BRITISH
COLUMBIA

September 14, 2012

Environmental Protection File: PR-105809
Water Protection File: 38050-40 DUNC South Island Aggregates

To: Luc LaChance, P. Eng., Senior Environmental Protection Officer

Re: South Island Aggregates, Stebbings Rd. – Review of Application for an Authorization to Discharge Waste

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Thank you for the opportunity to review and provide comments on the hydrogeologic aspects of the application for authorization to discharge waste, associated with proposed contaminated soil relocation, remediation and disposal at the South Island Aggregates granite quarry on Stebbings Road., Cowichan (Lot 23, Plan VIP 78459, Blocks 156, 201 and 323, Malahat Land District).

The application and site details are outlined in:

1. Active Earth Engineering Ltd. October 2011. "Application for an Authorization to Discharge Waste and Technical Assessment Report, 693 Stebbings Rd. Malahat, BC V0R 2L0." Prepared for South Island Aggregates Ltd. (referred to herein as the Technical Assessment, TA); and
2. Active Earth Engineering Ltd. February 2012. "Clarification and Additional Information – Technical Assessment Report for Authorization to Discharge Waste, 638 Stebbings Rd., Shawnigan Lake, BC" (referred to as the Additional Information document, AI).

The Ministry of Forests, Lands and Natural Resource Operations, Water Protection Division review is limited to the evaluation of factors related to hydrogeology within the application and supporting documents, and selected information submitted by objectors to the proposed site use. The review does not include original research or hydrogeologic investigation of the site or neighbouring properties.

Assessment of potential impacts to adjacent groundwater users

Aquifer classification:

The Ministry of Environment (MoE) Water Resources Atlas is referenced as a source of information on mapped aquifers in proximity to the proposed site. The Technical Assessment (p. 9 and p. 22) notes that the Shawnigan Lake/Cobble Hill aquifer (203) is located approximately 2 km north of the site, and the Spectacle Lake/Malahat aquifer (208) is located approximately 1 km east of the site. The lack of a mapped aquifer at a location does not indicate the absence of a water producing geological unit underlying the area. The boundaries of aquifers mapped by the Ministry of Environment reflect the availability of well information, and level of aquifer development at the time when the classification was completed, therefore actual aquifer boundaries may differ from the published map extent.

The boundary of the Spectacle Lake/Malahat aquifer is not expected to extend to the SIA site, because the western boundary of the aquifer is delineated by the Malahat Ridge, believed to be a groundwater divide.

The Shawnigan Lake/Cobble Hill aquifer boundary may extend beyond its presently mapped extent based on additional information available from wells constructed in the area since the aquifer was initially mapped in 1996; the geologic unit comprised of Wark Gneiss is mapped at the site, and the classified aquifer is considered to be comprised of the same geologic materials. The SIA site is found within the upper, southern reaches of the Shawnigan Creek watershed (~11,000 hectares in area), which is a potential recharge zone for the Shawnigan Lake/Cobble Hill aquifer. The classification of aquifer 203 as a IIA aquifer indicates that it is considered to have a moderate level of development (relatively low productivity and moderate well density) and a high vulnerability. The vulnerability assessment is qualitative based on the fact that groundwater levels are shallow, and the confining layer overlying the aquifer is relatively thin and absent in some areas (median depth to bedrock is 2.4 m, and median thickness of the confining layer is 0.3 m, with 49% of wells used to classify the aquifer report no confining layer present)[1].

Inventory of adjacent wells and water supply systems:

The TA provides an inventory of wells that are located on adjacent properties within a 1 km radius of the site. This listing may not include all proximal wells. A proximity search completed for this review suggests a minimum of 15 known wells located within a 1 km radius of the SIA site, however, TA Table D lists only 11 (see also WTN's 85100, 85309, 96126 and 105940).

The TA states that the Contaminated Sites Regulation (CSR) drinking water standards do not apply to the site due to the low permeability of the upper bedrock unit, and considering that there are no drinking water wells in proximity to the site. In the Additional Information document (p. 6) further clarification is also provided, stating that there were no drinking water wells in a down-gradient orientation within a 1 km search radius (excluding the on-site well because it is not used for potable purposes). Note that WTN 96095 is located ~900 km due north of the property boundary (MoE WELLS database, 2012). WTN 83568 is located ~800 m northeast of the property boundary, and reported to have a depth of only 53 ft and a high estimated yield of 40 gpm, suggesting a moderate permeability of the shallow bedrock in that area (see comments on hydrogeologic characterization of the site, below). The assessment of potential impacts to adjacent users does not consider future uses of the aquifer, including development of new wells and groundwater supplies prior to starting the soil relocation activities in the area when the quarry activities cease.

The MoE WELLS database may not include records for all wells in an area. Furthermore, many of the well locations listed in the Water Resources Atlas are approximated e.g. to centre of lot. A door to door survey of neighbouring properties should be conducted to quantify the number,

[1] Gallo, M. 1996. Aquifer 203-Classification Worksheet. B.C. Ministry of Environment. (Unpublished).

location and status of use of wells that could be impacted by off-site contaminant migration (a direct survey is considered more reliable that using the MoE WELLS database on its own).

In addition to the general inventory of wells, the proponent should identify points of diversion and water supply system sources proximal to the site and assess whether they may be impacted by the activities. The proponent should contact the Vancouver Island Health Authority to determine whether there are any water supply system wells and/or surface water intakes proximate to the site that could be impacted by offsite contaminant migration. There are also reported adjacent surface water users that should be considered. For example, the BC iMap online mapping reference currently shows drinking water point of diversion on Stebbings Creek and Stebbings Lake upstream of the site (Licence numbers C126146 and C126047), and one drinking water point of diversion on Shawnigan Creek (Licence F014946) approximately 4 km downstream of the site.

Assessment of site hydrogeology

Limestone deposits, including fault exposures and karst topography have been reported in the surrounding area, including in the lands to the south of the SIA site, and northwest of Devereux Lake[2]. The South Island Aggregates on-site well (WTN 86152), perhaps erroneously, reports limestone intersected at 258 and 307 ft below ground (bgs). Similarly, WTN 95485 in the TA Appendix D describes "frequent white calcite layers" starting at 265 ft bgs. The SIA technical assessment should provide more details regarding the presence of limestone within the local or regional geology, and its affect on hydrogeologic conditions.

The hydrogeologic properties of the shallow and deep geologic units (hydrologic conductivity values, TA Table C, p.18) are provided based on a limited number of hydraulic response tests, specifically rising head slug tests, within the on-site monitoring wells. For example the conductivity value for the deeper bedrock unit is based on one rising head test. The recognized limitations of these types of tests include that the results are representative of properties of the zone immediately surrounding the well bore, compared to longer duration pumping tests or other methods appropriate to fractured rock e.g. packer tests. Slug tests can also underestimate the hydraulic conductivity of a unit for various reasons[3,4]. In general, the references, numeric values and assumptions used for analysis of the hydraulic response testing are not sufficiently described in the TA (Appendix E).

The proponent has not utilized test results from the on-site quarry water supply well (WTN 86152), that could provide an additional source of data on formation permeability, particularly if tested in conjunction with monitoring of adjacent on-site and off-site wells.

The TA (p. 18) indicates that a third monitoring point is required to determine with precision the gradient and direction of groundwater flow based on on-site monitoring well static water levels.

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[2] Gulf Island Geotechnical Services. November 19, 2007. Review of groundwater resource, Prepared for Living Forest Communities, Devereux Lake Project, Cowichan Valley Regional District.
[3] Weight, W.D. and J.L. Sonderegger. 2001. Manual of applied field hydrogeology. McGraw-Hill.608 pp.
[4] Butler, J.J., C.D. McElwee, and W. Liu. 1996 Improving the quality of parameter estimates obtained from slug tests. Ground Water, 34(3): 480-490.

More information should be provided on the direction of groundwater flow. The time of travel to neighbouring down-gradient wells should be estimated.

On TA p. 18 a hydraulic gradient estimate of 5.2% is based on an inference that Devereux Lake is connected with the deep bedrock aquifer. However, there may be a connection between the lake and shallower water systems (i.e. it is not clear why the lake is considered to be connected only to the 'deeper' regional groundwater system). The local topography, presence of other wetlands and the headwaters of two tributaries on the SIA site (e.g. TA Figure 4 and B.C. TRIM mapping) suggest that there may be a confluence of surface water at the margins of the site, with the potential to interact with the shallower bedrock unit.

The technical assessment describes the existence of an upper confining layer of low permeability bedrock overlying a more permeable bedrock unit through which the regional groundwater flow occurs. The conclusion that permeability would increase with depth within a bedrock unit is contrary to hydrogeologic theory that finds permeability commonly decreases with depth due to increased hydrostatic and lithostatic pressure from the overlying materials.

The technical assessment does not provide detailed hydrogeologic data based on drill core or well-bore caliper surveys of fracture locations in the on-site monitoring wells or water supply well (TA p.17), therefore the reported fracture detail for all wells (including offsite wells and monitoring wells), is based upon the limited understanding provided from (air rotary) drill logs. No data (with the exception of one record) are included on fractures intercepted by the monitoring wells within the drill logs in the TA Appendix D. Core drilling and caliper surveys provide more useful and detailed information on fracture distribution in bedrock units. A more robust data set may also be provided from utilizing core to construct additional planned monitoring wells on the site, in addition to completing hydraulic tests of the new monitoring wells. A greater distribution of monitoring well locations across the site is also important, considering the heterogeneous nature of bedrock formations.

The groundwater flow velocities reported for the upper and lower bedrock unit, and subsequent calculations of horizontal travel times to down gradient water bodies (TA p. 19-20), are based on the assumption that "the fractures are sufficiently interconnected that they emulate porous media" (p. 18, TA). This is in contrast to the description of the primary geologic unit underlying the site as being highly impermeable. By treating the unit as equivalent to porous media the inference is that contaminants would travel via diffusion into the bedrock matrix (essentially assuming no fractures), hence the travel times are exceptionally large e.g. $3x10^6$ years time of travel to Shawnigan Lake through the upper bedrock unit. A more conservative approach would consider that groundwater flow and contaminant transport is likely to be much higher in a bedrock unit due to preferential flow through fractures. This highlights the importance of characterizing the fracture system to a greater extent such as utilizing core for bedrock monitoring well construction, and utilizing methodologies to estimate time of travel that consider contaminant flow through fractures.

The TA p.21 states that water wells within the area are "drilled to the minimum depth required to produce necessary yield," therefore based on inferences from the reported fracture depths in selected well logs there is a low permeability layer from the surface to approximately 75 m below present ground surface. To provide more information on fracture depths from drill logs, Table D (p. 21) could include the reported depth to fractures for wells within 1 km of the site; as an example, WTN 93401 approximately 600 m to the southwest reports 20-40 gpm producing fractures at 23-24 m below ground surface, much shallower than the 75 m inferred depth of low permeability bedrock. The AI document states that WTN 93401 is constructed in the lower geologic unit, however, this suggests that the overall thickness of the low-permeability "shallow" unit is diminished up-gradient of the site.

In general, it should be noted that the well records in the MoE WELLS database provide approximate information from the driller notes at the time of well construction and cannot reasonably be relied upon for a high degree of technical detail, for example there may be unreported shallow fractures (either dry or low water-bearing) that could be conduits for groundwater and contaminant flow. Additionally, since the WELLS database primarily has records of wells constructed for water supply there is an inherent bias to higher permeabilities.

Figures 6 and 7 show the potentiometric surface based on available water levels, including the on-site monitoring wells. It is noted that there is no substantial difference between water levels within the wells screened in the "shallow" aquifer (MW1S, MW2, MW3S, MW3D) compared to the well screened into the "regional" aquifer, MW1D. If the two layers are separate units with distinct hydrogeologic properties, one might expect a difference in the groundwater levels rather than the monitoring wells exhibiting similar potentiometeric head. In the case of MW3D and MW3S the wells were artesian and the water levels in MW 1S, 1D, and MW2 were shallow and close to the current pit bottom (TA, Table C, p.17). The final pit bottom is projected to be at an elevation of 313.5 m above sea level; the proponent should evaluate whether there will be an intersection of the quarry extent with the regional groundwater levels, as is inferred by Figures 6 and 7, such that pit dewatering may be required. Monitoring wells constructed to the elevation of the final pit bottom would be useful in this regard; additional nested wells and transducer monitoring of groundwater levels at selected sites would also provide confirmation of the vertical groundwater gradient and possible seasonal variation of groundwater levels that might occur.

If an interception with the water table is likely to occur during the quarry excavation phase, the proponent should provide more information on how possible presence of groundwater seepage at the pit bottom might affect the integrity of the soil storage cells, and potential dispersal of contaminants, and should include more information on the plan for dewatering and managing the water that is generated. Presently the TA (p. 40) states that "minor amounts of shallow groundwater seepage may occur from fractures in the bedrock side slopes and from the base of the permanent soil containment area." Within the TA this was proposed to be discharged untreated to the surface water containment area and to Shawnigan Creek. The TA p. 25 notes that MW3-D and MW1-D are stated to exceed Contaminated Sites Regulation Aquatic Life standards for cadmium. It is not clear if water quality impacts to surface water bodies might arise if deep groundwater discharge to the adjacent creek(s) is to occur. From the AI it is not clear if groundwater seepage from the site will be treated, similarly to the leachate collected.

The laboratory results for sampling of the monitoring wells (Table 1 and Appendix F) indicate that for MW3S there were E. coli 10 MPN/100 ml and Total coliform 1940 MPN/100 ml, which suggests the influence of a surface water source on the well. The proponent should evaluate the possible source of the high bacterial counts and the implications with respect to well construction and permeability of the shallow geologic unit.

Environmental Monitoring Plan

The TA (p. 25) states that the environmental monitoring plan will include groundwater monitoring well sampling twice per year. The groundwater monitoring plan is further detailed in the AI, p. 24, including locations, parameters and timing of sampling. It is recommended that additional monitoring be considered if changes occur from baseline quality.

Closure Plan

Table F (P. 73. TA) indicates that monitoring will be conducted once per year in down gradient perimeter wells. It is recommended that the groundwater monitoring frequency be increased to a minimum of twice annually (quarterly sampling is more typical for landfill sites) in keeping with the monitoring of surface water, leachate and other sources.

Summary

The present application for establishment of a contaminated soil disposal site at the South Island Aggregates quarry has been reviewed with respect to technical detail in the hydrogeologic characterization of the site. Additional data and site characterization are required prior to this permit application being considered further. The specific areas of concern are as follows:

1. Assumptions related to the thickness and very low permeability of the underlying bedrock unit are not sufficiently validated by the field investigations and data presented. In some cases they are counter to prevailing opinion, and hence need to be properly substantiated. Additional data, including construction of monitoring wells using core drilling and distributing the monitoring sites more widely over the site should be undertaken to better characterize the formation permeability and location/density of shallow fractures. The proponent should also include the onsite water supply well as a part of their site characterization.
2. The occurrence of limestone and karst formations in the local area should be investigated and the importance of this to the hydrogeology of the site must be better understood.
3. The cause of high bacterial counts observed in onsite monitoring well MW3S should be investigated with respect to implications related to permeability of the shallow bedrock formation.
4. Additional field investigations are required to identify adjacent water users (surface and groundwater) rather than relying solely upon data from the MoE Water Resources Atlas and WELLS database.
5. The characterization methods and calculation of travel times to adjacent water sources (wells and streams) should utilize, in part, methods that consider the preferential flow and heterogeneity of bedrock systems (i.e. presence of fractures), which is a more conservative and realistic approach compared to treating the rock aquifer as equivalent to porous media.
6. Insufficient information is provided to understand whether the pit bottom will intercept the water table, and whether dewatering, collection and treatment of groundwater will be required as part of the operational plan.

The importance of groundwater for both present and future local water supplies and the long-term nature of the possible impacts related to the site, warrant such a detailed evaluation of site hydrogeology.

Submitted for your consideration,

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