearing. There is no overwintering or spawning habitat for Arctic Char in this stream. Ninespine Stickleback use habitat in the vicinity of the railway crossing when downstream water levels are sufficient to allow access during the open-water period. Stickleback may use habitat in this stream for rearing, feeding, and potentially spawning. Depths are insufficient for overwintering. No fish data is available. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-28-1	CV-R07	2.2 - 3.7	4.44	23.7	5.0%	0.82	0.66	1.23	105	5.4	65	3.1	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-R07 that drains 130 m south to a small lake that may have sufficient depths for char overwintering. From this small lake, water then flows another 7 km generally southwards before draining into the north end of Angijurjuk Lake. In spring 2022, an intermittent high velocity barrier was present at and downstream of the crossing preventing fish passage. When surveyed in fall 2022, a subsurface flow barrier was present downstream of the crossing. Access between the rail crossing and larger downstream watersheds appeared to occur only during the early summer in 2021 and 2022. There is a permanent barrier 1.3 km upstream of this crossing where a series of falls is present over a stretch of 100 m.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing when water levels are sufficient for rearing; a number of char were captured in August 2021 when no downstream barriers to fish passage were present. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback use habitat in the vicinity of the rail crossing throughout the open-water period, when water levels are sufficient, for rearing, feeding, and potentially spawning. There is no overwintering habitat for Ninespine Stickleback in this stream. Arctic Char captured in August ranged from 65 to 113 mm. The mean fish size (105 mm) was used to assess fish passage in July.	Treatment 3
SCV-28-2	CV-R07b2	35	0.21	23.1	8.4%	0.31	0.25	Note 4	105	98	105	150	The Steensby railway alignment crosses a small, intermittent, unnamed stream at culvert site CV-R07b2 that drains 60 m south to a small, potentially overwintering lake. From this lake, water flows another 6 km generally southwards before draining into the northeast end of Angijurjuk Lake. There is an intermittent barrier between the rail centreline and the downstream lake. The stream flow became subsurface and water levels were too shallow for fish passage during both August survey periods and in spring 2021. There is also a permanent upstream barrier located 240 m upstream of the crossing that consists of subsurface flow through a large boulder garden.	Juvenile Arctic Char have not been captured or observed in this stream. Although habitat is not ideal for this species, juveniles are present in other tributaries of the small downstream lake. Char may therefore use this stream for rearing when water levels are sufficient. There is no overwintering or spawning habitat for Arctic Char in this stream. Ninespine Stickleback have not been captured or observed in this stream. There is suitable habitat in the vicinity of the rail crossing during spring for rearing and the species has been observed in other tributaries of the small downstream lake. There is no overwintering habitat for Ninespine Stickleback in this stream, but spawning may be possible when summer water levels are higher than those observed in 2021 and 2022. No fish data available. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-28-3	CV-R07b3	10 - 30	0.10	19.5	7.4%	0.21	0.17	Note 4	105	150	50	93	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-R07b3 that drains 95 m south to a small lake and then flows another 7.5 km generally southwards before draining into the northeast end of Angijurjuk Lake. The site could not be assessed during spring 2021 due to persistent ice and snow cover for the duration of the spring program and the stream was not surveyed in fall 2021 due to lack of water. There are no specific downstream barriers between the rail crossing and larger downstream watersheds, but the entire stream can become dry during summer and fall as observed in August 2021. There is an intermittent barrier 120 m upstream of the crossing where the stream becomes too shallow for fish passage. The full upstream extent of this stream has not been surveyed for permanent barriers, but the stream likely originates in a location close to this upstream barrier.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback use habitat in the vicinity of the rail crossing for rearing and potentially spawning. There is no overwintering habitat for stickleback in this stream. In July, the single captured Arctic Char had a fork length of 50 mm. The mean fish size (105 mm) was used to assess fish passage in July.	Treatment 1
SCV-29-1	CV-R07c2	2.4 - 16.5	1.09	31.1	5.1%	0.49	0.40	0.83	50	3.9	105	46	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-R07c2 that drains 70 m south to a small lake that flows another 6 km generally southwards before draining into the northeast end of Angijurjuk Lake. There is an intermittent downstream barrier between the rail crossing and the small fish-bearing lake. During every August site visit, flow became subsurface ~55 m downstream from the centerline but the area was passable to fish in the spring. There is a permanent barrier located 110 m upstream of the centerline where the flows are subsurface down a high gradient slope.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing for rearing when water levels are sufficient, likely only during spring. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback have not been captured or observed in this stream. It is unknown if the species is present in the watershed, but habitat in this stream is suitable for juvenile and adult use, including spawning. There is no overwintering habitat for stickleback. Arctic Char size ranges from 50 to 111 mm in the spring. The mean fish size (105 mm) was used to assess fish passage in August.	Treatment 3
SCV-38-3	LE-R38a-Y	No data available.	0.09	35.0	1.4%	0.13	0.10	Note 4	105	150	105	150	The Steensby railway alignment completely infills a small pond at site LE-R38a-Y. The infill also affects a portion of the pond's inflow stream, which is described in the assessment sheet for site CV-039-2d-Y. The pond is part of a stream system that flows from a much larger pond 440 m to the east towards another large pond 300 m to the west. The pond was only surveyed in August 2023; the previous rail alignment crossed the inflow stream and did not affect this pond. There are no permanent barriers between the pond and either the downstream or upstream lakes, though there are some intermittent barriers upstream where flows become subsurface during periods of low water.	Arctic Char have not been captured in this pond but have been captured in the inflow stream during each surveyed year (2021-2023). Juvenile char may use the pond for rearing, but there is insufficient depth for spawning. Large numbers of Ninespine Stickleback were captured and observed in the pond in August 2023. Stickleback can use the pond for rearing/feeding and, likely, spawning. Depths are insufficient for overwintering of either species. No Arctic Char have been caught here. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-38-5	CV-039-2d-Y	2.1 - 83.4	5.09	35.0	1.8%	0.58	0.47	1.09	185	62	105	28	This is a small, unnamed stream with a small catchment (5 km^2), and the crossing is near where it expands into a small pond at another culvert crossing (see sheet LE-R38a-Y). Overall, this stream flows westwards from a large pond 400 m upstream of the centreline to another large pond 310 m downstream, before flowing another 1.9 km towards the Ravn River. Measured depths were highly variable; often exceeding 1.0 m downstream from the 2023 centreline but more typically <0.30 m upstream. There are two intermittent subsurface flow barriers approximately 140 and 330 m upstream from the current centreline. Both barriers were only present during the particularly low water conditions observed during summer/fall 2022. There are no barriers between the centreline and the large downstream pond.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing throughout the open-water period for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback use habitat in the vicinity of the rail crossing for rearing/feeding and potentially spawning. There is no overwintering habitat for Ninespine Stickleback in this stream. Only one Arctic Char was captured (187 mm) in the spring, and several were observed. Fish passage was assessed using Arctic Char sizes of 185 mm for July and 105 mm for August.	Treatment 2
SCV-39-1	CV-039-2c-Y	No data available.	0.02	35.0	1.4%	0.10	0.08	Note 4	105	150	105	150	This is a small, wetted area with a very small catchment (0.02 km^2), which was only surveyed in August 2023 after the rail alignment was moved; at this time, it consisted of unconnected pools. The area had very little water in August 2023 and a detailed habitat assessment was not conducted. There is potential intermittent connectivity with the fish-bearing CV-039-2d-Y system 50 m to the north.	No fish were captured or observed in this area. Both species are however found in a nearby watershed, but there was a lack of water in the crossing area. The connectively is currently unknown but the habitat has conservatively been designated as a potential fish habitat. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-39-4	CV-039-2b-Y	Dry during surveys	0.01	36.2	0.5%	0.04	0.03	Note 4	105	150	105	150	This is a small, wetted area with a very small catchment (0.01 km^2). The site was only surveyed in August 2023 after the rail alignment was moved; at this time the area consisted of unconnected pools. The area had very little water in August 2023 and a full habitat assessment was not conducted. There is a dry channel present that may link these pools with the fish-bearing CV-039-2d-Y system 150 m to the north during periods of high water.	Arctic Char and Ninespine Stickleback were not captured or observed in this area in August 2023. While both species are found in a nearby watershed, there was no access to the crossing area due to a lack of water in August 2023. It is unknown if this lack of connectivity is permanent across all seasons and, therefore, the site was designated as potential fish habitat. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-40-1	CV-R24-Y	7.01 - 14	0.39	28.3	2.4%	0.25	0.20	Note 4	N/A	N/A	N/A	N/A	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-R24-Y that drains approximately 70 m south into a large pond. The pond is part of a low-lying drainage that includes many ponds and small streams with sometimes intermittent connectivity. The rail centreline crosses and/or encroaches upon several other waterbodies in this system. The watershed drains generally westwards for approximately 2 km before meeting a large river that then flows another 2.4 km north into the Ravn River. The current rail alignment is approximately 50 m upstream from the alignment that was surveyed in 2021 and 2022. The new alignment centreline is also at approximately the same location as an obsolete access road alignment. Even during spring surveys, there were some intermittent barriers present on this stream. A downstream intermittent shallow water barrier prevented access from the downstream pond. Another shallow intermittent barrier was noted approximately 200 m upstream from the 2021 and 2022 centreline, preventing access to/from the upstream ponds in this system. The entire stream was dry/nearly dry by summer/fall each year. A permanent upstream barrier is present at the farthest upstream headwater pond where there is no inflow and no additional upstream surface water.	See Note 3.	None
SCV-40-5	LE-R39d-Y	Pond	0.41	26.9	0.5%	0.14	0.12	0.14	105	150	105	150	The Steensby railway alignment encroaches a small pond at site LE-R39d-Y. The pond has an intermittent inflow south of the encroachment at rail culvert site CV-R27-Y. There is a defined outflow on the west side of the pond. The site was only surveyed in August 2023 after the rail alignment was moved.	Fish were not captured or observed in the pond in August 2023; however, Ninespine Stickleback have been captured in the inflow stream to the south. Arctic Char have not been captured in this watershed and it is unknown if they are present. Stickleback may use pond habitat for rearing/feeding and possibly spawning. Depths in the pond are not suitable for overwintering. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-40-4	CV-R27-Y	1.6 - 10.5	0.41	26.2	2.0%	0.24	0.19	0.33	105	150	105	150	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-R27-Y that drains approximately 30 m west to a small pond. The pond is part of a low-lying drainage that includes many ponds and small streams with sometimes intermittent connectivity. The rail centreline crosses and/or encroaches upon several other waterbodies in this system. The watershed drains generally westwards for approximately 2 km before meeting a large river that then flows another 2.4 km north into the Ravn River. In summer 2023, the proposed rail alignment was moved approximately 30 m downstream from the location surveyed in 2021 and 2023. An intermittent barrier is located immediately downstream from the rail centreline where the stream becomes very shallow during summer/fall, which can lead to fish stranding. Another stretch of very shallow water formed an intermittent barrier 50 m upstream from the centreline during summer/fall survey periods. There is a permanent barrier 825 m to the southeast where there is a pond with no defined surface water inflows to the system. This is the upstream extent of aquatic habitat in the watershed.	Arctic Char have not been captured or observed in this stream during any survey. If char can access this system, they may use habitat in the vicinity of the rail crossing for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream. One stranded Ninespine Stickleback was captured in a small pond area that was the only wetted area remaining in this stream in August 2023. This species has been captured in other waterbodies within the watershed and habitat is suitable for spawning, rearing, and feeding in the rail crossing area. There is no overwintering habitat present in this stream for this species. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1

TABLE H.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

APPLICATION FOR FISHERIES ACT AUTHORIZATION
FISH PASSAGE ASSESSMENT

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Systra Culvert ID	NSC Baseline Report Site ID	Bankfull Width Est.[2]	Proposed Culvert(s)[6]					Modelled Baseline Flow Velocities	Fish Swim Distance Modelling Maximum Swim Distance				Physical Characteristics and Flow Regime[7]	Biological Characteristics	Mitigation Measure (see Report for descriptions)
			Catchment Area	Length	Slope	July Avg Velocity	Aug Avg Velocity		July Size Class	July Swim Distance	Aug Size Class	August Swim Distance			
		Range (m)	(km^2)	(m)	(%)	(m/s)	(m/s)	m/s	mm	m	mm	m			
SCV-42-1	CV-R29-Y	12 - 19	2.67	29.5	0.5%	0.30	0.28	0.26	100	96	105	130	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-R29-Y that drains approximately 20 m west to a large pond. From the pond the stream flows another 2-3 km generally northwest to a large river that then flows for approximately 4 km north before emptying into the Ravn River. The proposed rail alignment was relocated approximately 10 m downstream (west) from the location surveyed in 2021 and 2022. There are no permanent barriers between the centreline and either the immediate upstream or downstream ponds. However, this stream becomes a series of unconnected pools and then dries up completely by summer/fall. Stream connectivity to adjacent waterbodies only occurs during very high water conditions. There are additional ponds to the east of the rail centreline with ephemeral interconnectivity with this stream. Fish access to these ponds, likely only occurs during peak freshet flows as most of the connecting streams/marshy habitat appear to dry up during summer. Conditions are similar downstream, though connectivity may be maintained for most of the open-water season from the rail centreline to an intermittent barrier located 960 m downstream.	Juvenile Arctic Char can use habitat for rearing in the vicinity of the rail crossing, however, only during periods of high to very high water levels (e.g., freshet) and they risk becoming stranded as water levels decrease throughout the open-water season. There is no spawning, overwintering, or adult habitat for Arctic Char in this stream. Ninespine Stickleback have not been captured or observed in this stream. However, they have been observed in similar habitat in nearby waterbodies along the rail alignment and could be expected to use habitat at CV-R29 for spawning and rearing when accessible. There is no overwintering habitat present in this stream. It is unknown if the upstream and/or downstream ponds have sufficient depths for stickleback overwintering. The estimated Arctic Char size ranges from 100 to 150 mm in June. The mean captured June fish size (100 mm) was used to assess fish in July, and the mean fish size (105 mm) was used to assess fish in August.	Treatment 1
SCV-44-4	CV-044-1-Y	2.5 - 26	2.28	23.7	1.2%	0.41	0.33	0.49	105	43	105	82	This is a small, unnamed stream with a small catchment (2.28 km^2) that drains approximately 95 m east to a large river that flows another 9.5 km north before meeting the Ravn River. There is a large pond approximately 70 m upstream from the centreline and a number of additional ponds with short interconnecting streams farther upstream in this watershed. There are no permanent barriers, but during periods of very low water, this site becomes a series of unconnected pools (observed during summer/fall 2022).	Juvenile Arctic Char have been captured in this stream and use the habitat for rearing, but not for spawning or overwintering as the habitat is non-suitable. Ninespine Stickleback have been observed and captured as well. The habitat is suitable for rearing and spawning but not for overwintering. Fork lengths were not recorded.	Treatment 1
SCV-44-6	CV-044-3-Y	3.3 - 17	3.48	30.4	1.6%	0.48	0.40	0.77	100	24	100	41	This is a small, unnamed stream in a small catchment (3.48 km^2) that drains approximately 150 m east to a large river that flows another 10.4 km north towards the Ravn River and then Angijurjuk Lake. There are two intermittent shallow barriers were observed during a very dry summer in 2022 (one upstream and one downstream). Arctic Char had become stranded.	Small numbers of larger juvenile Arctic Char (100-198 mm) were captured during spring surveys. Ninespine Stickleback were observed in spring 2022 both alive and some that appear to have been winterkilled. Fish were stranded in many isolated pools in August 2022, and may not have been able to access overwintering habitat without sufficient rain to restore access prior to freeze-up. Ninespine Stickleback have also been observed in this stream. The site is suitable for stickleback spawning and rearing/feeding. There is no overwintering habitat for the species in this stream. Arctic Char size ranges from 100 to 198 mm.	Treatment 2
SCV-45-2	CV-045-1	5 - 41	0.32	30.2	1.5%	0.23	0.24	0.23	N/A	N/A	N/A	N/A	This is an unnamed stream with a small catchment (0.32 km^2) that drains approximately 150 m north to a larger river that flows another 11.5 km to the Ravn River. Upstream from the centreline are a series of small ponds to the south with intermittent connectivity. A permanent downstream vertical drop (0.81 m) barrier is located near the confluence with the large downstream river. There is also an intermittent shallow water barrier 60 m upstream from the centreline that can be present even during some springs. The stream was dry at the time of the August 2022 survey.	See Note 3.	None
SCV-46-2	LE-047-1	21 - 35	2.57	26.6	0.5%	0.33	0.31	0.27	N/A	N/A	N/A	N/A	The Steensby railway alignment encroaches on a small pond and crosses its outflow stream at culvert site LE-047-1. This pond has inflow and outflow streams that are connected to larger ponds in the watershed. The inflow is a small seasonal stream to the southwest of the encroachment that provides connectivity to a number of larger ponds and small lakes that could potentially provide overwintering habitat. The outflow drains the pond towards a larger pond 70 m northeast. An insufficient depth barrier was present 30 m downstream from the centreline under low water conditions in mid-August 2022, but was not present during the early August 2023 survey. The upstream extent of aquatic habitat in this catchment is located approximately 2 km to the southwest where there is a pond with no additional inflows.	See Note 3. LE-047-1 is a culvert inside the embankment to allow drainage between two sides of a pond that the embankment transect.	None
SCV-47-1	CV-047-1	5.1 - 17.7	0.11	21.2	0.5%	0.11	0.09	0.13	105	150	105	150	This is a small, unnamed stream with a very small catchment (0.11 km^2) that drains 130 m northwest to a large pond that is part of a system of ponds and small, sometimes ephemeral streams that drain generally westward. Ultimately, this system drains north and into the Ravn River upstream of Angijurjuk Lake. Intermittent barriers are located downstream and upstream. All barriers are areas where there is shallow water, some present during spring.	No Arctic Char have been observed or captured here. Ninespine Stickleback have been captured in this stream and it is suitable for spawning and rearing, but not for overwintering.	Treatment 1
SCV-49-2	CV-049-2	4 - 46.5	0.77	27.3	1.3%	0.31	0.25	0.31	105	98	105	150	This is a small, unnamed stream with a small catchment (0.77 km^2) that drains approximately 85 m east to a large river that flows another 16.5 km generally northwards towards the Ravn River. The watershed extends approximately 2 km upstream from the centreline and includes a pond and small lake. During the August 2023 survey, an upstream barrier was identified approximately 2.5 km upstream of the crossing centreline. This barrier is located at a pond that has no additional surface water connections to any other waterbodies. There are no permanent downstream barriers between the crossing and the larger downstream river; however, during periods of very low water (e.g., summer/fall 2022) the stream is reduced to a series of isolated pools.	No Arctic Char have been observed or captured here, but there is a large, char-bearing river downstream that suggests potential Char use of this stream for rearing, but not spawning or overwintering. Ninespine Stickleback have been captured here. The habitat is suitable for spawning and rearing, but not for overwintering.	Treatment 1
SCV-49-3	CV-049-3	0.5 - 7.4	1.17	29.2	0.5%	0.24	0.22	0.27	105	150	105	150	This is a small, unnamed stream in a small catchment (1.17 km^2) that drains 260 m east to a large river that flows another 17 km generally northwards towards the Ravn River. The stream is connected upstream to a series of small ponds/lakes. One upstream barrier was observed during August surveys. During the extremely dry summer/fall of 2022, the stream was reduced to a series of unconnected pools. There is a downstream barrier where the stream became too shallow to allow for fish passage. Additionally, the stream was reduced to a series of unconnected pools during the dry summer/fall of 2022.	Arctic Char have not been observed/captured in this stream, but the proximity of a large, char-bearing river downstream from the centreline suggests potential char use of CV-049-2 for rearing when water levels are sufficient. There is no suitable spawning, overwintering, or adult Arctic Char habitat present. Ninespine Stickleback, including young-of-the-year, have been captured in this stream. Habitat is suitable for spawning and rearing/feeding for this species, however, there is no overwintering habitat.	Treatment 1
SCV-50-1	CV-050-1	0.45	0.21	35.0	1.3%	0.24	0.19	0.26	N/A	N/A	N/A	N/A	This is a small, unnamed stream in a small catchment (0.21 km^2) that drains 430 m east to a large river that flows another 17.3 km generally northwards to the Ravn River. There is a small pond 50 m upstream from the centreline that does not appear to have defined inflows. During all four survey periods, there was insufficient water for the site to be fish-bearing. However, a single dead Ninespine Stickleback was observed near the crossing in spring 2021 that likely became stranded the previous fall, suggesting ephemeral connectivity to more frequently wetted fish habitat. There are two downstream barriers present between the rail crossing and the larger downstream river. One intermittent shallow water barrier, 350 m downstream from the centreline, that was present during all site visits. The second downstream shallow water barrier was located approximately 30 m from the centreline and was present during three site visits. There is also an upstream intermittent shallow water/subsurface flow barrier approximately 20 m from the rail crossing.	Only one dead Ninespine Stickleback was observed in spring 2021. Stickleback may use the habitat for rearing and maybe spawning but not overwintering. Arctic Char have not been captured or observed in this stream. All fisheries data collected for all studies for the Mary River Project since the first baseline surveys in 2006 indicate that char avoid shallow, silty, wetland/pond areas that are often intermittently connected to larger streams and lakes. So, though char could potentially access this area from the large downstream river during periods of high water, their presence is near the rail centreline is unlikely. The only fish observed in the area was a single dead Ninespine Stickleback present in spring 2021. Habitat near the rail crossing appears to be frequently inaccessible to fish due to intermittent barriers. Stickleback may use habitat for rearing/feeding and potentially spawning when the area is accessible, though there is a high risk of natural stranding. There is no overwintering habitat at this site.	None
SCV-50-2	CV-050-2	14.2 - 24.6	0.78	15.7	0.5%	0.20	0.18	0.16	N/A	N/A	N/A	N/A	This is a small, unnamed stream with a small catchment (0.78 km^2) that drains 1.2 km northeast to a larger river that flows another 18.5 km generally northwards to the Ravn River. There is a small pond 175 m upstream from the centreline and other ponds with intermittent connectivity in the area. There are two shallow water/subsurface flow barriers downstream and one permanent upstream barrier, which appears to be where the surface flows originate in this system.	Arctic Char have not been captured or observed in this stream. All fisheries data collected for all studies for the Mary River Project since the first baseline surveys in 2006 indicate that char avoid shallow, silty, wetland/pond areas that are often intermittently connected to larger streams and lakes. So, though char could potentially access this area from the large downstream river during periods of high water, their presence is near the rail centreline is unlikely. A dozen dead, likely winterkilled, Ninespine Stickleback were observed in spring 2021. In addition, a single young-of-the-year stickleback was captured in August 2021 and several larger individuals were observed in August 2022. These fish did not appear to have access to overwintering habitat at the time of the surveys. Habitat near the rail crossing appears to be frequently inaccessible to fish due to intermittent barriers and may result in stranding/winterkill. Stickleback may use habitat for rearing/feeding and spawning. There is no overwintering habitat at this site.	None
SCV-51-2	CV-051-3	Dry during surveys	7.22	18.2	0.5%	0.44	0.40	0.22	N/A	N/A	N/A	N/A	This is a small, unnamed stream with a medium size catchment (7.22 km^2) that flows from a large pond 400 m to the southwest to a smaller pond 20 m east of the rail centreline. There is another 50 m-long pond, 30 m upstream from the centreline. This system then flows another 1.3 km west to a large river that flows another 19.9 km generally northwards towards the Ravn River. This marshy site lacked connectivity to any nearby waterbodies and was reduced to unconnected pools or was completely dry. Due to the lack of connectivity, full habitat surveys were not conducted. There are no downstream barriers between the rail crossing and the downstream pond or the large river farther downstream. The maximum extent of potential upstream movements by fish in this system is approximately 4.4 km to the west at a pond with no additional inflows. There may be sufficient depth in some of these upstream ponds/lakes to support overwintering. The stream may become too shallow for fish passage during periods of low water between the centreline and the large upstream pond.	Arctic Char were not caught or observed in the vicinity of the rail crossing; however, the connectivity with a large, char-bearing river downstream suggests there is potential for rearing habitat in the area. There is no spawning, overwintering, or adult Arctic Char habitat in this stream. Ninespine Stickleback were captured during each of the four site visits, including some young-of-the-year during both August surveys. The stream provides potential spawning and rearing/feeding habitat for Ninespine Stickleback. There is no overwintering habitat for this species present in this stream.	None
SCV-52-2	CV-052-2	2.5 - 71	3.61	25.5	0.5%	0.38	0.30	0.58	105	54	105	110	This is a small, unnamed stream with a small catchment (3.61 km^2) that drains 246 m northeast from a small lake into a pond before flowing another 400 m northeast towards a large river that is a tributary of the Ravn River (approximately 18 km to the north). The small upstream lake has not been surveyed, but satellite imagery suggests potentially sufficient depth for some overwintering of both species. Depths in the downstream pond are likely insufficient to support overwintering. There are no downstream barriers between the rail centreline and larger downstream watersheds. The furthest upstream pond in this catchment (2.3 km to the southwest) lacks surface water inflows and is the farthest upstream extent of potential fish movements. In addition, during very dry periods (e.g., summer/fall 2022) the stream becomes disconnected from both the upstream and downstream lakes/ponds and is reduced to a series of unconnected pools over its entire length. There is a stranding risk for any fish present during these periods.	Arctic Char have not been observed at this site, but they are known to occur in the large downstream river. There is no spawning or overwintering for char here. Ninespine Stickleback have been captured in the stream. It supports spawning and rearing but not overwintering.	Treatment 1
SCV-53-1	CV-053-1	8 - 25	0.38	27.2	0.7%	0.20	0.16	0.23	105	150	105	150	Intermittent - can consist of unconnected pools during dry periods. This is an unnamed stream with a small catchment (0.38 km2) that flows 370 m southwest from a pond into a small lake. The stream at nearby CV-052-2 is an outflow of this same small lake. See the assessment sheet for site CV-052-2 for additional details about this watershed. The small downstream lake has not been surveyed, but satellite imagery suggests potentially sufficient depths for some overwintering for both species. Depths in the upstream pond could potentially also be sufficient for overwintering of at least some Ninespine Stickleback. There were no defined barriers upstream or downstream of this site. However, during very dry periods (e.g., summer/fall 2022) the stream can become disconnected from both the upstream and downstream lakes/ponds and reduced to a series of unconnected pools or completely dry up over its entire length. There is a stranding risk for any fish present during these periods as evidenced by the winterkilled stickleback found at the site in spring 2022.	Arctic Char have not been observed here, but have been observed in other waterbodies in this catchment for rearing. There is no spawning or overwintering habitat for char at this site. Ninespine Stickleback have been captured here and use the habitat for rearing. It is suitable for spawning but not for overwintering.	Treatment 1
SCV-56-1	CV-056-1	13 - 65	0.59	21.4	0.5%	0.21	0.17	Note 4	105	150	105	150	Intermittent - intermittent barriers during dry periods do not allow fish passage. This is an unnamed stream in a small catchment (0.59 km^2) that drains 2.2 km generally northeastward to some large ponds and, potentially, another 250 m towards a large river that is a tributary of the Ravn River. The site is also intermittently connected to several lakes/ponds >2 km upstream. There is potential for some of these waterbodies to have sufficient depth for overwintering. There were intermittent shallow water/subsurface flow barriers located 280 m downstream and 200 m upstream present during both of the August survey periods.	Arctic Char have not been observed and it is not known whether they are present in this watershed. Habitat could be suitable for juvenile rearing. Ninespine Stickleback have been captured / observed. They use this habitat for rearing and spawning, but it is not suitable for overwintering.	Treatment 1
SCV-57-3	LE-057-2	No data available	1.07	35.0	2.0%	0.52	0.42	Note 4	N/A	N/A	N/A	N/A	This is a lake encroachment site with a culvert installed in the embankment that will experience seasonal inflow and outflow. Part of a larger watershed with interconnected ponds/lakes. Small lake (1.01 km^2) with low flows (average July discharge of 0.056 m^3/s). The lake is small (450 x 1250 m). Satellite imagery suggest lake max depths that exceed 2.0 m.	Arctic Char have not been captured or observed and it is unknown if they are present. The habitat would be suitable for rearing and potentially spawning and overwintering if it is char accessible. Ninespine Stickleback have been observed or captured which provides rearing and potentially spawning and overwintering.	None

TABLE H.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

APPLICATION FOR FISHERIES ACT AUTHORIZATION
FISH PASSAGE ASSESSMENT

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Systra Culvert ID	NSC Baseline Report Site ID	Bankfull Width Est.[2]	Proposed Culvert(s)[6]					Modelled Baseline Flow Velocities	Fish Swim Distance Modelling				Physical Characteristics and Flow Regime[7]	Biological Characteristics	Mitigation Measure (see Report for descriptions)
			Catchment Area	Length	Slope	July Avg Velocity	Aug Avg Velocity		Maximum Swim Distance						
									July Size Class	July Swim Distance	Aug Size Class	August Swim Distance			
		Range (m)	(km^2)	(m)	(%)	(m/s)	(m/s)	m/s	mm	m	mm	m			
SCV-62-1	CV-062-1	31 - 53	4.41	25.4	0.5%	0.41	0.33	0.54	100	38	60	20	This is an unnamed stream that with a medium size catchment (4.48 km^2) that drains 3 km west into a small lake and then another 7.7 km generally northwestward to the south end of a large lake with overwintering potential in the mid-rail area. The stream also connects to a large pond 670 m upstream. The stream is relatively wide in areas with average wetted width along the surveyed reach ranging from 13.5 m in August 2022 to 32.6 m in spring 2021. Depths were generally shallow to moderate throughout the survey reach across all sampling periods, never exceeding 0.9 m and typically ≤0.5 m. There are no barriers between the rail crossing and the downstream lakes. There is one permanent barrier approximately 1.5 km upstream of the rail crossing where there is subsurface flow through a boulder garden.	Juvenile Arctic Char use the habitat for rearing. There is however no spawning, overwintering or adult habitat for char here. Ninespine Stickleback have been observed and use the habitat for rearing and potentially spawning. No overwintering for this species. During spring, Arctic Char at the crossing ranged from 100-180 mm in size. In August, this ranged from 40 to 180 mm.	Treatment 2
SCV-63-1	CV-063-1	18 - 25	6.43	23.8	2.1%	0.74	0.61	Note 4	N/A	N/A	N/A	N/A	This is an unnamed stream with a moderate catchment (6.43 km^2) that drains 2.8 km west to a small lake that may provide overwintering habitat. The watershed continues for another 7.7 km generally northwestwards before draining into the south end of a much larger lake. This stream drains some hills approximately 5 km to the east of the centreline. There were downstream and upstream intermittent shallow water/subsurface flow barriers present during four of the five survey periods. The downstream barrier was 870 m and the upstream barrier was 116 m from the centreline. The stream channel was mostly dry and comprised of unconnected pools in August 2022 and August 2023.	Neither Arctic Char nor Ninespine Stickleback were observed or captured in this stream in the vicinity of the crossing but were captured approximately 2 km upstream in a more consistently wetted reach of the watershed in August 2022 during other surveys associated with railway baseline data collection. Ninespine Stickleback are likely present in the lakes/ponds downstream and upstream and could potentially use habitat in this area during periods of very high flow. Arctic Char could similarly use habitat at the crossing centreline, though accumulated data for all Mary River Project studies suggests the species tends to avoid the shallow, marshy habitat found at CV-063-1.	None
SCV-64-1	CV-064-1	30 - 40.2	7.47	34.3	0.8%	0.52	0.47	0.38	N/A	N/A	N/A	N/A	This is an unnamed stream with a moderate catchment (7.47 km^2) that drains 3.3 km generally west to a small lake that may provide overwintering habitat. The watershed continues for another 7.7 km generally northwestwards before draining into the south end of a much larger lake. This stream drains some hills approximately 4 km to the east of the centerline. There were downstream and upstream intermittent shallow water/subsurface flow barriers present during four of the five survey periods. The downstream barrier was located 570 m and the upstream barrier was located 1.5 km from the centreline.	Arctic Char have not been observed or captured here. Char could potentially access this area but their presence near the rail centerline is unlikely. Ninespine Stickleback were found stranded in small, isolated pools and use the habitat for rearing, but not spawning or overwintering.	None
SCV-65-2	CV-065-2	15.4 - 49	0.50	22.1	0.9%	0.24	0.24	0.23	N/A	N/A	N/A	N/A	This is an unnamed stream with a small catchment (0.5 km^2) that drains approximately 4 km generally westwards into the south end of small lake and then another 7.7 km generally northwestwards before draining into the south end of a much larger lake in the mid-rail area. Neither of these downstream lakes has had detailed bathymetric surveys but satellite imagery and aerial surveys of both suggests depths are potentially sufficient to support overwintering. The watershed extends approximately 3 km upstream and includes a few small ponds along the main channel. There are no downstream barriers between the rail crossing and larger downstream watersheds. There was a subsurface flow barrier located 200 m upstream of the centerline, near the confluence with the adjacent channel crossed by the rail at site CV-065-2a, that was identified in spring and is likely permanent.	Arctic Char have not been observed or captured here, but the habitat near the centerline is suitable for rearing, but not overwintering or spawning. Ninespine Stickleback use the habitat for rearing and possibly spawning, but not overwintering. Fish were not captured or observed during either spring survey. One Ninespine Stickleback measuring 35 mm was captured in August 2022. Additional stickleback were observed as far as 380 m downstream and 160 m upstream from the centreline in spring 2023 during the barrier search.	None
SCV-65-3	CV-065-2a	20.3 - 33.5	0.50	21.3	1.7%	0.25	0.23	0.20	N/A	N/A	N/A	N/A	This is an unnamed stream in a small catchment (0.5 km^2) that drains approximately 4 km generally westwards into the south end of small lake and then another 7.7 km generally northwestwards before draining into the south end of a much larger lake in the mid-rail area. Satellite imagery and aerial surveys of the downstream lakes suggests depths are potentially sufficient to support overwintering. The watershed extends approximately 3 km upstream and includes a few small ponds along the main channel. There are no downstream barriers between the rail crossing and larger downstream watersheds. There was a subsurface flow barrier located 200 m upstream of the centerline, near the confluence with the adjacent channel crossed by the rail at site CV-065-2, that was identified in spring and is likely permanent.	Arctic Char have not been observed or captured at this site but habitat near the rail centreline is suitable for juvenile rearing if the species is present in the watershed. There is no overwintering or spawning habitat in this stream for Arctic Char. Ninespine Stickleback were not captured or observed at this site but were found in the adjacent channel crossed by the rail at site CV-065-2. The two branches merge approximately 320 m downstream from the centreline and stickleback may potentially use this site for rearing and possibly spawning. There is no overwintering habitat in this stream.	None
SCV-69-2	CV-069-2	58.3	2.13	36.0	0.5%	0.31	0.28	0.25	N/A	N/A	N/A	N/A	This is an unnamed stream on a small catchment (2.13 km^2) that drains 1.5 km southeast to a large river (northwest branch of the Cockburn River) that flows another 21.6 km generally southwards before draining into the north end of Cockburn Lake. Due to intermittent and potential permanent downstream barriers present during most surveys, detailed habitat assessments were not conducted.	See Note 3.	None
SCV-71-1	CV-071-1	16 - 70	4.68	36.9	0.5%	0.37	0.33	0.34	N/A	N/A	N/A	N/A	This is an unnamed stream on a moderate size catchment (4.68 km^2) that drains 570 m east to a larger river (northwest branch of the Cockburn River) that flows another 19 km generally southwards before draining into the north basin of Cockburn Lake. There are no downstream barriers between the rail crossing and larger downstream watersheds. There are no defined upstream barriers, but the source of surface water in this small stream is approximately 1.3 km upstream from the centreline where the stream collects meltwater from the hills to the west of the rail.	See Note 3.	None
SCV-72-1	NEWCULV-23	11 - 36.6	2.37	17.4	1.9%	0.53	0.42	Note 4	N/A	N/A	N/A	N/A	Intermittent - permanent upstream barriers. Stream can be reduced to unconnected pools in the summer/fall.	See Note 3.	None
SCV-73-1	CV-073-1	9.1 - 27.1	2.37	16.5	2.1%	0.46	0.38	0.49	N/A	N/A	N/A	N/A	This is an unnamed stream on a small catchment (2.37 km^2) that drains 375 m east to a larger river (northwest branch of Cockburn River) that flows another 16.8 km generally southwards before draining into the north end of Cockburn Lake. There are no downstream barriers between the rail crossing and the larger river. There is a permanent upstream barrier of subsurface flow in boulders approximately 45 m from the centreline.	See Note 3.	None
SCV-74-1	CV-074-1	4.4 - 11.36	0.71	19.9	2.5%	0.35	0.28	0.41	N/A	N/A	N/A	N/A	This is an unnamed stream on a small catchment (0.71 km^2) that drains 285 m south to a large river (northwest branch of the Cockburn River) that flows another 17.1 km generally southwards before draining into the north end of Cockburn Lake. In addition to the culvert crossing, a 135 m reach of this stream will be infilled by the rail footprint. There are five barriers affecting this rail crossing site. The stream branches into three channels upstream, each with a permanent barrier within 25 m of the centreline. Two barriers were identified downstream: one intermittent and one potentially permanent barrier. A downstream intermittent subsurface flow barrier was present approximately 185 m from the centreline where the stream flowed through a rocky channel during the extremely low water conditions observed in summer/fall 2022. A probable permanent barrier was identified within the rail footprint (near the centreline) where depths were consistently very shallow during each site visit.	See Note 3.	None
SCV-78-2	CV-078-2	5.3 - 6.4	0.11	35.0	6.4%	0.30	0.24	0.55	N/A	N/A	N/A	N/A	This is an unnamed stream on a small catchment (0.11 km^2) that drains 170 m east to a large river (northwest branch of Cockburn River) that flows another 12 km generally southwards before draining into the north basin of Cockburn Lake. There are two intermittent downstream barriers where the streamflow becomes subsurface in a mossy area under low water conditions (i.e., every August site visit). There is also a permanent upstream subsurface flow barrier in a boulder garden immediately upstream from the centreline (within the rail embankment). There was no surface water farther upstream from this barrier even during freshet.	See Note 1.	None
SCV-80-2	CV-080-1c	9.4 - 28.1	0.53	35.0	6.2%	0.41	0.33	Note 4	N/A	N/A	N/A	N/A	Intermittent - permanent barrier located downstream.	See Note 3.	None
SCV-81-6	CV-081-5b	26.9	0.20	25.2	9.9%	0.33	0.27	Note 4	N/A	N/A	N/A	N/A	Intermittent - intermittent subsurface flow and insufficient depth barriers located 45 m and 80 m downstream. No surface water upstream of the crossing.	See Note 3,	None
SCV-81-7	CV-081-5a	21.8 - 53	2.68	28.4	3.9%	0.58	0.47	0.64	N/A	N/A	N/A	N/A	Intermittent - upstream and downstream barriers.	See Note 3.	None
SCV-82-2	CV-082-2a	16 - 24	0.79	28.4	3.4%	0.38	0.31	0.49	N/A	N/A	N/A	N/A	Intermittent - both downstream and upstream barriers; both include intermittent subsurface flow.	See Note 3.	None
SCV-84-1	CV-084-1	Dry during surveys	2.02	33.6	14.0%	0.82	0.76	0.67	N/A	N/A	N/A	N/A	Intermittent - low point at rail centerline was dry during all site visits.	See Note 3.	None
SCV-117-2	CV-117-2	1.8 - 3	2.30	21.3	7.9%	0.80	0.67	1.36	105	5.8	95	7.6	This is an unnamed stream with a small catchment (2.30 km^2) that drains 580 m southwest to Cockburn Lake. There is an intermittent downstream barrier between the rail crossing and Cockburn Lake. In the fall, a subsurface flow barrier develops under low water conditions at, and in patches downstream and upstream of, the centreline. There are two intermittent barriers upstream of the rail crossing. In the spring, there is a high velocity barrier that is present under high water conditions 50 m upstream of the crossing. In the fall, there is a subsurface flow barrier that develops under low water conditions 120 m upstream of the crossing. There is also a probable permanent barrier approximately 1 km upstream from the site, where the stream flow becomes subsurface though a rocky channel that continues for hundreds of meters.	Juvenile Arctic Char use the habitat for rearing. There is no spawning or overwintering habitat. Ninespine Stickleback have not been captured of observed here, but may use the area for rearing during periods of high water. Spawning may also occur although there is a risk of stranding. There is no overwintering habitat here. Only one Arctic Char was caught (95 mm) in August 2023.	Treatment 3
SCV-117-3	CV-117-3	0.34 - 2.11	0.65	17.3	9.8%	0.54	0.43	1.07	N/A	N/A	N/A	N/A	This is an unnamed stream in a small catchment (0.64 km^2) that drains 600 m southwest to Cockburn Lake. This stream is split into two parallel channels at the centreline (see CV-117-4) but is merged into one channel 180 m upstream and 100 m downstream of the centreline. Most of the flow in this watershed is carried through the CV-117-4 channel; the CV-117-3 channel was dry or nearly dry during all site visits. There is an intermittent subsurface flow barrier downstream that develops under low-water conditions. There is an intermittent subsurface flow barrier 160 m downstream, where the stream is merged into a single channel, that develops under low water conditions. There is also a permanent steep gradient barrier with little surface water approximately 230 m upstream of centreline (also where the channels are merged).	Arctic Char have not been captured or observed in either channel. Due to its proximity to Cockburn Lake, juvenile Arctic Char could potentially use habitat in the vicinity of the rail crossing during periods of very high water for rearing. However, of the two, this channel is the least likely to ever support fish. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback have not been captured or observed in either channel. Stickleback may use habitat in the vicinity of the rail crossing during periods of very high water for rearing/feeding. There is no overwintering habitat for stickleback in this stream and, given the general lack of water, the stream unlikely to support spawning.	None
SCV-117-4	CV-117-4	1.1 - 4.6	0.65	20.2	5.9%	0.46	0.37	0.61	105	30	105	58	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-117-4 that drains 600 m southwest to Cockburn Lake. This stream is split into two parallel channels at the centreline (see CV-117-3) but is merged into one channel 180 m upstream and 100 m downstream of the centreline. Most of the flow in this watershed is carried by the CV-117-4 channel; the CV-117-3 channel was dry or nearly dry during all site visits. There is an intermittent subsurface flow barrier 160 m downstream, where the stream is merged into a single channel, that develops under low water conditions. There is also a permanent steep gradient barrier with little surface water approximately 230 m upstream of centreline, also where there is only a single channel.	Arctic Char have not been captured or observed in either channel. Due to its proximity to Cockburn Lake, juvenile Arctic Char could potentially use habitat in the vicinity of the rail crossing during periods of very high water for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback have not been captured or observed in either channel. Stickleback may use habitat in the vicinity of the rail crossing during periods of very high water for rearing/feeding. There is no overwintering habitat for stickleback in this stream and, given the general lack of water, the stream unlikely to support spawning. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-118-3	CV-118-2	4 - 8	1.70	23.8	13.5%	0.78	0.63	1.10	N/A	N/A	N/A	N/A	Intermittent - permanent high gradient vertical drop barriers exist upstream. Low water levels during August survey periods may also limit or impede fish movements upstream.	See Note 2.	None
SCV-123-4	CV-123-7a	2 - 6	1.05	23.0	3.7%	0.42	0.34	0.50	105	40	105	75	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-123-7a that drains 1.8 km generally southwestwards towards the south basin of Cockburn Lake. This stream is one channel within a highly braided reach of a much larger river. There are a total of seven distinct channels along the rail centreline that are part of this system. Approximately 700 m upstream and 700 m downstream from the CV-123-7a centreline, all seven channels are merged into a single large river forming an extensive alluvial fan. The hydrology in this area is complex, as the largest channels can become extensively braided during summer/fall. The smaller channels are more dynamic, changing their flow paths over time. There is also an exchange of water between and within branches via ephemeral connecting channels during periods of extreme flows. A bridge is proposed to span the first three channels at site CV-123-4a. The three remaining channels in this system are approximately 180-340 m south of site CV-123-7a; these channels will be crossed by of one culvert (site CV-124-1a) and two bridges (sites CV-124-2a and 3a). This channel transports less water than the channels to the north and, as a result, an intermittent subsurface flow barrier had formed by the August 2022 survey. The barrier was located 70 m downstream from the rail centreline before the stream channel merged with the other channels in this system. There are no upstream barriers between the rail crossing and several small lakes that are part of the upper watershed.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing throughout the open-water period for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback have not been captured or observed in this stream. It is unknown if the species is present in this stream but are known to occur in Cockburn Lake. No fish size data available. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1

TABLE H.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

APPLICATION FOR FISHERIES ACT AUTHORIZATION
FISH PASSAGE ASSESSMENT

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Systra Culvert ID	NSC Baseline Report Site ID	Bankfull Width Est.[2]	Proposed Culvert(s)[6]					Modelled Baseline Flow Velocities	Fish Swim Distance Modelling				Physical Characteristics and Flow Regime[7]	Biological Characteristics	Mitigation Measure (see Report for descriptions)
									Maximum Swim Distance						
			Catchment Area	Length	Slope	July Avg Velocity	Aug Avg Velocity		July Size Class	July Swim Distance	Aug Size Class	August Swim Distance			
		Range (m)	(km^2)	(m)	(%)	(m/s)	(m/s)	m/s	mm	m	mm	m			
SCV-124-1	CV-124-1a	4 - 19	1.64	30.6	4.5%	0.55	0.45	0.67	105	18	105	32	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-124-1a that drains 1.5 km generally southwestwards towards the south basin of Cockburn Lake. This stream is one channel within a highly braided reach of a much larger river. There are a total of seven distinct channels along the rail centreline that are part of this system. All seven channels merge into a single large river at approximately 700 m upstream from the centreline forming an extensive alluvial fan. The hydrology in this area is complex, as the main channels in both watersheds become extensively braided. The smaller channels are dynamic, changing their flow paths over time. There is also an exchange of water between and within branches via ephemeral connecting channels during periods of extreme flows. A bridge is proposed to span the first three channels at site CV-123-4a, 290-300 m to the north. Channels at sites CV-123-6a and 123-7a, 270 and 200 m to the north, respectively, are proposed culvert crossings. The three remaining channels in this system will be crossed by a culvert (site CV-124-1a; this sheet) and two bridges (sites CV-124-2a and 3a). The three CV-124 series of channels merge with each other within 200 m downstream of the rail centreline and then merge with flows from the four CV-123 channels another 180 m farther downstream. There are no downstream barriers between the rail crossing and Cockburn Lake. There are intermittent subsurface flow barriers 30-40 m upstream from the rail centreline that form during periods of low water. These barriers are found in rockier, steeper sections of the channel. Overall, the three CV-124 channels appear to transport less of the water in this catchment than the four CV-123 channels to the north and, as a result, are more prone to the formation of subsurface flow barriers during summer and fall.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing throughout the open-water period for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback have not been captured or observed in this stream. It is unknown if the species is present in the stream but are known to occur in Cockburn Lake. No fish size data available. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 3
SCV-126-1	CV-126-1-N	Dry during surveys	0.31	35.0	5.3%	0.33	0.27	Note 4	N/A	N/A	N/A	N/A	Discontinuous - permanent barrier upstream. Two additional permanent subsurface flow barriers present are located within the embankment footprint. There is also an intermittent downstream barrier; in spring this barrier becomes submerged within the wetted area of the pond.	See Note 1.	None
SCV-127-1	LE-127-1-Y	Dry during surveys	0.05	13.9	0.5%	0.08	0.06	Note 4	N/A	N/A	N/A	N/A	The pond at site LE-127-1-Y is small and ephemeral. It was wetted during site visits in August 2021 and July 2022 but completely dry in August 2022. The site could not be assessed in spring 2021 due to persistent ice and snow cover for the duration of the spring survey program. Although habitat quantity is limited and intermittent, the pond is part of a grassy marshy area with intermittent connectivity to other nearby ponds and lakes.	See Note 3.	None
SCV-127-2	LE-127-2-Y	No available data	0.03	13.6	0.5%	0.07	0.05	Note 4	N/A	N/A	N/A	N/A	The Steensby railway alignment crosses through a small bay that is part of a larger pond/lake at site LE-127-2-Y. The main inflow and outflow are both intermittently wetted. The pond has intermittent connectivity via its outflow with another pond to the south that is encroached on by the rail at site LE-127-3. Both the inflow and outflow experience insufficient depths/subsurface flows during periods of low water to provide fish passage. The site could not be assessed in spring 2021 due to persistent ice and snow cover for the duration of the spring survey program.	See Note 3.	None
SCV-127-3	LE-127-2h-Y	No available data	0.03	16.6	4.7%	0.13	0.10	0.12	105	150	105	150	The Steensby railway alignment encroaches a small pond at site LE-127-2h-Y. The pond was only surveyed in August 2023 as the previous rail alignment did not affect this waterbody. The pond had no defined inflow and a dry outflow at the time of the site survey in August 2023 but may connect to nearby ponds during high water conditions.	It is unknown if Arctic Char are present anywhere in this watershed, but they could use habitat in this pond for intermittent rearing, if present. The pond may provide intermittent rearing and potentially spawning habitat for Ninespine Stickleback. The pond is of insufficient depth to support overwintering. No fish were captured or observed. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-129-1	LE-129-1-Y	50.4 - 70.1	3.55	25.0	0.7%	0.41	0.39	0.29	100	38	130	84	The Steensby railway alignment crosses an unnamed stream at culvert site LE-129-1-Y that flows approximately 825 m east into an unnamed lake that likely provides overwintering habitat for both fish species. There is a large pond approximately 15 m upstream from the centreline that provides fish habitat but lacks sufficient depth for overwintering. In August 2023, the proposed rail alignment was moved approximately 25 m to the east from the alignment that was surveyed in 2021 and 2022. The crossing was previously located on the pond, whereas the current alignment crosses the lake outflow. The stream area affected by the current alignment was surveyed in July and August 2023. There are no barriers present between the centerline and a lake 825 m downstream that likely provides overwintering habitat for both fish species or the pond to the west of the rail alignment.	Arctic Char and Ninespine Stickleback have been observed/captured in this stream and the upstream pond during the open-water season. The stream provides rearing/feeding habitat for char. Ninespine Stickleback use the stream habitat for rearing/feeding and likely also for spawning. Depths are insufficient to support overwintering for either species. Arctic Char size ranges from 100 to 150 mm in July and 132 to 191 mm in August.	Treatment 1
SCV-131-1	CV-131-1	30 - 100.58	0.34	35.0	1.7%	0.22	0.18	0.23	85	130	85	130	This is an unnamed stream with a small catchment (0.34 km^2) that has complex flow patterns. Most of the surveyed area is marshy with no flow. During periods of high water, flows appear to run west to east from a small lake to a larger river/lake system approximately 580 m downstream. However, during periods of low water levels (particularly in the lake to the west), what little flow occurs appears to be draining both west and east from an unidentified high point in the middle of the marshy area. To maintain data consistency across seasons, habitat transects to the east of the centreline were considered downstream and those to the west were upstream. There are multiple intermittent subsurface flow barriers within the surveyed reach during periods of low flow. There are no permanent barriers preventing fish access to the rail centreline from either the small lake to the west or the larger river/lake system to the east. Ninespine Stickleback were occasionally observed in pools that had become disconnected from the main channel and no longer had access to upstream and downstream overwintering habitat during spring and August site visits. Stranding and subsequent winterkill may occur in portions of this stream.	There are multiple intermittent subsurface flow barriers within the surveyed reach during periods of low flow. There are no permanent barriers preventing fish access to the rail centreline from either the small lake to the west or the larger river/lake system to the east. Ninespine Stickleback were occasionally observed in pools that had become disconnected from the main channel and no longer had access to upstream and downstream overwintering habitat during spring and August site visits. Stranding and subsequent winterkill may occur in portions of this stream. Arctic Char size ranges from 83 to 154 mm in July and 82 to 163 mm in August.	Treatment 1
SCV-131-2	LE-131-1	No available data	0.34	27.7	0.7%	0.16	0.15	0.12	N/A	N/A	N/A	N/A	The Steensby railway alignment crosses a small pond at site LE-131-1. The main inflow is intermittently wetted and there is no defined outflow. During periods of low water, the inflow becomes shallow and subsurface flows are present. There was very little to no water in the channel during the August 2022 survey. The site could not be assessed in spring 2021 due to persistent ice and snow cover for the duration of the spring survey program.	See Note 3. All fisheries data collected for all studies for the Mary River Project since the first baseline surveys in 2006 indicate that char avoid shallow, silty wetlands/ponds that are often ephemerally connected to larger streams and lakes. So, though char could potentially access this area from other waterbodies within the catchment, their presence is near the rail centreline is unlikely.	None
SCV-132-1	LE-132-1	No available data	0.67	28.6	0.5%	0.18	0.17	0.14	N/A	N/A	N/A	N/A	The Steensby railway alignment will infill a portion of a large pond at site LE-132-1. The pond has a seasonally wetted inflow stream that connects upstream (west) to a series of ponds over a 3.2 km area, some of which may provide overwintering habitat for Ninespine Stickleback. There is no defined outflow though there are nearby ponds immediately to the east that may connect to LE-132-1 during periods of high water. The site could not be assessed in spring 2021 due to persistent ice and snow cover for the duration of the spring survey program.	See Note 3. Arctic Char have not been captured or observed. All fisheries data collected for all studies for the Mary River Project since the first baseline surveys in 2006 indicate that char avoid shallow, silty, wetland/pond areas that are often ephemerally connected to larger streams and lakes. So, though char could potentially access this area from other waterbodies within the catchment, their presence is near the rail centreline is unlikely. It is also possible that Arctic Char are absent from this entire small wetland/pond system.	None
SCV-133-3	CV-133-2	Dry during surveys	0.02	35.0	3.3%	0.10	0.08	0.13	N/A	N/A	N/A	N/A	The Steensby railway alignment crosses a small, unnamed stream at site CV-133-2 that drains 35 m southeast to a small lake. The origin of this stream is 20 m to the northwest where surface flows emerge from a rocky hillside. The rail was temporarily realigned approximately 20 m upstream prior to the August 2022 survey. Due to a downstream barrier and a general lack of water during all site visits, detailed habitat measurements were not collected at this site. Substrate composition was recorded as mostly fines and various sizes of cobble. There is a permanent barrier just downstream of the centreline where the stream is shallow and consisted of unconnected pools in spring 2022 and was mostly dry during summer/fall 2021, 2022, and 2023. However, the barrier is within the current rail embankment footprint and approximately 10 m of potential fish habitat may be affected downstream of the barrier. The site is not connected to any upstream overwintering fish habitat.	No fish were observed at this site during any site visit. However, there is potential use of habitat downstream of the permanent barrier within the rail embankment footprint for both species, particularly given the proximity of a potential overwintering lake downstream. If present in the stream, juvenile Arctic Char may use habitat within the rail footprint area downstream of the barrier for rearing during the spring when there is sufficient water depth. Ninespine Stickleback may also use the area for feeding in spring, but spawning is unlikely as the stream consistently dries up during summer/fall. There is no overwintering habitat for either species in this stream.	None
SCV-144-2	CV-143-2a	2.9 - 18.6	1.31	35.0	0.8%	0.32	0.26	0.38	105	90	105	150	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-143-2a that is part of a braided stream system shared by the culvert crossing at CV-143-2b. This system drains 170 m northwest to a pond and, from there, flows another 340 m generally westwards before draining into a larger lake that may provide overwintering habitat. To the west of this larger lake, this watershed includes a series of ponds/lakes with intermittent connectivity to Steensby Inlet. The stream will also be crossed by an access road at site AR-CV-144-2 approximately 80 m downstream. There are no downstream barriers between the rail crossing and the two nearest downstream ponds/lakes. There are permanent barriers 600 m upstream of this crossing consisting of a 1 m vertical drop and boulders in the main channel and subsurface flow in all other channels.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing throughout the open-water period for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream but these uses may be supported in some of the nearby lakes. There is potential for amphidromous juveniles to use habitat in this catchment, though their movements would likely be restricted to the lowermost streams/lakes closest to the coast. Ninespine Stickleback use habitat in the vicinity of the rail crossing throughout the open-water period for rearing and potentially spawning. There is no overwintering habitat for Ninespine Stickleback in this stream. Similar to char, there may be some amphidromous individuals using the lowermost reaches. They likely would not reach habitat as far upstream as this road crossing. No fish size data for Arctic Char. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-144-3	CV-143-2b	7 - 90	1.31	35.0	1.3%	0.37	0.30	0.43	105	58	105	110	The Steensby railway alignment crosses a small, unnamed stream at culvert site CV-143-2b that is part of a braided stream system shared by the culvert crossing at CV-143-2a. This system drains 170 m northwest to a pond and, from there, flows another 340 m generally westwards before draining into a larger lake that may provide overwintering habitat. To the west of this larger lake, this watershed includes a series of ponds/lakes with intermittent connectivity to Steensby Inlet. The stream will also be crossed by an access road at site AR-CV-144-2 approximately 80 m downstream. There are no downstream barriers between the rail crossing and the two nearest downstream ponds/lakes. There are permanent barriers 600 m upstream of this crossing consisting of a 1 m vertical drop and boulders in the main channel and subsurface flow in all other channels.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing throughout the open-water period for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream but these uses may be supported in some of the nearby lakes. There is potential for amphidromous juveniles to use habitat in this catchment, though their movements would likely be restricted to the lowermost streams/lakes closest to the coast. Ninespine Stickleback use habitat in the vicinity of the rail crossing throughout the open-water period for rearing and potentially spawning. There is no overwintering habitat for Ninespine Stickleback in this stream. Similar to char, there may be some amphidromous individuals using the lowermost reaches. They likely would not reach habitat as far upstream as this road crossing. No fish size data for Arctic Char. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1
SCV-144-5	AR-CV-144-2	No available data	2.61	28.7	0.6%	0.34	0.28	Note 4	105	75	105	130	An access road in the Steensby Port Area crosses a small, unnamed stream at culvert site AR-CV-144-2 that is part of a braided stream system. The Steensby railway alignment crosses this stream 80 m upstream from the road centreline at sites CV-143-2a and CV-143-2b (one culvert on each of the main channels). This system flows for 1.6 km, generally westwards, from a small lake (ST-38) upstream of the road crossing to a larger lake (ST-23) downstream. Both of these lakes appear to have sufficient depth to support overwintering, however a permanent barrier prevents fish access to the upstream lake (ST-38) from the road crossing area. There are also two smaller ponds along this reach: one 280 m upstream; and another 130 m downstream. The overall catchment includes several other ponds and lakes. This catchment also has intermittent connectivity to Steensby Inlet 1.2 km to the northwest. There are no downstream barriers between the rail crossing and the two nearest downstream ponds/lakes. There are permanent barriers 650 m upstream of this crossing where the main channel has a 1 m vertical drop with boulders in the channel and all other channels become subsurface flow.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing in the open-water period for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream but potentially in some of the nearby lakes. There is potential for amphidromous juveniles to use habitat in this catchment, though their movements would likely be restricted to the lowermost streams/lakes closest to the coast. Ninespine Stickleback use habitat in the vicinity of the rail crossing in the open-water period for rearing and potentially spawning. There is no overwintering habitat for Ninespine Stickleback in this stream. Similar to char, there may be some amphidromous individuals using the lowermost reaches. They likely would not reach habitat as far upstream as this road crossing. No fish size data for Arctic Char. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 1

TABLE H.2

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

APPLICATION FOR FISHERIES ACT AUTHORIZATION
FISH PASSAGE ASSESSMENT

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Systra Culvert ID	NSC Baseline Report Site ID	Bankfull Width Est.[2]	Proposed Culvert(s)[6]					Modelled Baseline Flow Velocities	Fish Swim Distance Modelling				Physical Characteristics and Flow Regime[7]	Biological Characteristics	Mitigation Measure (see Report for descriptions)
			Catchment Area	Length	Slope	July Avg Velocity	Aug Avg Velocity		Maximum Swim Distance						
									July Size Class	July Swim Distance	Aug Size Class	August Swim Distance			
		Range (m)	(km^2)	(m)	(%)	(m/s)	(m/s)	m/s	mm	m	mm	m			
SCV-149-1	CV-145	3.7 - 36	0.11	35.0	1.7%	0.14	0.11	0.14	85	130	110	150	The Steensby railway alignment and port access road cross a small, unnamed stream at culvert site CV-145 that drains a lake (ST-36) 460 m upstream from the centreline towards Steensby Inlet 430 m to the south. There is a second access road crossing on this stream approximately 200 m downstream of the rail centreline at site SP-AR-004. The rail alignment has undergone several changes over the course of the 2021-2023 baseline field studies and survey areas, centrelines, and associated upstream and downstream habitat transect locations and electrofishing survey areas have varied in accordance. The information presented herein from the 2021-2023 baseline field programs has been adjusted with reference to the current (i.e., November 13, 2023) rail centreline. The upstream lake has no fish-bearing inflows and is not connected to other lakes. It has sufficient depths for overwintering and spawning and likely supports isolated populations of char and stickleback with some potential for amphidromy (see below). Port area catchments were surveyed in spring 2021 for connectivity to the marine environment and barriers, but not for electrofishing surveys or full habitat assessments. There is an intermittent vertical barrier located approximately 60 m downstream of the rail centreline that was present in August 2021, 2022, and 2023 surveys. Higher water levels observed in spring 2022 had reduced the height of the drop, allowing fish passage to and from the upstream lake. However, there is a risk of fish stranding downstream of this vertical drop prior to freeze-up. In addition, the stream becomes very shallow and diffuse as it nears Steensby Inlet. Only during high tide, when seawater connects with the more channelized, deeper areas of the stream, is there potential access from marine habitat. Aerial surveys of the area during high tide in August 2023 confirmed connectivity. There are no barriers between the centreline and the upstream lake (ST-36). However, the inflow to this lake consists of subsurface flows from hills at its northeast end. Lake ST-36 is the upstream extent of fish movements in this watershed.	Juvenile Arctic Char use habitat in the vicinity of the rail crossing throughout the open-water period for rearing. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback also use habitat within the vicinity of the rail crossing throughout the open-water period for foraging and rearing and potential spawning. Arctic Char size ranges from 83 to 149 mm in July and only one fish was captured in August with a size of 110 mm.	Treatment 1
SCV-150-2	SPS-29a	18 - 38	1.21	35.0	3.4%	0.45	0.36	0.45	105	32	105	63	The Steensby railway alignment and port access road cross a small unnamed stream at culvert site SPS-29a, 50 m upstream from Lake ST-36. The stream is fed by subsurface flows that originate at multiple locations from a ridge along the north end of the valley separating lakes ST-353 and ST-36. The source waters flow from the ridge in opposing directions towards Lake ST-36 and ST-353 (also referred to as 3 km Lake) and There is no surface water connectivity between the two lakes. In August 2023, the rail alignment was shifted 10 m upstream from the 2021/2022 alignment. There is a permanent barrier within the rail/road centreline, which is the upper extent of surface flows draining west into Lake ST-36. There is no additional surface water father upstream of the crossing. Any fish use of habitat at the SPS-29a rail and road crossing is be limited to those populations in the ST-29 drainage. There are no downstream barriers between the rail and road centrelines and Lake ST-36.	Although they have not been captured in this stream, juvenile Arctic Char could potentially use habitat in the lower reaches of this stream for rearing when water levels are sufficient to allow access from Lake ST-36. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback have been captured in this stream and use it for rearing and potentially spawning. No fish data available. The mean fish size (105 mm) was used to assess fish passage in both July and August.	Treatment 3
SCV-AR-002	SP-AR-002	12.4 - 18	0.24	27.3	4.5%	0.18	0.16	Note 4	95	150	35	46	A proposed Steensby Port access road crosses a small stream at SP-AR-002. The stream drains a small, very shallow pond 290 m northeast and flows for another 250 m to a small lake (Lake ST-32) northwest of the road crossing. The downstream lake may have sufficient depths to support overwintering of both species. This stream is also crossed by the proposed airstrip from approximately 120-240 m upstream of the road centreline. There are several permanent barriers from 120-200 m upstream from the road centreline consisting of vertical drops, high gradient, and subsurface flows. These barriers are all within the footprint for the airstrip. There is an intermittent barrier located approximately 40 downstream from the road centreline consisting of subsurface flow under boulders that was present during August 2021-2023 surveys.	Arctic Char have been captured in this stream near the crossing, but they are more common near the downstream lake. Juvenile char could potentially use habitat from the lake upstream to the nearest barrier permanent barrier for rearing during the open-water period. However, there is a risk of stranding when water levels drop; a small juvenile captured in August 2023 was stranded in an unconnected pool and without increases in water levels would have been unable to return to the downstream lake prior to freeze-up. It is unknown if Ninespine Stickleback are present in the downstream lake. If present, stickleback could also use habitat up to the permanent barrier for rearing/feeding. Spawning is unlikely due to the intermittent connectivity and surface water in summer/fall. There is no overwintering habitat for either species in this stream. Arctic Char size ranges from 36 to 77 mm in August. In July, only one fish	Treatment 1
SCV-AR-004	SP-AR-004	11.8 - 45	0.67	21.0	5.0%	0.14	0.13	Note 4	85	130	110	150	A proposed Steensby Port access road crosses a small, unnamed stream at culvert site SP-AR-004. This stream drains a lake (ST-36) 650 m northeast of the road centreline towards Steensby Inlet 220 m to the south of the centreline. The upstream lake has no fish-bearing inflows and is not connected to other lakes. It has sufficient depths for overwintering and spawning and likely supports isolated populations of char and stickleback with some potential for amphidromy (see below). The stream is also crossed by the proposed rail and an access road approximately 200 m upstream (rail centreline). The stream is split into two channels, approximately 30 m apart, at the access road centreline. The channels merge 30 m upstream and 30 m downstream from the road centreline. There is an intermittent vertical barrier located approximately 145 m upstream of the road centreline that was present in August 2021, 2022, and 2023 surveys. Higher water levels observed in spring 2022 had reduced the height of the drop, allowing fish passage to and from the upstream lake. However, there is a risk of fish stranding downstream of this vertical drop prior to freeze-up. In addition, the stream becomes very shallow and diffuse as it nears Steensby Inlet. Only during high tide, when seawater connects with the more channelized, deeper areas of the stream is there potential access from marine habitat. Aerial surveys of the area during high tide in August 2023 confirmed connectivity. There are no barriers between the centreline and the upstream lake (ST-36). However, the inflow to this lake consists of subsurface flows from hills at its northeast end. Lake ST-36 is the upstream extent of fish movements in this watershed.	Juvenile Arctic Char use habitat in the vicinity of this crossing in the open-water period for rearing. However, there is a risk of stranding in downstream areas as water levels decrease in summer/fall. There is no spawning or overwintering habitat for Arctic Char in this stream. Ninespine Stickleback also use habitat within the vicinity of this access road crossing during periods of high water for foraging and rearing, and potential spawning, though the intermittent upstream barrier may cause stranding of juvenile stickleback in summer/fall. Arctic Char size ranges from 83 to 149 mm in July. In August, only one fish was captured with a size of 110 mm.	Treatment 1

I:\1\02\00181\86\A\Report\1 - FAA Application\Rev 0\Appendix H - Fish Passage Risk Assessment\[Table H.2 Fish Passage Assessment (might need to bump if we include AC fish catch data) WOG.GMJ.BAC-30JAN24.xlsx]Culvert Permitting Data UPDATED

NOTES:

1. PERMANENT FISH BARRIER UNDER THE RAIL EMBANKMENT, FISH PASSAGE NOT REQUIRED.
2. FISH BARRIER UPSTREAM OF THE CROSSING, MINOR HABITAT LOSS ASSUMED IN LIEU OF FISH PASSAGE.
3. ARCTIC CHAR ARE NOT PRESENT IN THIS TRIBUTARY. POTENTIAL NINESPINE STICKLEBACK HABITAT ONLY.
4. BASELINE CALCULATIONS NOT COMPLETED DUE TO HAVING NO SURVEY INFORMATION OR THE CROSSING HAVING NO DEFINED CHANNEL.
5. RESULTS OF THE DFO SPOT TOOL, BASED ON 50% PASSING OF THE SELECTED SIZE CLASS.
6. CULVERT DESIGN INFORMATION PROVIDED BY SYSTRA
7. INTERMITTENT FLOW REFERS TO STREAMS THAT DO NOT FLOW CONTINUOUSLY DURING THE OPEN WATER SEASON. FLOW ONLY OCCURS DURING FRESHET OR FOLLOWING RAINFALL EVENTS. AT OTHER TIMES THE CHANNEL MAY BE DRY AND/OR HAVE UNCONNECTED POOLS OF STANDING WATER.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	01FEB'24	ISSUED WITH REPORT NB102-181/86-1	GMJ	RAC

Key assumptions in this hydraulics analysis include:

- The culverts are multi plate pipe arch culverts made from corrugated steel
- Depths and velocities are associated with the hydraulic normal depth (i.e., there is no backwatering from downstream)
- Where the channel is split into multiple channels (e.g., at fans), flow is assumed to be uniformly distributed amongst the channels
- A Manning's n of 0.024 for CSP culverts (Hatch, 2018)
- A Manning's n of 0.045 for the embedded culverts (Charlotte-Mecklenburg, 2014)

All results presented in the following sections are modelled cross-section average velocity and maximum water depth results for the embedded culvert.

Field fisheries surveys have been completed at the fish-bearing water crossings along the Steensby Railway alignment from 2021 to 2023 (North/South Consultants Inc., 2024; Appendix F1). The field surveys were intended to provide empirical assessments of the presence/absence of fish, to identify fish barriers, and to document aquatic habitats in the water crossing streams. The monitoring has included habitat assessments including depth, wetted width, bank full width and velocities and assessment of potential fish use upstream and downstream of each applicable crossing.

It is assumed that the embedded culvert has a similar gradient and bed material roughness to the adjacent channel, therefore, it would be expected that the culvert would have similar hydraulic characteristics to the adjacent channel.

The measured data shows the variability in depth and velocity within a reach, which will be maintained in the culverts. Katopodis and Gervais (2016) note that fish can detect and utilize zones of lower velocity and that studies of fish movement through culverts have shown that small fish can take advantage of the low-velocity boundary layer along the culvert wall to achieve passage where hydraulic conditions permit (Light et al., 2013; Peterson et al., 2013; Powers et al., 1997). The concept of a low velocity "sweet spot" is shown on Figure H.3.

Katopodis and Gervais (2016) note that misrepresentation of swimming performance can occur when passage success is reported based on average velocity when in fact fish are using zones of lower velocity. The size of the fish relative to the low velocity zone is a factor in the ability to exploit these areas during passage. Hence, calculated average velocities should not be strictly interpreted as the flow velocity that the juvenile and young-of-year Arctic Char in the subject streams will need to pass.

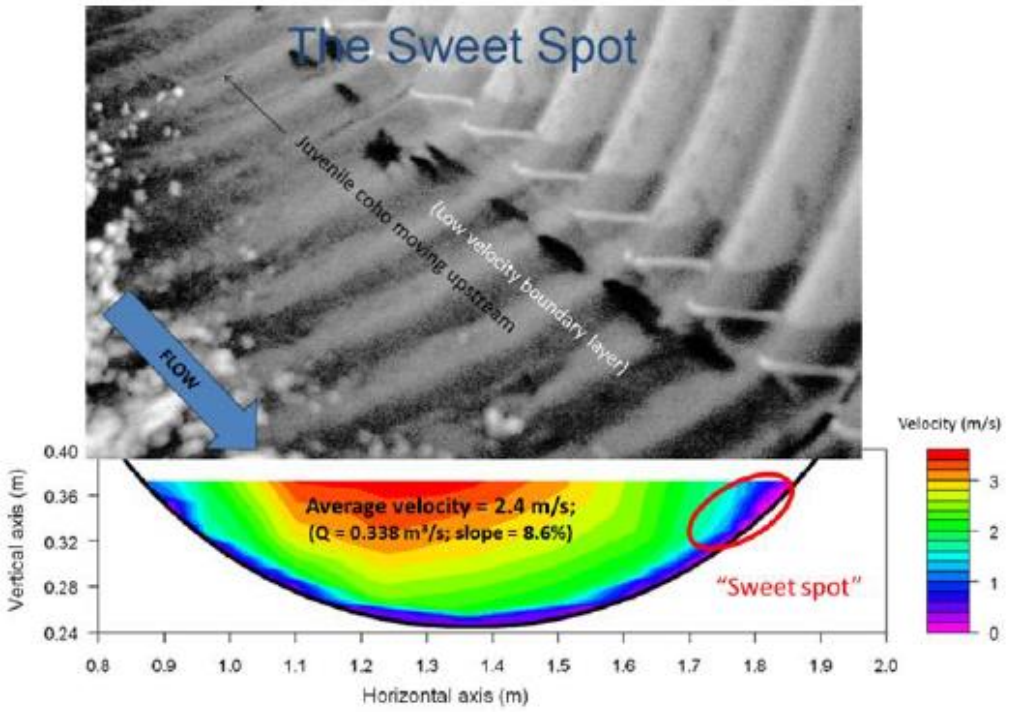

Figure H.3 Low Velocity "Sweet Spot" Used by Smaller Fish (Katopodis and Gervais, 2016)

5.0 FISH PASSAGE ASSESSMENT

5.1 FISH SIZE CLASS DETERMINATION

Fisheries data collected by North/South Consultants (NSC) was reviewed as part of this assessment. Information from the NSC habitat assessment sheets developed for each site detailing historic fish catch information including size and number of fish caught was reviewed (see Appendix 2 of Appendix F1, North/South Consultants Inc., 2024). Table H.3 summarizes the fish catch data from 2021, 2022 and 2023, including the number of fish collected, the mean and standard deviation fork length, and the range of fish sizes recorded during spring, summer/fall, and for both seasons. A graph presenting fork length – frequency data for all streams along the Steensby railway is presented on Figure H.4.

Table H.3 Fish Size Class Determination

Sampling Period	Fork Length (mm) Statistics			
	n	Mean	StdDev	Range
Spring	146	105.5	47.4	40-400
Summer/Fall	285	111.2	38.5	11-310
All Seasons	431	109.3	41.8	11-400

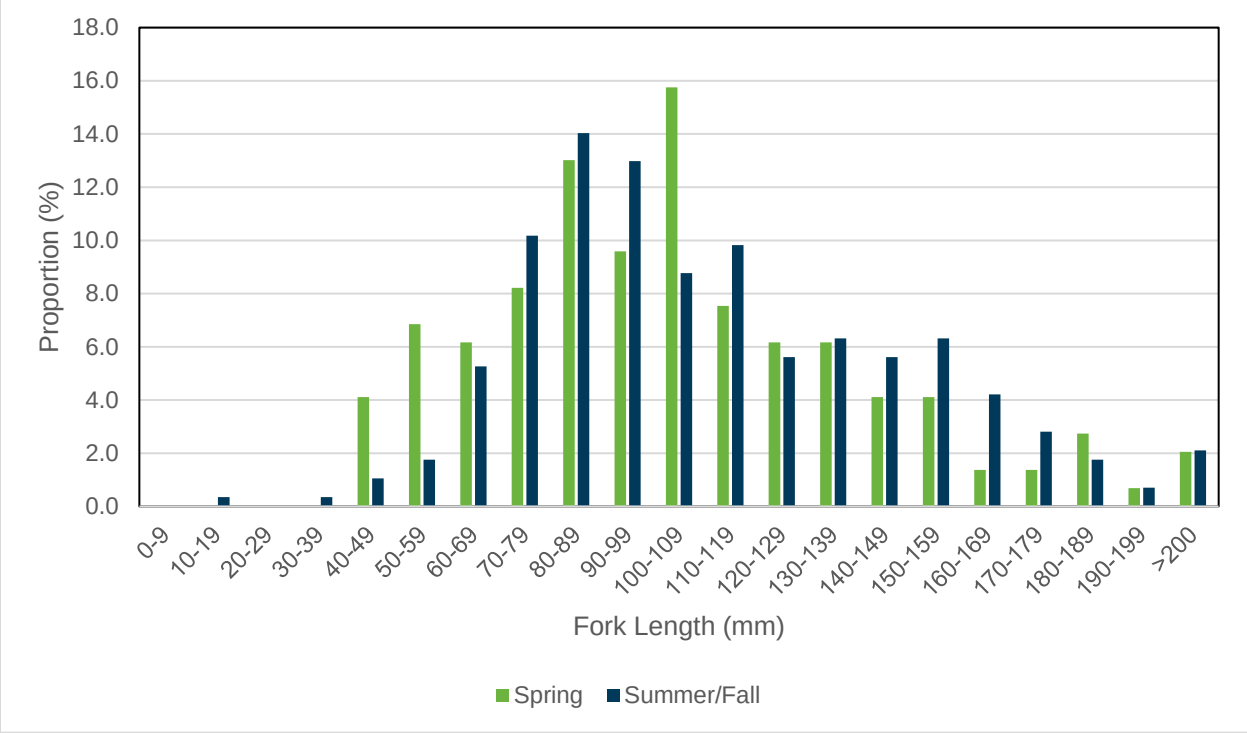

Figure H.4 Fork Length – Frequency Graph for All Streams Along the Steensby Railway

Based on the historical fish catch results, and correspondence with NSC a fish size class to be used for velocity thresholds was determined for each proposed water crossing. Where crossing-specific fish size classes were not available for one or both seasons, fish size data from a nearby similar crossing were used. Where this wasn't available, the mean fork length for spring of 105 mm was used. The size classes used in the assessment are presented in Table H.2.

5.2 MAXIMUM FISH SWIM DISTANCE

The modelled culvert velocity calculated for each water crossing and the associated fish size class was inputted into the DFO's Swim Distance & Water Velocity Tool (SPOT Tool; DFO, 2023). The SPOT Tool calculates the maximum swim distance that an Arctic Char of this size can swim against the modelled culvert velocity.

DFO requires that the obstruction of the free passage of fish is prohibited. KP has employed the 50% passing of the appropriate size class of fish as the means to determine if free passage of fish will be maintained on the basis that this is a conservative approach, considering the following factors:

The SPOT tool criteria used was for 50% of the applicable size class, which is determined to be reasonable for a number of reasons:

- The modelled culvert velocity is based on the average cross section velocity, and as discussed in Section 4.0 may be misrepresented as fish can find low velocity sweet spots and make their way up the culvert.

- The culverts will embedded 40% of the total diameter, and fish rest spots will be designed within each culvert at the distance specified by the DFO SPOT Tool.
- The minimum fish size captured previously in a given stream was used. For streams where fish had not been captured and sized, the mean size class for all streams in spring of 105 mm was adopted.

The maximum fish swim distance results can be seen in Table H.2.

5.3 FISH REST AREA DESIGN

Rest areas (i.e., velocity refugia) will be provided within culverts where the fish passage assessment indicates the selected size class fish cannot swim the entire length of the proposed culverts.

Three “treatments” are proposed to preserve fish passage, as follows:

- **Treatment 1** - Culvert will be embedded 40% with riprap and material like the natural streambed to create a rough surface with hydraulic diversity and velocity shadows throughout the culvert. The natural substrate placed within all culverts will ensure that roughness will be maintained even with some infilling of natural sediment load. This will be applied to all culverts where fish passage is required.
- **Treatment 2** - In addition to Treatment 1, for culverts with slopes <3%, boulder clusters will be placed within the embedded substrate of the culverts at the required intervals (Figure H.5). The boulder size required to withstand flows and remain in place will be determined by using force and moment stability analyses as described by the U.S. Department of the Interior (2015).
- **Treatment 3** - In addition to Treatment 1, for culverts with slopes >3%, step pools (Figure H.6) will be installed inside the length of the culverts using keystone-anchored step structures, as described by Moses and Lower (2003).

The results of the fish passage assessment, including which crossings require one of the above treatments, is presented in Table H.2. With the assigned mitigation measures, fish passage will be maintained post-remediation relative to baseline: 100 % of the fish passage will be maintained for those fish that wish to pass at various times of year.

Crossings where the assigned treatment is “none” are those where fish passage is not required, either because there is a permanent fish barrier under the embankment, or the decision was made to accept habitat loss at this location under the embankment and upstream to a permanent barrier located a short distance upstream of the crossing.

Issued for Construction (IFC) drawings for the crossings will include typical drawings for the natural substrate, boulder clusters, and step pools.

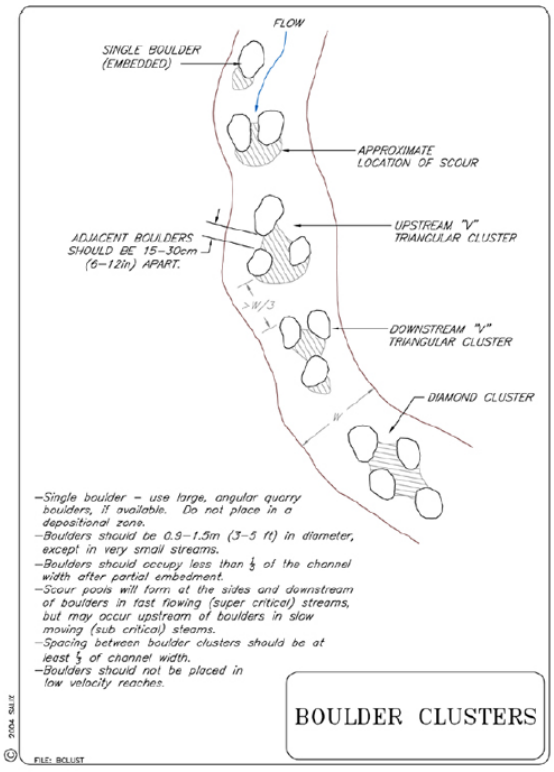

Figure H.5 Boulder Clusters Concept

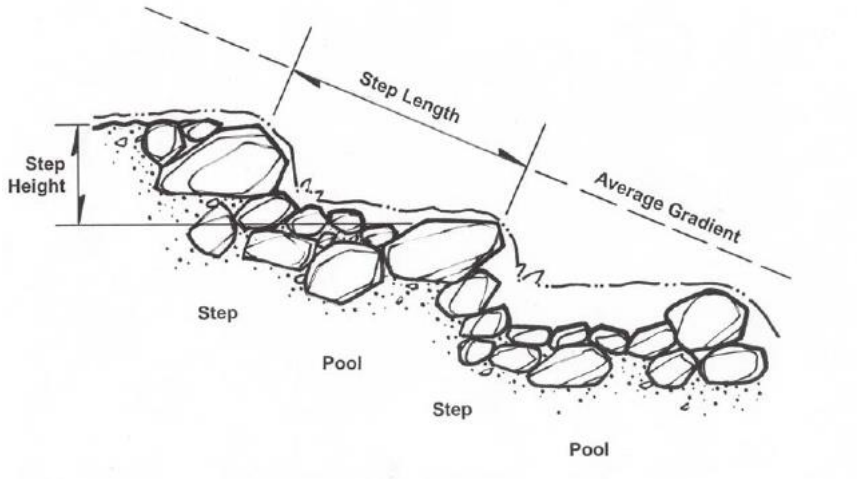

Figure H.6 Example Step Pool Design (Moses and Lower, 2003)

6.0 CONCLUSIONS

The results of the fish passage assessment are presented in Table H.2.

It was identified that fish passage was not required at several crossings, for the following reasons:

- A permanent fish barrier was identified under the rail embankment.
- A permanent fish barrier was identified a short distance of the crossing, which had a high slope, and thus fish passage is not proposed in lieu of considering the small amount of upstream fish habitat as a loss.
- Arctic char is not present in the stream.
- The crossing is a culvert that will be installed in a pond that the railway embankment encroaches, and thus there should not be a concern with increased velocities through the culvert.

For the above crossings (37 of 88), the mitigation measure for fish passage was identified as “none” in Table H.2. For the remaining 51 crossings where fish passage needs to be maintained, one of the three treatments described in Section 5.3 were identified to preserve fish passage. Of the remaining 51 culvert crossings the mitigation measures were identified as follows:

- 39 will require only culvert embedment with natural substrate plus some boulders so that streambed “roughness” will be maintained (Treatment 1)
- 4 will require boulder clusters to be installed at specified intervals within the culvert (Treatment 2)
- 8 will require step pools to be installed within the culvert (Treatment 3)

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