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ARCTIC GRAYLING PASSAGE CRITERIA – BACK RIVER PROJECT

To support the options analysis for the culvert replacement at the Rascal Stream West Reach 1 crossing, fish passage criteria, including target velocities and water depths, were developed to maintain upstream passage of Arctic Grayling (*Thymallus arcticus*). Rascal Stream supports a population of Arctic Grayling that spawns in various stream sections of Rascal Stream West between Goose Lake and Rascal Lake in early to mid-June (Sabina 2017). During spring freshet conditions, adult Arctic Grayling migrate from overwintering habitats in Goose Lake into lower Rascal Stream West, through Reach 1 (and under the existing crossing) to locations further upstream where there are suitable gravel substrates for spawning and egg incubation.

The distance Arctic Grayling could swim in a range of velocities before fatigue was calculated using the DFO Swim Performance Online Tools (SPOT) (Katopodis and Gervais 2016, DiRocco and Gervais 2020). Two fish lengths, an input for the fish passage calculations, were assessed based on the minimum and mean adult (mature) fish lengths (i.e., 200 mm and 300 mm, respectively) for Arctic Grayling that may use a small barren-ground watercourse for spawning in the central Canadian Arctic (De Beers 2015).

Two sets of design criteria are recommended to represent above-average flows in June for the passage of at least 50% of adult fish during peak movements of Arctic Grayling. The two sets of design criteria are intended to reflect the assumptions that larger fish are strong swimmers, and that larger fish have the potential to begin their migration upstream under higher flows, with smaller fish initiating their migration as peak flows subside. For reference, baseline velocities in Rascal Stream West Reach 1 were previously modelled as 0.57 m/s under June Q25 (75th percentile flows) and as 0.65 m/s under June Q10 (90th percentile flows) (Golder 2020a, b).

Therefore, the design criteria the Rascal Stream West Reach 1 crossing includes criteria based on the fatigue curve for a 20-cm length fish under June Q25 flows and the fatigue curve for a 30-cm length fish under June Q10 flows. This approach is considered a conservative assessment, in part, because of the focus on mean length of mature Arctic Grayling. Approximately 50% of the adult Arctic Grayling present Rascal Stream West Reach 1 are expected to be larger than 300 mm, and these fish would be able to pass using the criterion used in this assessment.

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Based on the outputs from the DFO SPOT, it is recommended that the design velocities are the following:

- less than 0.73 m/s (Table 1) for smaller-sized Arctic Grayling under June Q25 flows
- less than 1.02 m/s (Table 1) for typical-sized Arctic Grayling under June Q10 flows

If the velocities exceed the design criteria for the evaluated body sizes of adult Arctic Grayling, velocity mitigation (e.g., baffles, boulders) may be required. The swim distances provided in Table 1 can be used to inform the spacing of the velocity mitigation. For example, if the velocity is calculated to be 1.33 m/s under spring freshet flow, the velocity mitigation is recommended to be spaced 6 m apart to accommodate all sizes of mature fish that may be migrating at that time (i.e., six baffles or sets of large boulders positioned through the culvert).

For water depths, it is recommended that the water is at least 10 cm deep during typical flow conditions. This minimum depth is based on 1.5-times the expected maximum body depth of the Arctic Grayling using the watercourse (Maine DOT 2008), allowing for unrestricted access through the culvert. This is considered a conservative guideline as Arctic Grayling have an average body depth of 5.4 cm (calculated using 18.1% of the total length per FishBase [2020]), and based on this body depth measurement, Arctic Grayling would require a minimum water depth of 8.2 cm (i.e., 5.4 cm x 1.5) for passage.

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

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Attachment 1:Table 1

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Table 1: Swimmable Distance of Adult, Arctic Grayling (Before Fatigue) in Different Velocities[a]

Velocity (m/s)	200-mm fish length[b]	300-mm fish length[c]	Velocity (m/s) Continued	200-mm fish length[b]	300-mm fish length[c]	Velocity (m/s) Continued	200-mm fish length[b]	300-mm fish length[c]
0.64	56	150	1.10	11	31	1.58	3.8	10
0.66	51	140	1.11	11	30	1.60	3.6	10
0.68	47	130	1.12	11	29	1.62	3.5	9.6
0.70	43	120	1.14	10	27	1.64	3.4	9..2
0.72	39	110	1.16	9.5	26	1.66	3.2	8.9
0.73	38	100	1.18	9.0	25	1.68	3.1	8.6
0.74	36	100	1.20	8.6	24	1.70	3.0	8.3
0.76	34	92	1.22	8.1	22	1.72	2.9	8.0
0.78	31	86	1.24	7.8	21	1.74	2.8	7.7
0.79	30	82	1.26	7.4	20	1.76	2.7	7.5
0.80	29	79	1.28	7.1	19	1.78	2.6	7.2
0.82	27	74	1.30	6.7	19	1.80	2.5	7.0
0.84	25	68	1.32	6.4	18	1.82	2.5	6.8
0.86	23	64	1.34	6.1	17	1.84	2.4	6.5
0.88	22	60	1.36	5.9	16	1.86	2.3	6.3
0.90	20	56	1.38	5.6	15	1.88	2.2	6.1
0.92	19	52	1.40	5.4	15	1.90	2.2	5.9
0.94	18	49	1.42	5.2	14	1.92	2.1	5.8
0.96	17	46	1.44	5.0	14	1.94	2.0	5.6
0.98	16	43	1.46	4.8	13	1.96	2.0	5.4
1.00	15	41	1.48	4.6	13	1.98	0	5.3
1.02	14	38	1.50	4.4	12	2.00	0	5.1
1.04	13	36	1.52	4.2	12	2.02	0	5.0
1.06	12	34	1.54	4.1	11	2.04	0	4.8
1.08	12	32	1.56	3.9	11	2.06	0	4.7

(a) Arctic Grayling was used to calculate the swim distance using the Swim Distance and Water Velocity Tool (Katopodis and Gervais 2016, DiRocco and Gervais 2020).

(b) 230 m is the longest swimmable distance reported using SPOT for a 200 mm Arctic Grayling.

(c) 290 m is the longest swimmable distance reported using SPOT for a 300 mm Arctic Grayling.