Golder Associates

TECHNICAL MEMORANDUM

DATE 10 April 2017 **REFERENCE No.** 1114220046-670-TM-Rev0

TO Derek Holmes, Regional Manager, BC Aggregate Operations
BURNCO Rock Products Ltd.

FROM Dave Carter **EMAIL** Dave_Carter@golder.com

PIT LAKE HYDRODYNAMIC MODELLING FOR BURNCO AGGREGATE PROJECT - IMPLICATIONS TO FISH AND FISH HABITAT

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by BURNCO Rock Products Ltd. to prepare an Environmental Assessment Certificate Application/Environmental Impact Statement (EAC Application/EIS) for a proposed sand and gravel mine project ("the Project") within the Lower McNab Valley, approximately 35 km northwest of Vancouver, British Columbia. Sand and gravel will be extracted from an open pit using an electric powered floating clamshell dredge equipped with a primary crusher linked to a floating conveyor system. This equipment will be initially placed on the western area of the deposit and will dig downward and will form a pit lake (natural groundwater). The dredge will float on the surface of the pit lake and extract aggregate material. It is anticipated that the pit lake will gradually enlarge to size of approximately 28 ha over a period of approximately 16 years. The majority of groundwater seepage from the pit lake will enter the foreshore area downgradient (i.e., south) of the pit.

To evaluate the temperature of the groundwater seepage from the pit lake into the downgradient area, hydrodynamic modelling of the pit lake was performed. The predicted groundwater seepage temperatures to downstream creeks (including McNab Creek) are provided in a companion technical memorandum (Golder 2017). This technical memorandum uses those predictions to evaluate how potential changes in groundwater seepage temperatures may affect the fish and fish habitat in the downgradient watercourses WC 2 and McNab Creek.

2.0 RESULTS

The hydrodynamic model predicted monthly water temperatures in the pit lake at years 5, 10 and closure. The groundwater seepage from the pit lake into WC 2 and McNab Creek was then estimated by averaging the upper 5 m of the temperature profile. Essentially 100% of the groundwater seepage into the downstream watercourses originates from the pit lake at closure and post closure. In years 5 and 10, the groundwater seepage into the downstream watercourses from the pit lake represents a smaller portion of the groundwater input, the majority of the groundwater input is groundwater that by-passes the pit lake.

A comparison of estimated average monthly groundwater seepage temperatures (in Years 5, 10 and at closure) and 2011 observed temperatures in WC 2 and McNab Creek are presented in Table 1. A summary of documented temperatures supporting various salmonid life history events (McCullough et al. 2001) is provided in Table 2. To compare the predicted seepage water temperatures with life history events, a fish periodicity table for McNab Creek and WC 2 was developed based on local baseline information and published records (Groot and Margolis 1991; Figure 1).

Table 1: Estimated Groundwater Seepage Temperatures and Observed Temperatures in the Constructed Groundwater-Fed Channel and McNab Creek

	Estimated Seepage Temperature			**Observed Monthly Temperature Data (2011)***	
	Year 5: Monthly average (°C)	Year 10: Monthly average (°C)	Closure: Monthly average (°C)	WC 2: Monthly average (°C)	McNab Creek: Monthly average (°C)
Jan	5.29	4.68	4.56	7.03	2.78
Feb	4.91	4.47	4.38	6.49	2.55
Mar	4.96	5.12	5.15	6.35	3.07
Apr	6.35	7.65	7.91	6.42	4.13
May	8.14	11.2	11.8	6.89	4.94
Jun	8.98	12.4	13.0	7.34	6.12
Jul	9.42	12.7	13.4	7.75	8.45
Aug	9.34	12.2	12.7	8.25	12.0
Sep	8.90	10.7	11.1	8.56	12.2
Oct	9.41	9.67	9.72	8.17	8.62
Nov	8.17	6.88	6.62	7.82	4.97
Dec	6.92	5.85	5.64	7.29	3.19

Notes: * 2011 was a fairly average year for monthly temperatures and is considered a reasonable representation of normal temperatures.

Table 2: Temperature Considerations for Salmon and Trout Life Stages

Life Stage	**Consideration**	**Temperature Range (°C)***
Spawning	Spawning is most frequently observed	4 to 14
Incubation	Results in Good Survival	4 to 12
	Optimal Range	6 to 10
Juvenile Rearing	Lethal	23 to 26
	Optimal for growth	10 to 16
Adult Migration	Lethal	21 to 22
	Optimal Swimming	15 to 19

Notes: *Values derived from McCullough et al. (2001) and Bjornn and Reiser (1991).

3.0 DISCUSSION

Seasonal fluctuations in water temperatures can affect the distribution, health, and survival of salmonids. The life histories of salmonids are tied to water temperatures. Cooler water in the fall signal upstream migrations. Spawning is initiated when water temperatures decrease to suitable temperatures. Eggs incubate over the winter and early spring when temperatures are cool while spring water temperatures are a potential cue for smolt migration.

A review of the predicted groundwater seepage temperatures shows that the monthly average temperatures at closure have the largest seasonal range and are the most different when compared with observed temperatures in WC 2. At closure the groundwater seepage is approximately 1^{o} to 2.5^{o} C cooler during the winter (November to March) but remains within the temperature range where salmonid spawning most frequently occurs. The groundwater seepage temperatures during the winter are below the optimal range for incubation but within the range where incubation shows good survival. These predicted winter temperatures are above those observed in McNab Creek, where average temperatures fall below the range where incubation shows good survival.

The predicted groundwater seepage temperatures during the late spring (May to June) are 4^{o} to 6^{o} C above observed temperatures in WC 2. The predicted average monthly groundwater seepage temperatures for May are above the range for optimal incubation but within the range for good survival. In June the predicted average monthly groundwater seepage temperatures are 1^{o} C above the range of good incubation survival. All of the salmon with have emerged by this time but it is possible that cutthroat trout emergence could still be occurring. This is not considered a serious risk as the proposed offset habitat, to be constructed below the pit lake, will be better suited to spawning salmon as cutthroat trout tend to select small tributaries less than 1 m wide for spawning.

During the summer months (May to September) the predicted groundwater seepage temperatures are 2^{o} to 6^{o} C above the observed water temperatures in WC 2. This is expected to benefit juvenile salmonid rearing as the predicted monthly average temperatures are closer to, or within the range of, optimal growth of juvenile salmonids.

At closure it is predicted that some groundwater seepage from the pit lake will make its way into the lower reach of McNab Creek. The volume of groundwater seepage (0.029 m^3/s at the end of dry season and 0.013 m^3/s at the end of wet season) relative to the mean annual discharge of McNab Creek (4.4 m^3/s) is minor and unlikely to meaningfully effect the temperature of the creek. Irrespective of this, the groundwater seepage temperatures entering McNab Creek during this time will be the same as those entering WC 2 and will be similarly suitable for salmonids during their various life history stages.

Overall the predicted groundwater seepage temperatures are expected to be suitable for salmonids and are expected to support the function of the proposed offset habitat. This conclusion is consistent with those presented in the EAC Application/EIS.

4.0 CLOSURE

We trust that this information is sufficient for your immediate requirements.

Yours very truly,

GOLDER ASSOCIATES LTD.

<Original signed by>

<Original signed by>

Katelyn Zottenberg, BSc, RPBio
Environmental Scientist

Dave Carter, MSc, PBiol
Associate, Senior Environmental Scientist

KZ/DC/kv

Attachment: Figure 1: Watercourse 2 Fish Periodicity Table

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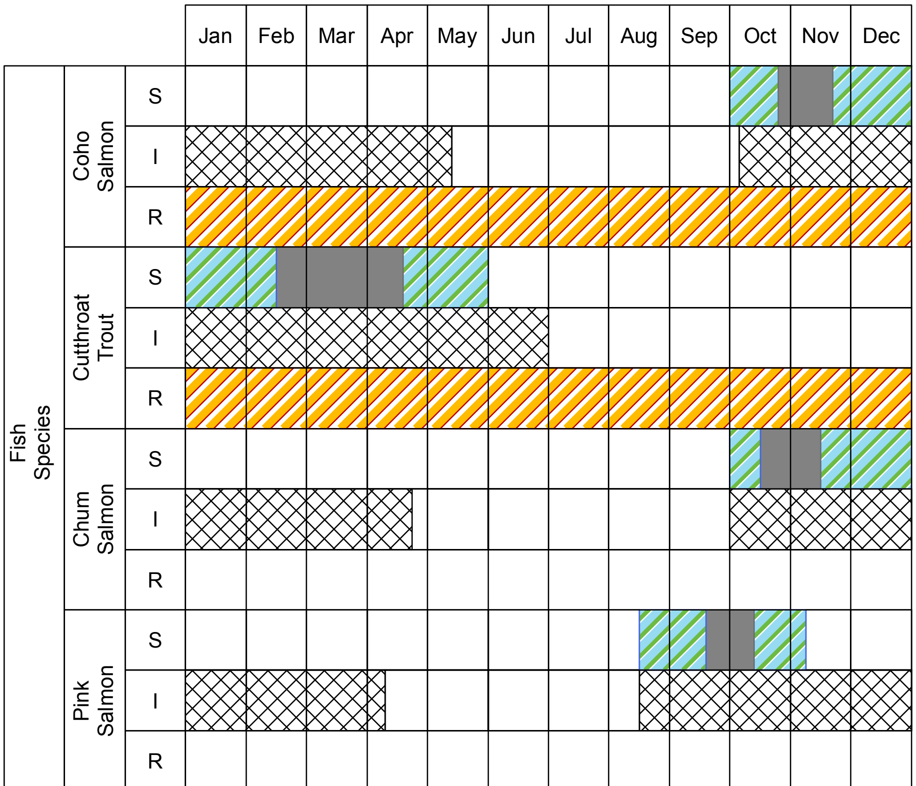
5.0 REFERENCES

Bjornn TC, Reiser DW. 1991. Habitat requirements of anadromous salmonids. Influences of forest and rangeland management on salmonid fishes and their habitats. Am Fish Soc Special Publ 19:83-138.

Groot, C.; Margolis, L., eds. 1991. Pacific salmon life histories. Vancouver, BC: University of British Columbia Press. 564 p.

McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue paper 5 summary of technical literature examining the physiological effects of temperature on salmonids: prepared as part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. Seattle, WA, U.S. Environmental Protection Agency, Region 10.



Average Monthly Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline 2011	7.03	6.49	6.35	6.42	6.89	7.34	7.75	8.25	8.56	8.17	7.82	7.29
5 Years	5.29	4.91	4.96	6.35	8.14	8.98	9.42	9.34	8.90	9.41	8.17	6.92
10 Years	4.68	4.47	5.12	7.65	11.2	12.4	12.7	12.2	10.7	9.67	6.88	5.85
Closure	4.56	4.38	5.15	7.91	11.8	13.0	13.4	12.7	11.1	9.72	6.62	5.64
Δ T at Closure	-2.47	-2.11	-1.20	+1.49	+4.91	+5.66	+5.65	+4.45	+2.54	+1.55	-1.20	-1.65

LEGEND

- SPAWN (S)
- PEAK SPAWNING (S)
- REARING (R)
- INCUBATION (I)

REFERENCE

PROJECT

BURNCO ROCK PRODUCTS LTD.
BURNCO AGGREGATE PROJECT, HOWE SOUND, B.C.

TITLE

WATERCOURSE 2 FISH PERIODICITY TABLE

Golder Associates

PROJECT NO. 11-1422-0046			PHASE No.	
DESIGN	DC	7 Mar. 2017	SCALE AS SHOWN	REV. 0
GIS	JP	10 Mar. 2017	**FIGURE 1**	
CHECK	KZ	10 Mar. 2017		
REVIEW	DC	10 Mar. 2017		

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