TECHNICAL MEMORANDUM

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TO Derek Holmes
BURNCO Rock Products

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PROPELLER WASH ASSESSMENT, HOWE SOUND, BC

Golder Associates Ltd. has undertaken a desktop analysis of horizontal velocities derived from propeller action associated with the passage and movement of commercial aggregate barge tug boats (tugs) to and from the proposed marine barge terminal site. The propeller wash assessment is developed in support of the EA for the BURNCO Aggregate Environmental Assessment Project in Howe Sound. The objective of the assessment was to compare the propeller-derived velocities and related potential for scour at depths with horizontal velocities and related potential for scour at depths associated with natural waves.

Tug vessel specifications were provided by BURNCO's proposed commercial tug operator (SeaSpan) for a typical aggregate barge tug:

- Propeller diameter 2.13 m;
- Propeller speed 150 rpm (in dock) 320 rpm (in transit);
- Transit speed 4 to 6 knots (approx. 3 m/s);
- Propeller centreline 2.5 m below water line;
- Target water depth at 20 m (depth of potential influence on glass sponge); and
- Target water depth of 3 m to 10 m for potential effects related to tug movements near the terminal.

The target water depth of 20 m was specified for the purposes of assessing potential velocity impacts to glass sponge reefs within Howe Sound. Twenty m is a minimum depth for potential sensitive sponge reef habitat (Dennison, G. 2012)[1]. No data regarding the physical features (e.g. roughness, slope, aspect) of 20 m target habitats was available. Target water depths of 3 m to 10 m were also specified for the purposes of assessing potential velocity impacts of tugs operating in the terminal area on benthic and fish habitats. These water depths were derived from available bathymetry of the terminal area.

[1] Dennison, G. 2012. Diving Howe Sound Reefs and Islands. Underwater Council of British Columbia, Vancouver, BC

1.0 METHODS

Estimates of propeller induced velocities were developed using the approach of Prosser (1986)[2]. Estimates of maximum horizontal velocity associated with wind waves were developed from waves hindcast from available wind data for the Strait of Georgia using the Halibut Bank Ocean Buoy (Environment Canada Station 46146). Wind data from Pam Rocks (Environment Canada Station 10459NN) was not used as the majority of the habitat sites identified are located towards the entrance Howe Sound and are often exposed to winds in the Strait of Georgia. Estimates of maximum surface tidal current (e.g. peak ebb and flood) were extracted from available sources (e.g. Buckley (1977)[3], Thompson (1981)[4],CHS Chart 3463[5], Stronach et al. (1993)[6]. Additionally estimates of peak current at depth provided by local scuba diving websites[7] were considered.

In the absence of data regarding the physical features of target habitats, estimates of velocity were used as a proxy for estimates of bed shear stress to evaluate the potential for scour impacts to the target habitat. A free water condition at the target depths allowed for comparison of derived velocities independent of roughness or drag effects of the bed.

2.0 RESULTS

Example wave conditions based on available data are summarized in Table 1. The fetch length presented in Table 1 is the longest fetch in Howe Sound from the BURNCO site at the McNab watershed at a direction of SSE (approximately 135 degrees). Typical water depths are in excess of 200 m therefore, the wind waves are expected to be limited by fetch. Longer fetches in Strait of Georgia would likely produce larger waves that may propagate into Howe Sound. These larger waves with longer wavelengths would likely result in greater velocities at depth near the mouth of Howe Sound but would likely be attenuated within Howe Sound by diffraction through the various channels.

Table 1: Estimates of typical wave heights and periods

Wave Event Return Period	Wind Speed (m/s)	Fetch Length (km)	Significant Wave Height (m)	Significant Wave Period (s)
Annual Average	5.0	17	0.4	2.4
5-year	22.9	17	2.6	5.7
100-year	27.1	17	3.3	6.3

Estimates of the peak ebb and flood tidal surface currents in Howe Sound are provided in Table 2. Some estimates are from near the entrance to Howe Sound, others are from the northern end of the sound.

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[2] Prosser, M.J. 1986. Propeller Induced Scour. BHRA The Fluid Engineering Centre, BHRA Project RP A01415, report prepared for the British Ports Association.

[3] Buckley, J.E. 1977. The currents , winds, tides of Northern Howe Sound. Unpublished Ph.D. Thesis, UBC Department of Phsyics and Institute of Oceanography, 246 pp.

[4] Thompson, R.E. 1981. Oceanography of the British Columbia Coast. Department of Fisheries and Oceans, Canadian Special Publications of Fisheries and Aquatic Sciences 56.

[5] Canadian Hydrographic Service. Chart 3463 Strait of Georgia, Southern Portion

[6] Stronach J.A., A.J. Webb, T.S. Murty and W.J. Cretney. 1993. A 3-D model of Suspended Sediment Transport in Howe Sound, BC. Atmosphere-Ocean 31(1), 73-97.

[7] http://www.best-scuba-diving-vacations-in-british-columbia.com/british-columbia-tides.html accessed May 26, 2014

The middle section of the sound appears to have lower peak ebb and flood currents based on Stronach et al. 1993.

Table 2: Estimated Peak Tidal Currents (Ebb and Flood) in Howe Sound

Estimated Peak Current	Location	Source
0.25 m/s at surface	Entrance to Howe Sound	Thompson (1981)
0.5 knots (0.25 m/s) at surface	Queen Charlotte Passage	CHS Chart 3463
0.15 to 0.2 m/s at surface	North and South Howe Sound	Stronach et al. (1993)
0.5 m/s at surface	Anvil Island to Squamish River	Buckley (1977)
Minimum 0.5 m/s at depth	Entrance to Howe Sound	Recreational diver reports

Buckley (1977) noted that currents were strongest at 10 m water depth in the northern part of Howe Sound. Based on the data provided in Table 2, the estimated peak current (ebb and flood) at 20 m depth is 0.5 m/s or higher.

A vessel in motion or using its propeller to remain stationary generates a fluid jet (propeller wash) directed in the opposite direction to the direction of the vessel travel. As the jet propagates through the water column, it widens and reduces in velocity. In free water, the fluid jet dissipates until its velocity is of the order of magnitude of background velocities derived from natural currents and waves. Based on the available vessel specifications, the corresponding estimates of velocity at the target depths were:

- The specified tug remaining stationary in the terminal area idling at 150 rpm may generate velocities in excess of 0.25 m/s to a distance of no more than approximately 120 m astern of the vessel for the water depths present at the terminal (3 m to 10 m water depth; Table 4). The zone of maximum velocity is only a few metres astern of the vessel at 3 m water depth, increasing to approximately 40 m astern of the vessel at 10 m water depth.
- The specified tug in transit at a maximum speed of 6 knots (approximately 3 m/s) operating at 320 rpm may generate maximum horizontal velocities of 0.04 m/s at 20 m water depth. The point of maximum velocity occurs approximately 180 m to the rear of the vessel. The distance behind the vessel of the point of maximum velocity is larger because the vessel is moving in the opposite direction to the direction of the fluid jet.

Velocities at the target depth are naturally derived from wave activity in Howe Sound. Using first order wave theory, and assuming deep water, peak horizontal velocity estimates were calculated. Based on the hindcast wind data:

- The Average Annual deep water wave in Howe Sound with a significant wave height (H_{sig}) of 0.4 m and significant wave period (T_{sig}) of 2.4 s results in negligible horizontal velocities at 20 m water depth.
- The 5-year deep water wave in Howe Sound with a H_{sig} of 2.6 m and T_{sig} of 5.6 s results in maximum horizontal velocities of 0.24 m/s at 20 m water depth.
- The 100-year deep water wave in Howe Sound with a H_{sig} of 3.3 m and a T_{sig} of 6.3 s results in maximum horizontal velocities 0.44 m/s at 20 m water depth.

The estimated velocities at 20 m water depth from the analyzed sources are summarized in Table 3.

Table 3: Summary of velocity estimates at 20 m water depth

Condition	Velocity Estimate (at 20 m water depth) (m/s)
Specified tug in transit at 320 rpm	0.04
Average Annual Wind Wave	~0
5-year Wind Wave	0.24
100-year Wind Wave	0.44
Tidal Current (peak ebb and flood)	0.50 or higher

Table 4: Summary of velocity estimates for specified tug idling at the terminal

Depth of Water	Max velocity astern	Distance to max velocity astern of vessel	Distance astern of vessel where velocities exceed 0.25 m/s
3 m	11.5 m/s	2 m	0 m to 121 m
4 m	2.6 m/s	7 m	3 m to 120 m
5 m	1.45 m/s	13 m	5 m to 120 m
6 m	1.01 m/s	18 m	8 m to 120 m
7 m	0.77 m/s	24 m	10 m to 119 m
8 m	0.63 m/s	30 m	14 m to 117 m
9 m	0.53 m/s	35 m	18 m to 116 m
10 m	0.45 m/s	41 m	22 m to 114 m

3.0 DISCUSSION

The fluid jet associated with propeller action from a tug remaining stationary at the terminal idling at 150 rpm appears to be the limiting case. The fluid jet associated with propeller action from a moving vessel typically dissipates into the surrounding environment faster than one associated with a stationary vessel because the point of generation of the jet is not fixed so the jet is not sustained at a given location. In general, sustained velocities greater than 0.25 m/s are required to suspend typical seabed sediments[8].

[8] US Environmental Protection Agency (USEPA) and US Army Corps of Engineers (USACE). 1998. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual Appendix C. Prepared By USEPA and Department of The Army, USACE. February 1998.

4.0 CONCLUSION

The specified tug idling at the terminal generates velocities in excess of 0.25 m/s to a distance of no more than approximately 120 m for the water depths present at the terminal (3 m to 10 m water depth). The specified tug in transit generates velocities at 20 m depth that are negligible. These generated currents are typically or the order of or less than the peak current occurring under the natural forcing of the tidal cycle.

Yours very truly,

GOLDER ASSOCIATES LTD.

Reviewed by

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