March 7, 2018 Reference No. 088877

Mr. Allan Leuschen
Senior Environmental Protection Officer
Authorizations – South
Environmental Protection Division
Ministry of Environment
2080 Labieux Road
Nanaimo, British Columbia V9T 6J9

Dear Mr. Leuschen:

Re: 2018 Technical Work Plan and Schedule
Upland Landfill
Upland Excavating, Campbell River, British Columbia

1. Introduction

GHD has prepared this letter on behalf of Upland Excavating Ltd. (Upland) in response to the Ministry of Environment & Climate Change Strategy (ENV), February 1, 2018 letter regarding the Upland application for an Operational Certificate. As requested in ENV's February 1, 2018 letter, this letter provides the detailed work plan and schedule to address the recommendations listed in Section 5.1 of the Ministry Assessment Review Memorandum dated January 31, 2018 (Auth. No.:Pr-10807).

Clarifications of the Section 5.1 recommendations were discussed with ENV during meetings held on February 15 and February 26, 2018. The clarifications made during these meetings are summarized on the table "Points of Clarification for ENV Hydrogeologic Assessment" under the column titled "Feb 15 Meeting - Clarifications" which is attached to this letter as Table 1. A draft work plan framework was discussed during the February 26, 2018 meeting with ENV, where further clarifications were provided.

The following Work Plan provides a description of the work to be carried out to address the recommendations and provide the additional information required by ENV.

2. Work Plan

2.1 Task 1 - Leak Detection System

GHD will prepare the design of the leak detection system and a protocol for determining the location of the leakage through the primary liner should it occur. The leak detection system will be installed beneath the base of the landfill and leachate treatment pond. Figure 1 provides a conceptual schematic of the leak detection system design, which will consist of a sand drainage layer below the primary composite liner system. The secondary liner system beneath the sand drainage layer will include a 1.5 millimetre (mm) HDPE geomembrane and a geosysthetic clay liner (GCL).

![GHD]

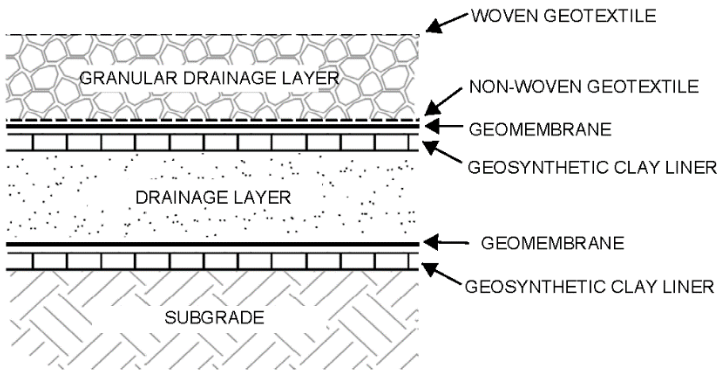

Figure 1 Base liner system with leak detection layer schematic

In the event of primary liner leakage, leachate will be collected and conveyed in sand drainage layer to perforated collection piping. The leachate will be contained by secondary liner system.

2.2 Task 2 - Integrated Contingency Plan

An Integrated Contingency Plan will be prepared for the Landfill. The contingency measures included in the Plan as summarized herein are considered practical and implementable. The conceptual design/implementation protocol for each of the contingency measures will be included in the Plan. The contingency measures include a leak detection system and operational controls, as follows:

- Include a leak detection system under the base of the landfill and leachate treatment pond to address potential concerns with increased leakage through the primary liner system.
- Operate the leachate collection system under dry condition to eliminate leachate head on the primary liner system.
- Replace or repair the primary liner system in the leachate treatment pond.
- Early deployment of intermediate or final geomembrane cover over completed /inactive phases of the landfill to reduce/eliminate generation of leachate.

The Contingency Plan will be integrated with the Trigger Level Assessment Program (TLAP) described in Task 3. Water quality and leakage rate monitoring will be carried out under the TLAP. The quality of the groundwater adjacent to the landfill and leachate pond and the quality of the water captured in leak detection system will be assessed relative to the water quality thresholds included in TLAP. The rates of leakage monitored with the leak detection systems will be subject to the leakage rate thresholds included in the TLAP. When TLAP thresholds are reached, contingency measures will be implemented.

2.3 Task 3 - Trigger Level Assessment Program

A three tiered TLAP will be developed to assess on-Site water quality and primary liner system leakage rates at the Site. Each of the tiers are described below.

2.3.1 Water Quality

Thresholds for water quality at the Site will be developed based on defined water quality standards that are protective of the downgradient environment. The trigger level program will define specific trigger monitoring locations, which will include monitoring locations immediately downgradient of the landfill footprint, the leachate treatment pond and the downgradient property boundary.

Tier I – Routine monitoring

Routine groundwater quality and leak detection system monitoring will be conducted quarterly following the schedule and analytical parameter list outlined in the DOCP (GHD, amended 2017). The regular long-term monitoring program will form the basis of Tier I monitoring.

Tier II – Confirmatory sampling and further investigation

If during a single monitoring event, three or more trigger parameter concentrations exceed the established trigger concentrations at a single trigger monitoring location, the Tier II Confirmation Monitoring program will be implemented. The Tier II Confirmation Monitoring program will consist of resampling the monitoring location under increased frequency. If the presence of water quality impacts are confirmed above the action level threshold, an evaluation of the degree, nature, and potential source(s) of the exceedance will be undertaken leading Tier III of the TLAP.

Tier III – Contingency remedial measures and compliance monitoring

Under the third tier, an implementation plan for the deployment of specific contingency measures and compliance monitoring will be developed. The purpose of compliance monitoring will be to assess and evaluate the effectiveness of the contingency measure(s) implemented. A specific compliance monitoring program cannot be detailed in the TLAP as the extent and type of future groundwater quality impacts, if any, are unknown. The TLAP will provide description of the action levels and scenarios for which the contingency measures outlined in the Contingency Plan will be deployed.

2.3.2 Primary Liner Leakage Rates

The anticipated maximum primary liner leak rate was determined using HELP modeling. Of the total maximum annual leachate generated approximately 0.121 m^3/year (0.00033 m^3/day) may potentially leak through the landfill base and enter the mixing zone beneath the landfill footprint. Additional clarification on the estimated liner leakage rate is included under Task 6 of this Work Plan.

Liner leakage rates will be monitored as part of the quarterly environmental monitoring program. Both the landfill and the landfill pond leak detection systems will be monitored.

Action level thresholds for liner leakage rates will be developed based on modeled rates and measured baseline leakage rates established through monitoring during the early stages of landfill development.

The trigger level program will follow the same tiers, as outlined in Section 2.3.1 above. Regular leak detection system monitoring will form part of the Tier I TLAP. If leakage rates are detected to be increasing over time or if a single monitoring event detects leachate leakage rates above the action level threshold Tier II monitoring will be initiated. Tier II monitoring will consist of monitoring at an increased frequency to confirm increased leachate leakage in the leak detection system over the threshold level. Contingency measures and continued monitoring will be implemented under Tier III, as required.

2.4 Task 4 - Potential Hydrogeologic Effects of Seasonality

Potential seasonal effects on groundwater flow at the Site will be assessed by updating the existing forecasted groundwater quality model to account for changes in groundwater elevations.

Seasonal changes in precipitation are anticipated to be reflected in changing groundwater elevations. It is expected that groundwater elevations will likely rise and fall uniformly across the Site with the seasons so that, while the saturated thickness may change, the average hydraulic gradient across the Site should remain generally consistent. However, changes in gradients as well as saturated thickness will be examined.

Groundwater flux (Q) will continue to be estimated using the hydraulic conductivity (K), the horizontal hydraulic gradient (i), and the saturated thickness of the aquifer unit (a).

$$\text{Groundwater flux} = K * i * a$$

As per the ENV recommendations, the hydraulic conductivity value will be rounded up to 2 x 10^{-2} cm/sec for the updated model. In addition, Patrick Consulting Inc. recommended that the model incorporate an uncertainty factor of ±10%. Similar to previous presentations, this uncertainty will be applied to the updated model.

GHD has carried out preliminary updates to the model scenarios to investigate sensitivities to changing conditions. To date, groundwater monitoring at the Site has been completed during January, March, April, September, October, and November (between 2015 and 2017). Hydraulic gradients for these time periods range from 0.026 to 0.031 m/m with a median value of 0.028 m/m. Groundwater elevations at MW3-14 have varied from 155.30 to 157.25 metres above mean sea level over the same time period which corresponds to a range of saturated thickness of 4.45 to 6.42 m.

The ranges in hydraulic gradients and saturated thickness with the rounded hydraulic conductivity results in flux estimate ranging from 405 to 1,040 m^3/day. In comparison, the results presented in the Technical Addendum letter estimated flux to range from 540 to 660 m^3/day. The Technical Addendum letter results were inclusive of the ±10% uncertainty and used a hydraulic gradient of 0.03 m/m, hydraulic conductivity of 0.017 cm/sec, and an average saturated thickness of 5.45 m.

The preliminary results show that the lowest flux estimates are still sufficient to attenuate the minor groundwater quality impacts related to the future landfill operation. All forecasted groundwater concentrations meet their respective BC CSR AW and DW criteria.

The forecasted groundwater quality model will be further updated to include a range of groundwater flux values to model different seasonal scenarios. Groundwater flux values will be calculated from groundwater elevation data and extrapolated for the various seasons based on climatic data. Worst-case scenario groundwater conditions are expected to occur under low groundwater flux conditions, as less dilution would occur. Lower groundwater flux conditions would typically occur during the dry season i.e. summer months.

The objective of the additional modeling is to determine the expected range groundwater quality under different seasonal groundwater conditions at the site and to determine the sensitivity of the water quality parameters to changes in input groundwater flux (as modeled by groundwater elevations).

The updated model results for the range of scenarios will be assessed against the Contaminated Site Regulation Drinking Water and Aquatic Life Standards to ensure that the anticipated performance of the landfill will result in groundwater quality that is acceptable with respect to legislative criteria.

2.5 Task 5 - Characterization of the Potential for Groundwater Discharge within 500 metres

Current Environmental has completed a survey to inventory the presence of surface water receptors in both a cross gradient (south west) and downgradient (south and south east) of the Site.

GHD has previously concluded that Site groundwater is not hydraulically connected to the wetland area and two streams identified by Current Environmental and that groundwater does not daylight within 500 m of the southern and eastern Site property boundary. Topographic data (1:20,000) accessed on the British Columbia (BC) Water Resources Atlas (February 21, 2018), shows that the surface water features identified by Current Environmental are located between contour lines 200 m and 240 m. Based on groundwater level data collected to date, Site groundwater elevations range from 176 m (upgradient) to 150 m (downgradient) AMSL and groundwater flow is in a northwest to southeast direction. The difference in elevation between surface water and Site groundwater suggests that groundwater cannot recharge the surface water features identified by Current Environmental since these surface water features are located cross-gradient of the Site and the groundwater table is at least 24 m below ground surface at these locations.

Topographic data for lands located within 500 m of the southern and eastern Site boundaries are between contour lines 180 m and 160 m. The difference in downgradient topography and the downgradient groundwater elevation of 150 m AMSL suggests that groundwater will not daylight within the area of the aquatic life assessment (i.e. within 500 m downgradient of the Site).

To verify the understanding of potential surface water and groundwater connectivity, Current Environmental will conduct a confirmatory assessment and prepare a full inventory and characterization of surface water receptors that are located within or in the vicinity of the lands within 500 m of the property boundary. GHD will prepare a detailed cross-section to illustrate the surface water and groundwater regime within 500 m of the site and the relevant proximal vicinity of the 500 m setback; and provide a technical justification for the surface water bodies being beyond any potential impacts from the Landfill.

2.6 Task 6 - Assessment for Potential for Liner Deterioration

A technical response to address the potential for and the timing of composite liner deterioration in the context of the landfill operating life and contaminating site life will be prepared. The Site life of the landfill is 25 years and the post-closure contaminating life span of the landfill is 28 years, based on the contaminating life span assessment presented in the DOCP. The technical response will be based on a review of literature on liner deterioration rates, the performance life of the selected liner system; and will provide clarification on the total estimated leachate leakage rate from the liner.

2.7 Task 7 - Additional Bedrock Characterization

Potential additional characterization of the bedrock hydrogeological properties includes characterization of the bedrock ridge between the pit and Rico Lake, and the rock beneath the pit floor.

Bedrock Ridge

An additional bedrock ridge monitoring well, MW14-17 was proposed in the Technical Addendum. To further characterize the geology of the bedrock ridge area, MW14-17 will consist of, at minimum, a shallow bedrock monitoring well within the upper weathered zone and a competent bedrock well below the upper weathered zone.

The deeper competent bedrock monitoring well will be installed through two steps. First, a borehole will be advanced through the overburden using 158 mm inside diameter (ID) hollow-stem augering techniques with regular split-spoon soil sampling. Dry HQ bedrock coring techniques will be used to advance through the augers and create a 97 mm diameter corehole through the upper weathered zone into competent bedrock. To increase characterization, continuous rock core will be extracted during corehole advancement. Frequency and orientation of any fracturing below the upper weathered zone will be noted. In order to allow for identification of potential groundwater flow within the competent bedrock, compressed air, not water, will be used to circulate drill cuttings during corehole advancement. It is anticipated that the competent bedrock corehole will be advanced to a depth of 4.5 m below the top of bedrock surface.

Hollow-stem augering techniques will be used to advance through overburden to facilitate the installation of the shallow weathered bedrock well. Tricone bedrock drilling methods will be used to advance into the weathered bedrock surface. It is anticipated that the shallow weathered bedrock corehole will be advanced to a depth of approximately 1.5 m below the top of bedrock surface. The stratigraphy observed in the competent bedrock corehole will be used to determine an appropriate depth for the weathered bedrock monitoring well.

Each monitoring well will be instrumented with 51-mm diameter flush-threaded SCH. 40 PVC well screens (#10-slot) and SCH. 40 PVC riser pipes, silica sand pack, bentonite gravel seal and completed with a concrete surface seal with above-ground protective steel casing. It is anticipated that the bedrock monitoring wells will be completed with 1.5 m long screens, however, the installation details will be adjusted to suite the stratigraphic conditions encountered in the field.

Once installations are complete, both monitoring wells will be developed to clear debris from the drilling process. Development will consist of removing 5 to 10 well volumes or until purge water is stable and visually clear (i.e. measured pH, conductivity, and temperature of purge water is consistent between purge volumes). Development will be completed using dedicated standard diameter tubing and inertial foot valve equipment.

Following development, additional hydraulic conductivity testing in the new competent bedrock well will be completed. Hydraulic conductivity, K, values and bedrock fracture characterization will provide additional evidence to support that potential for leachate migration through the bedrock ridge can be ignored.

Groundwater sampling at the additional nested bedrock ridge monitoring wells and Site-wide hydraulic (water level) monitoring will be completed one week following well development. Groundwater samples will be collected using inertial purging/sampling methods consistent with previous groundwater sampling events at the Site. Samples will be analyzed for general chemistry, nutrients, and dissolved metals parameters. Field parameters (pH, conductivity, temperature) will be recorded at the time of sampling.

The relevant sections of the HHCR report will be updated to provide documentation of the well installation(s), stratigraphic logs, updated geologic cross-sections, an updated assessment of existing water quality, and a reassessment of the potential hydraulic connection between Rico Lake and the Site. A discussion of any potential implications for the performance of the landfill design will be provided.

Pit Floor

GHD does not believe that further assessment of the degree of fracturing in the shallow weathered bedrock below the pit floor is needed.

Significant fracturing has been noted in the boring advanced within the Pit (MW4A-15), including evidence of weathering (i.e. iron staining) and secondary mineralization observed in some fractures. Analysis of hydraulic conductivity testing of the weathered zone gives a K ~ $2x10^{-2}$ cm/s, which is very permeable and essentially an equivalent porous media. As a result, the upper weathered bedrock zone and overlying sand and gravel aquifer can functionally be considered the same hydrogeologic unit.

For the competent bedrock, K ~ 1 10^{-5} cm/s which is three orders of magnitude lower than the sand and gravel/weathered bedrock K. Anderson and Woessner (1992)[1] indicate that just a two order of magnitude contrast in hydraulic conductivity between adjacent strata may be sufficient to consider the lower conductivity unit as an impermeable boundary. This conclusion is based on the findings from Freeze and

[1] Anderson, M.P., and W.W. Woessner, 1992. Applied Groundwater Modeling, Simulation of Flow and Advective Transport, Academic Press, Inc., San Diego, CA.

Witherspoon (1967)[2] and Neuman and Witherspoon (1969)[3] that a hydraulic conductivity contract of two orders of magnitude or more causes refraction in flow lines such that flow in the higher conductivity strata is essentially horizontal and flow in the lower conductivity strata is essentially vertical. If the hydraulic gradient across the two strata is low (directed either from the higher to lower permeability strata, or from the lower to higher permeability strata), the magnitude of flow exchanged between the two strata will be negligible.

On this basis, GHD believes additional bedrock wells (shallow or deep) beneath the floor of the Pit are not warranted at this time.

2.8 Task 8 - Sand and Gravel Aquifer Pumping Tests

Single Well Response Tests (SWRT) were previously completed in the sand and gravel aquifer monitoring wells MW1-14, MW3-14, MW4B-15, and MW9-17. The results showed that hydraulic conductivity of the aquifer is approximately 2×10^{-2} cm/sec. To provide further confidence to the estimated hydraulic conductivity of the sand and gravel aquifer, GHD will undertake an aquifer pumping test. A pumping test will allow for hydrogeologic characterization of the sand and gravel aquifer over a wider radius and longer time period.

An 8-hr constant rate and follow-up recovery test will be completed in the sand and gravel aquifer at MW4B-15. MW4B-15 will be equipped with a temporary pump. Given the high hydraulic conductivity of the sand and gravel aquifer, a significant pumping rate will be needed in order to have an influence on the aquifer surrounding MW4B-15. In addition, the discharge of extracted groundwater will need to be temporarily stored or be redirected downgradient of the pumping well in order to infiltrate into the subsurface without influencing water levels in the vicinity of MW4B-15. A licensed well-drilling subcontractor familiar with pumping large quantities of groundwater will be retained to assist in completing the pump test setup. Prior to beginning the pump test, GHD will complete all necessary water use approvals with the ENV.

Electronic pressure transducers will be temporarily installed in the sand and gravel aquifer monitoring wells MW3-14, MW2-14, and MW2A-16 as well as in the shallow bedrock well, MW4A-15. Water levels will be recorded via the pressure transducers prior, during, and after the constant rate test. GHD field staff will also collect manual depth to water measurements to confirm and calibrate the measurements collected by the pressure transducers. Manual depth to water measurements will be taken at increased frequency at MW4A/B-15 throughout testing.

The time-drawdown and distance-drawdown data obtained from testing will be used to calculate the sand and gravel aquifer's hydraulic conductivity and transmissivity values. These values will be compared against the results of the SWRTs.

[2] Freeze, R.A., and P.A. Witherspoon, 1967. Theoretical Analysis of Regional Groundwater Flow: 2. Effect of Water-Table Configuration and Subsurface Permeability Variation, Water Resources Research 3(2), pp. 623-634.

[3] Neuman, S.P., and P.A. Witherspoon, 1969. Theory of Flow in a Confined Two Aquifer System, Water Resources Research 5(4), pp. 803-816.

3. Reporting

GHD will prepare a technical response in letter format to address the recommendations provided by ENV in the Ministry Assessment Review dated January 31, 2018. The technical letter will include the information generated by undertaking Tasks 1 through 6 as described in Section 2 of the Work Plan. The additional bedrock characterization (Task 7) and the aquifer pumping test (Task 8) will be carried out upon issuance of the draft OC and results will be presented in the final versions of the Design, Operations and Closure Plan (DOCP) and Hydrogeology and Hydrology Characterization Report (HHCR). The final versions of the DOCP and HHCR will include any amendments that may be required to comply with the conditions of the OC.

4. Schedule

The proposed schedule for completing the tasks outlined in the Work Plan is provided below. The technical response for Task 1 to 6 is intended to be submitted to ENV by March 21, 2018 (within 60 days of ENV's February 1, 2018 letter). It is anticipated the additional bedrock characterization (Task 7) and aquifer pumping test (Task 8) will be carried out in Q2/Q3 with the final DOCP/HHCR finalized in Q3/Q4.

Table 4.1 Schedule

Tasks	Estimated Timing
Submission of Detailed Work Plan	March 7, 2018
Submission of Technical Letter for Tasks 1 through 6	March 21, 2018
Completion of additional bedrock investigation	Q2/Q3 2018
Completion of additional aquifer pumping tests	Q2/Q3 2018
Submission of final revised DOCP and HHCR including work completed for Tasks 7 and 8	Q3/Q4 2018

We trust this work plan and schedule adequately meets the requirements provided.

Sincerely,

GHD

Rose Marie Rocca, B.Sc.

Roxanne Hasior, B.A.Sc.

Allan Molenhuis, B.Sc.

Gregory D. Ferraro, P.Eng.

RH/cs/17

Encl.

cc: Terry Stuart – Upland Excavating Ltd.
Mark Stuart – Upland Excavating Ltd.
Brian Fagan – Upland Excavating Ltd.

Table 1

Clarification Table - Meeting February 15, 2018
2018 Technical Work Plan and Schedule
Uplands Landfill
Upland Excavating, Campbell River, BC

Item #	Pg. #	Section #	Sec 5.1 - ENV Recommendations	ENV Review	Points of Clarification	Feb 15 Meeting - Clarifications	Feb 15 Meeting - Action Items
1	1	1.1		"Report titled "2017 Design, Operations, and Closure Plan", prepared by GHD for ENV on behalf of Upland Excavating Ltd. and dated May 27, 2016."	Has the reviewer reviewed the updated 2017 DOCP and HHCR? May 27, 2016 is the date of the 2016 DOCP and HHCR reports. May 31, 2017 is the date of the 2017 DOCP and HHCR reports.	ENV confirmed the most recent version of each report has been completed	
2	2	1.2		"A secondary geosynthetic Clay Liner (GCL) consisting of 0.75 m of compacted clay with a minimum hydraulic conductivity of 1 x 10-7 cm/sec (1 x 10-9 cm/sec). "	Did the reviewer mean (1 x 10-9 m/sec)?	Confirmed yes	
3	3	3.1	The potential discharge of groundwater to receptors within 500 m of the site should be characterized.	"A number of surface water bodies and water courses are potential surface water receptors that may be affected in the event that leachate impacted groundwater daylights off-site. "	Does the ENV consider the 2 streams identified by the biologist as the potential SW receptors? Does the ENV consider Rico Lake as a potential SW receptor?	ENV requested GHD to provide further discusion/assement of the potential for hydraulic connection to the upgradient and cross gradient recptors.	GHD to provide a technical response on the potential for hydraulic connection between SW and GW at the 2 cross gradient streams identified by Current Environmental within 500 m of the Site.
4	4	3.1		"The site and groundwater characterization investigations did not adequately address the potential for a hydraulic connection between groundwater and surface water receptors off-site. Therefore, for the protection of groundwater as a pathway and as a resource itself, early leak detection beneath the landfill liner and effective contingency measure to mitigate adverse effects should be considered as a part of permitting..."	An inspection for the presence of receptors within 500 m of the Site was completed. A wetland area and streams are cross-gradient of the Site and located at a higher elevation than Site groundwater elevations. Recharge source is the neighbouring small mountain. Is it required to show groundwater does not surface within 500m of the Site ? A leak detection system is suggested as contingency measure (see next line item)	It was clarified that the ENV reviewed the Aquatic Life Assessment Memo completed by Current Environmental. ENV recommend GHD further develop this assessment by describing the hydraulic connection between SW and GW as well as provide an inventory of receptors 500 m downgradient of the Site.	GHD to further assess the potential for GW to daylight within 500 m downgradient of the Site. Approach to completing the further assessment required for Feb 26, 2018 meeting.
5	3	2	A liner leak detection system should be installed for the new landfill cell. Such a system would facilitate early leak detection beneath the landfill liner. Given the site hydrogeology, detection of leakage via proximal monitoring wells should not be exclusively relied upon for detection of liner leaks.	"The migration potential and degree of transport attenuation for these constituents in groundwater varies based on a number of factors. However, under conditions of high groundwater velocity such as those at the Site, the potential for off-site impact is significant in the event of a breach in the landfill liner system. In that even, the impact would be difficult to control and remediate."	Please elaborate on the need for a leak detection system as it is not typical in non-haz landfills in NA Due to the high groundwater velocity, it is true that impact would be difficult to control. However, potential low-level impacts will be subject to high levels of dilution and attenuation prior to reaching off-site. A leak detection system is suggested as a contingency measure. Leak detection systems are not normally required for non-haz landfills in NA jurisdictions. Leak detection system previously identified as a contingency measure May 15, 2017 meeting	ENV asked if the leak detection system is going to be proposed. Client Group advised leak detection system is being considered as per ENV recommendation. A leak detection system is above and beyond the requirement for a non-hazardous solid waste landfills. ENV clarified the leak detection system is being recommended as it may have the potential to satisfy public concern. GHD identified that an integrated contingency plan that can include trigger level programs and increased frequency in phased capping and/or complete capping of the landfill.	Client Group to consider inclusion of leak detection sytem. GHD to provide detail on other contingency measures that would either integrate with or be in place of a leak detection sytem for ENV review and consideration. The framework of the integrated contingency plan to be reviewed at Feb 26, 2018 meeting
6	4	3.1	The proponent should comment on whether the estimated rate of liner leakage reported and used in the groundwater quality assessment takes into account anticipated increases in leakage via deterioration over time.	"The estimated leakage rate from the liner is estimated to be 0.121 m3/year or approximately 0.33 L/day (GHD, 2016). It should be noted that this estimate does not appear to take into account the fact that the liner will likely deteriorate over time and result in increased leakage."	What deterioration of the composite liner is anticipated during the contaminating lifespan of the waste? That is the purpose of determining the contaminating life span. Performance life of liners is accepted well beyond 100 years. Geomembrane liners have a warranty of 50 years. The Site life of the landfill is 25 years. The contaminating lifespan of the Site is 28 years. Therefore, should liner deterioration occur, it would be well beyond the lifespan of the landfill.	ENV referenced literature on liner deterioration. ENV recommends a leak detection system be considered as a contingency measure to address for the potential liner deterioration. ENV requested GHD summarize the potential for liner deterioration	GHD to develop technical response to address the potential of and timing of liner deterioration in context of the timing of the landfill operating life and contaminating site life of the waste.
7	5	3.2.1	Investigations should be designed and completed to capture the potential hydrogeological effects of seasonality (e.g. annual periods of high and low precipitation).	"Seasonal groundwater elevation fluctuations within monitoring wells are known to range from 1.3 m to 2.5 m which could have a non-negligible effect on hydraulic gradient. Therefore, the current groundwater flow estimate may not reflect the seasonal variation in groundwater flow velocity, and in turn its contaminant transport potential"	Does the ENV agree with the following approach? GHD believes that groundwater elevations will likely rise and fall uniformly across the site with the seasons so that, while the saturated thickness might change, the average hydraulic gradient through the site remains consistent. Seasonality will be investigated as part of the annual water quality monitoring program. Water levels will be measured in Q2 (April - June) and Q3 (July - Sept) to demonstrate negligible change in gradients. To date, groundwater elevations have been measured during periods of intermediate and high precipitation.	ENV requests the results of the additional modelling work completed by GHD. Future environmental monitoring data (i.e. water levels) collected at the Upland landfill should be utilized to confirm modelling results. In addition to the above, ENV recommends GHD review Campbell River Landfill ground water elevation monitoring data collected during the dry season (i.e. Q2) as an indication that the average hydraulic gradients within the sand and gravel aquifer remains consistent throughout the year.	Initial modelling results were completed in response to the Ministry Environmental Impact Assessment Memo. GHD to provide the initial modelling results completed before the Feb 26 Meeting.

Table 1

Clarification Table - Meeting February 15, 2018
2018 Technical Work Plan and Schedule
Uplands Landfill
Upland Excavating, Campbell River, BC

Item #	Pg. #	Section #	Sec 5.1 - ENV Recommendations	ENV Review	Points of Clarification	Feb 15 Meeting - Clarifications	Feb 15 Meeting - Action Items
8	6	3.2.2	Bedrock hydrogeology should be characterized via drilling of dedicated boreholes as part of an expanded investigation for determining the hydraulic properties and fracture frequencies of the bedrock. The potential for contaminant transport within the bedrock flow regime should be evaluated.	"The greatest degree of fracturing was noted within the Pit in the borehole advanced for installing monitoring well MW4A-15. However it should be noted that MW4A-15 was drilled into the upper 5 m of bedrock and may not represent deeper bedrock conditions. One location does not provide sufficient data to interpret bedrock conditions site-wide. Furthermore, the sonic drilling that was used for the boring is itself capable of inducing fractures into the rock matrix. "	Does the ENV agree with the following approach? GHD does not believe that further assessment of the degree of fracturing in the shallow weathered bedrock is needed since our hydraulic conductivity testing of the weathered zone gives a K ~ 0.02 cm/s – very permeable so essentially an equivalent porous media, and likely could be lumped in with the sand and gravel aquifer. GHD proposed an additional bedrock well MW14-17 in the Technical Addendum. To increase the ridge characterization, we would extract cores and note any fracturing below the upper weathered zone. Additional k-testing in the new competent bedrock well will also be completed. This data will support that potential leachate migration in the bedrock can be ignored. For the competent bedrock, we have a K ~ 1e-5 cm/s. This is three orders of magnitude lower than the sand and gravel/weathered bedrock K. Anderson and Woessner (1992) indicate that just a two order of magnitude contrast in hydraulic conductivity between adjacent strata may be sufficient to consider the lower conductivity unit as an impermeable boundary. This conclusion is based on the findings from Freeze and Witherspoon (1967) and Neuman and Witherspoon (1969) that a hydraulic conductivity contract of two orders of magnitude or more causes refraction in flow lines such that flow in the higher conductivity strata is essentially horizontal and flow in the lower conductivity strata is essentially vertical. If the hydraulic gradient across the two strata is low (directed either from the higher to lower permeability strata, or from the lower to higher permeability strata), the magnitude of flow exchanged between the two strata will be negligible. **	GHD requested ENV clarification that further bedrock characterization is only required in the vicinity of monitoring well MW14-17 along the bedrock ridge between Rico Lake and the Pit. ENV considering this clarification	GHD to prepare technical approach and rationale for further characterization of the bedrock. Rationale will include assement of the potential for any leakage to reach the bedrock aquifer given the hydrogeologic setting and the potential inclusion of a leak detect6ion system. ENV to provide further clarification of rcommendation on/before the Feb 26 meeting
9	7	3.2.3		"The potential exists for it to create a hydraulic connection between the waste management area and off-site, but this could be mitigated through site grading and removal or interception of this layer during construction."	The potential to create a hydraulic connection between the waste management area and off-Site would be mitigated following the stormwater management plan setout in Section 8.0 of the DOCP. Further clarification is required on where this potential exists.	-	
10	8	3.2.4		"The shallow aquifer discussed as part of the HCM is unlikely to play significant role in groundwater and potential transport unless it's saturated for prolonged periods and hydraulically connected across the inferred groundwater divide. Neither scenario is likely but these have not been definitively discussed or ruled out in the site characterization. "	Further clarification is required on the potential phenomena that would result in a discernible bedrock water quality impact.	-	GHD to further assess the potential for impact to bedrock water quality impact
11	10	4		The comments of the third-party reviewers identify data gaps in the site investigations that call for additional data collection in order to add certainty to areas of the hydrogeological conceptual model.	Pumping test can be carried out but may not provide a more accurate K value than rounding to 2x10-2 cm/s. Clarification required on how pump testing results would be used ?	-	To be further discussed at Feb. 26, 2018 meeting
12	10	4			Dr. Wendling brings up a data gap in flow understanding in the NE quadrant. Clarification required why this is pertinent to landfill performance assessment ?	-	To be further discussed at Feb 26, 2018 meeting
13	9	3.2.5		"In particular, GW cites technical deficiencies such as the use of the well record of RW-98020, which is not reliable give that it was a domestic use water well and the well-logs were not intended to be interpreted for detailed geology. "	GHD only used the RW-98020 for depth to bedrock and the presence of water bearing zones. This log was not used for detailed geology	-	
14	11	5.1	When reporting annual water quality results, Upland should provide an interpretation of the results, including results pertaining to the current landfill cell, as well as the proposed cell if approved.	-	Yes, refer to January 8, 2018 Water Quality Monitoring Report	-	Future water quality reports to include assessment of existing waste management area
15	11	5.1	The following list should be included the suite of indicator parameters: redox parameters such as field-measured dissolved oxygen and/or oxidation-reduction potential (ORP) and other major cations (i.e., sodium, potassium, calcium and magnesium).	-	Listed parameters currently included in proposed monitoring program. Refer to DOCP Section 14. Does the ENV require further clarification?	No further clarification required	GHD to confirm
16	11	5.1	Definitive criteria for the protection of applicable receptors should be prescribed for groundwater, and where exactly those criteria will apply should be established (i.e. on-site or off-site). Such criteria will form the basis for comparison of water quality results and may be used as a threshold for triggering contingency or emergency responses.	-	Definitive criteria is provided in Section 4.1 of the 2017 HHCR. WQG Aquatic Life criteria is proposed for trigger level at downgradient site boundary. Does the ENV require further clarification?	Yes, ENV requires further clarification It is stated that the ENV recommendation as stated under Column D, Item #16, is based on the consideration of GW as a potential receptor. ENV suggests that GHD should consider additional scenarios when determining definitive criteria on and off Site.	Additional scenarios will be discussed during the February 26 meeting. Client Group/GHD to present trigger level program with definitive criteria.

Notes:

** References:

Anderson, M.P., and W.W. Woessner, 1992. Applied Groundwater Modeling, Simulation of Flow and Advective Transport, Academic Press, Inc., San Diego, CA.
Freeze, R.A., and P.A. Witherspoon, 1967. Theoretical Analysis of Regional Groundwater Flow: 2. Effect of Water-Table Configuration and Subsurface Permeability Variation, Water Resources Research 3(2), pp. 623-634.
Neuman, S.P., and P.A. Witherspoon, 1969. Theory of Flow in a Confined Two Aquifer System, Water Resources Research 5(4), pp. 803-816.