



GW SOLUTIONS

ASSESSMENT & PROTECTION OF GROUNDWATER

November 23, 2017
Project No.16-27

Campbell River Environmental Committee
2353 Dolly Varden Road
Campbell River, BC
V9W 4W5

(Via email)

Attention: **Leona Adams**

Re: **Review of GHD Technical Addendum and Peer Review Response Upland Landfill – Waste Discharge Application Tracking Number 335965 and Authorization Number 107689 7295 Gold River Highway, Campbell River, British Columbia**

GW Solutions Inc. (GW Solutions) is pleased to present the following letter-report summarizing our review of GHD Technical Addendum dated October 20, 2017 and Patrick Consulting Inc. letter-report dated September 8, 2017.

1 REVIEW OF PATRICK CONSULTING INC. SEPTEMBER 8, 2017 LETTER-REPORT

GW Solutions provides comments when referring to sections of the document issued by Patrick Consulting Inc. Text from Patrick Consulting Inc. is shown in italics.

1.1 Section 1: Scope of Work and Documents Reviewed

GW Solutions has no comments.

1.2 Section 2: Results of Review and Comments

2.1.1: GW Solutions considers that the groundwater flow in the bedrock still needs to be characterized; particularly in the south and southwest sections of the site.

2.1.2: Site Setting: GW Solutions agrees with Guy Patrick (GP) that the potential discharge of groundwater to surface within 500 m of the site boundaries needs to be further characterized because this will dictate the standards applying to the quality of the groundwater leaving the site. Shallow monitoring wells should be completed at the 500 m distance from site boundary to assess depth to groundwater and confirm groundwater is not discharging to surface within this 500 m zone.

2.1.2: Geology (note sub-section numbering error): GW Solutions agrees with lack of characterisation of the bedrock (presence, frequency and degree of fracturing), and the need for better definition of the lower portion of the “ridge” located between Rico Lake and the site.

2.1.3: GW Solutions agrees with GP’s comments. However, when GP states, page 4, that [...] *Of relevance, the data indicate that in no event does groundwater migrate from the Site towards Rico Lake [...]*. GW Solutions stresses that based on AVAILABLE DATA, it does not appear that groundwater moves towards Rico Lake. However, GW Solutions believes groundwater movement in the fractured bedrock still needs to be characterized to confirm this assumption.

2.1.4: Groundwater velocities and flux: GW Solutions agrees with GP.

2.1.5: Groundwater chemistry: Section 4.1. Applicable water quality standards. GW Solutions agrees with GP that it is not clear that AW standards are not applicable.

2.1.6: GW Solutions has no comments.

2.2.1: Groundwater flux: The assessment of the groundwater flux should reflect the required improvement in understanding of the complex groundwater regime including the groundwater movement in the sand and gravel aquifer AND in the fractured bedrock aquifer (still to be defined).

Leachate generation: Does the proposed leakage rate of 0.121 m³/year (1/3 l per day) consider the increased probability of leakage with an aging liner system?

1.3 3.0 Recommendations

GW Solutions agrees with GP recommendations. However, GW Solutions considers that GP has omitted the fact that the groundwater regime in the fractured bedrock aquifer has not been characterized, and this is a major flaw in the hydrogeological assessment.

2 COMMENTS ON GHD TECHNICAL ADDENDUM

GW Solutions provides comments when referring to sections of the document issued by GHD. Text in italics refers to text from GHD's report.

2.1 Section 1. Introduction

GHD refers to Patrick Consulting Inc. as a third-party peer review. GW Solutions would like clarification whether Patrick Consulting Inc. work was paid by Upland Excavating Ltd. (Upland). If this is the case, then Patrick Consulting Inc. should not be considered as an independent third party review.

2.2 Section 2. Peer Review Recommendations

GW Solutions has no comments.

2.3 Section 3. Hydraulic Conductivity, Advective Flow Velocity, and Flux Estimates

GW Solutions has no comments.

2.4 Section 4. Potential Flux from the West Boundary

As identified in the Peer Review, groundwater flow along the west boundary is interpreted to flow from west to east towards and into the sand and gravel aquifer beneath the Pit (i.e. from the bedrock ridge area towards the Pit area of the Site). As discussed in Section 2.3.3.2 of the HHCR, groundwater flow from the southwest corner of the Site is also interpreted to flow towards and into the sand and gravel aquifer.

GW Solutions considers that the groundwater regime in the fractured bedrock aquifer still needs to be defined, particularly on the south and west sides of the Uplands property. GHD's position is not supported by sufficient evidence.

Groundwater from the west and southwest flows towards the Pit area primarily as unsaturated flow through the vadose zone and potentially inconsistently during periods of higher precipitation.

GW Solutions requests that GHD provides data to confirm this assumption.

The limited fractures noted in the well record for private supply well RW-98020 located immediately northwest of the Site, and MW5A-15 located along the southern boundary of the Site, provide evidence of the competency of the bedrock at and in the vicinity of the Site.

GW Solutions questions the fact that the drilling method(s) used for the drilling of the water well RW-98020 and for the installation of the monitoring well allowed proper recording of the degree of fracturation of the bedrock. Drilling of the water well was completed using a destructive method (i.e., air-rotary drilling, by opposition to coring method that allows collection of an undisturbed core of the bedrock). In addition, the log of Well 98020 only reports the water bearing fracture, from a water

well yield perspective, and does not describe the degree of fracturation of the bedrock.

MW5A-15 was drilled using a sonic rig. The log indicates bedrock encountered at the bottom of the hole over a length of 2.4 m, with weathered rock in its upper part. The sonic vibration has generated fractures; therefore, it is difficult to interpret the native level of fracturation. As a result, GHD's statement is unsupported.

At the time of the inspection, there was no evidence of groundwater seepage occurring at either the bedrock face from the sand and gravel sidewall materials, or within the Pit floor.

The inspection was conducted on September 14, 2017, at the time when the water table in the fractured bedrock would be at its lowest seasonal elevation. It is not representative of what the groundwater flow in the fractured bedrock would be in the wet time of the year, when the water table is at its highest elevation.

The Peer Review recommended a more rigorous assessment of groundwater elevations along the bedrock ridge to better quantify the flux originating from the west boundary. In order to accomplish a more rigorous assessment, it is proposed that an additional monitoring well nest be installed along the bedrock ridge area between test pit TP3-17 and TP6-17. Figure 1 illustrates the proposed monitoring well nest location (MW14). MW14 will provide for a more detailed characterization of bedrock, the presence of fractures and overburden and bedrock groundwater levels along the bedrock ridge. MW14 can be installed as part of the expanded monitoring well regime established for the Site once the initial landfill cell construction is completed. This well will allow for monitoring upgradient groundwater quality from the west, derived in part from Rico Lake.

GW Solutions agrees that monitoring wells must be completed in the fractured bedrock to define the groundwater regime in the fractured bedrock. GW Solutions recommends that more than one monitoring well be completed along the western and southern side of the property to adequately define the groundwater regime in this particularly sensitive corner of the property, where a hydraulic connection with Rico Lake is possible.

As noted in the Peer Review, refinement of the flux originating from the west will have little or no impact on the groundwater quality assessment for the proposed Landfill. The flux beneath the Landfill footprint utilized in the forecasted groundwater compliance model is based on direct measurements of aquifer conditions (groundwater elevations and saturated thickness) beneath the landfill footprint and is inclusive of all upgradient inputs, including any flux from the west or southwest.

GW Solutions disagrees with this statement because Uplands has not considered the groundwater regime through the fractured bedrock aquifer.

2.5 Section 5. CSR Aquatic Life Standards

5.1 through 5.4: GW Solutions has reviewed this section, including Table 13.1 (Attachment C). Although GW Solutions understands there is no threshold under Protocol 21 / BC Contaminated Site Regulation Schedule 6 for Aquatic Life for phosphorous, GW Solutions is concerned that the proposed discharge of phosphorous at concentrations estimated to range between 0.515 and 0.547 mg/l may jeopardize the quality of the receiving aquatic environment. For comparison, BC MoE threshold for protection of Aquatic Life for phosphorous (Acute) is 0.005 mg/l.

5.5 Conservative assumptions: If a large magnitude earthquake were to occur, GW Solutions is concerned that the integrity of the liner system would be jeopardized; this will have a negative impact on the groundwater quality.

3 CONCLUSIONS

GW Solutions draws the following conclusions based on the review of Patrick Consulting Inc. report and GHD's Technical Addendum:

1. GW Solutions considers that the groundwater regime in the fractured bedrock aquifer still needs to be defined, particularly on the south and west sides of the Uplands property.
2. GW Solutions agrees that monitoring wells must be completed in the fractured bedrock to define the groundwater regime in the fractured bedrock. GW Solutions recommends that more than one monitoring well be completed along the western and southern side of the property to adequately define the groundwater regime in this particularly sensitive corner of the property, where a hydraulic connection with Rico Lake is possible.

Although the model describing the anticipated modification of the groundwater quality resulting from the proposed operations indicates that the groundwater quality is expected to meet the applicable regulations, GW Solutions is concerned about the vulnerability of the ecosystems and aquatic life in the Quinsam River watershed (e.g., for phosphorous). Should the proposed landfill expansion proceed, a very robust monitoring program should be designed to monitor groundwater quality at the property boundary and downstream of it. Also, a contingency plan must be designed, should the monitoring results indicate a degradation of the groundwater quality different than expected according to the model.

4 STUDY LIMITATIONS

This document was prepared for the exclusive use of the Campbell River Environmental Committee. The inferences concerning the data, site and receiving environment conditions contained in this document are based on information obtained during investigations conducted at the site by GW Solutions and others, and are based solely on the condition of the site at the time of the site studies. Soil, surface water and groundwater conditions may vary with location, depth, time, sampling methodology, analytical techniques and other factors.

In evaluating the subject study area and water quality data, GW Solutions has relied in good faith on information provided. The factual data, interpretations and recommendations pertain to a specific project as described in this document, based on the information obtained during the assessment by GW Solutions on the dates cited in the document, and are not applicable to any other project or site location. GW Solutions accepts no responsibility for any deficiency or inaccuracy contained in this document as a result of reliance on the aforementioned information.

The findings and conclusions documented in this document have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care normally exercised by hydrogeologists currently practicing under similar conditions in the jurisdiction.

GW Solutions makes no other warranty, expressed or implied and assumes no liability with respect to the use of the information contained in this document at the subject site, or any other site, for other than its intended purpose. Any use which a third party makes of this document, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. GW Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or action based on this document. All third parties relying on this document do so at their own risk. Electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore no party can rely upon the electronic media versions of GW Solutions' document or other work product. GW Solutions is not responsible for any unauthorized use or modifications of this document.

GW Solutions makes no other representation whatsoever, including those concerning the legal significance of its findings, or as to other legal matters touched on in this document, including, but not limited to, ownership of any property, or the application of any law to the facts set forth herein.

If new information is discovered during future work, including excavations, sampling, soil boring, predictive geochemistry or other investigations, GW Solutions should be requested to re-evaluate the conclusions of this document and to provide amendments, as required, prior to any reliance upon the information presented herein. The validity of this document is

affected by any change of site conditions, purpose, development plans or significant delay from the date of this document in initiating or completing the project.

The produced graphs, images, and maps, have been generated to visualize results and assist in presenting information in a spatial and temporal context. The conclusions and recommendations presented in this document are based on the review of information available at the time the work was completed, and within the time and budget limitations of the scope of work.

The Campbell River Environmental Committee may rely on the information contained in this memorandum subject to the above limitations.

5 CLOSURE

Conclusions and recommendations presented herein are based on available information at the time of the study. The work has been carried out in accordance with generally accepted engineering practice. No other warranty is made, either expressed or implied. Engineering judgement has been applied in producing this letter-report.

This letter report was prepared by personnel with professional experience in the fields covered. Reference should be made to the General Conditions and Limitations attached in Appendix 1.

GW Solutions was pleased to produce this document. If you have any questions, please contact me.

Yours truly,

GW Solutions Inc.

A handwritten signature in blue ink, appearing to be 'G. Wendling', is written over a circular professional engineer stamp. The stamp is from the Province of Ontario and contains the text: 'PROFESSIONAL ENGINEER', 'G. R. WENDLING', and 'SOLUBILITY'.

Gilles Wendling, Ph.D., P.Eng.

President



APPENDIX 1

GW SOLUTIONS INC. GENERAL CONDITIONS AND LIMITATIONS

This report incorporates and is subject to these “General Conditions and Limitations”.

1.0 USE OF REPORT

This report pertains to a specific area, a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment. This report and the assessments and recommendations contained in it are intended for the sole use of GW SOLUTIONS’s client. GW SOLUTIONS does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than GW SOLUTIONS’s client unless otherwise authorized in writing by GW SOLUTIONS. Any unauthorized use of the report is at the sole risk of the user. This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of GW SOLUTIONS. Additional copies of the report, if required, may be obtained upon request.

2.0 LIMITATIONS OF REPORT

This report is based solely on the conditions which existed within the study area or on site at the time of GW SOLUTIONS’s investigation. The client, and any other parties using this report with the express written consent of the client and GW SOLUTIONS, acknowledge that conditions affecting the environmental assessment of the site can vary with time and that the conclusions and recommendations set out in this report are time sensitive. The client, and any other party using this report with the express written consent of the client and GW SOLUTIONS, also acknowledge that the conclusions and recommendations set out in this report are based on limited observations and testing on the area or subject site and that conditions may vary across the site which, in turn, could affect the conclusions and recommendations made. The client acknowledges that GW SOLUTIONS is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the client.

2.1 INFORMATION PROVIDED TO GW SOLUTIONS BY OTHERS

During the performance of the work and the preparation of this report, GW SOLUTIONS may have relied on information provided by persons other than the client. While GW SOLUTIONS endeavours to verify the accuracy of such information when instructed to do so by the client, GW SOLUTIONS accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

3.0 LIMITATION OF LIABILITY

The client recognizes that property containing contaminants and hazardous wastes creates a high risk of claims brought by third parties arising out of the presence of those materials. In consideration of these risks, and in consideration of GW SOLUTIONS providing the services requested, the client agrees that GW SOLUTIONS’s liability to the client, with respect to any issues relating to contaminants or other hazardous wastes located on the subject site shall be limited as follows:

- (1) With respect to any claims brought against GW SOLUTIONS by the client arising out of the provision or failure to provide services hereunder shall be limited to the amount of fees paid by the client to GW SOLUTIONS under this Agreement, whether the action is based on breach of contract or tort;
- (2) With respect to claims brought by third parties arising out of the presence of contaminants or hazardous wastes on the subject site, the client agrees to indemnify, defend and hold harmless GW SOLUTIONS from and against any and all claim or claims, action or actions, demands, damages, penalties, fines, losses, costs and expenses of every nature and kind whatsoever, including solicitor-client costs, arising or alleged to arise either in whole or part out of services provided by GW SOLUTIONS, whether the claim be brought against GW SOLUTIONS for breach of contract or tort.

4.0 JOB SITE SAFETY

GW SOLUTIONS is only responsible for the activities of its employees on the job site and is not responsible for the supervision of any other persons whatsoever. The presence of GW SOLUTIONS personnel on site shall not be construed in any way to relieve the

client or any other persons on site from their responsibility for job site safety.

5.0 DISCLOSURE OF INFORMATION BY CLIENT

The client agrees to fully cooperate with GW SOLUTIONS with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The client acknowledges that in order for GW SOLUTIONS to properly provide the service, GW SOLUTIONS is relying upon the full disclosure and accuracy of any such information.

6.0 STANDARD OF CARE

Services performed by GW SOLUTIONS for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

7.0 EMERGENCY PROCEDURES

The client undertakes to inform GW SOLUTIONS of all hazardous conditions, or possible hazardous conditions which are known to it. The client recognizes that the activities of GW SOLUTIONS may uncover previously unknown hazardous materials or conditions and that such discovery may result in the necessity to undertake emergency procedures to protect GW SOLUTIONS employees, other persons and the environment. These procedures may involve additional costs outside of any budgets previously agreed upon. The client agrees to pay GW SOLUTIONS for any expenses incurred as a result of such discoveries and to compensate GW SOLUTIONS through payment of additional fees and expenses for time spent by GW SOLUTIONS to deal with the consequences of such discoveries.

8.0 NOTIFICATION OF AUTHORITIES

The client acknowledges that in certain instances the discovery of hazardous substances or conditions and materials may require that

regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by GW SOLUTIONS in its reasonably exercised discretion.

9.0 OWNERSHIP OF INSTRUMENTS OF SERVICE

The client acknowledges that all reports, plans, and data generated by GW SOLUTIONS during the performance of the work and other documents prepared by GW SOLUTIONS are considered its professional work product and shall remain the copyright property of GW SOLUTIONS.

10.0 ALTERNATE REPORT FORMAT

Where GW SOLUTIONS submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed GW SOLUTIONS's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by GW SOLUTIONS shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by GW SOLUTIONS shall be deemed to be the overall original for the Project. The Client agrees that both electronic file and hard copy versions of GW SOLUTIONS's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except GW SOLUTIONS. The Client warrants that GW SOLUTIONS's instruments of professional service will be used only and exactly as submitted by GW SOLUTIONS. The Client recognizes and agrees that electronic files submitted by GW SOLUTIONS have been prepared and submitted using specific software and hardware systems. GW SOLUTIONS makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.