

## Supporting Scientific Report Information re Upland Landfill Application Authorization Number 107689

### 1. Lack of sufficient data to support the application

“In Waterline’s opinion, insufficient baseline groundwater and surface water data has been collected by GHD to fully characterize the local and regional hydrogeological system in relation to the proposed landfill project.”

Source: Waterline Hydrogeological Review of the Proposed Upland Landfill, February 25, 2019, section 2.2  
<https://crecwebcom.files.wordpress.com/2019/03/waterline-resources-inc.-report-feb-25-2019-2.pdf>

“Given the lack of long-term groundwater monitoring data, it is not possible to assess the following:

- The highest historical groundwater level that occurred on site over the monitoring period,
- How the groundwater elevations change (or don’t change) in response to changes in the water level in Mclvor Lake which is controlled by BC Hydro at the Ladore Dam, and
- The hydraulic response in the sand and gravel and fractured bedrock beneath the Site to significant precipitation events or unusually wet periods.”

Source: Waterline Hydrogeological Review of the Proposed Upland Landfill, February 25, 2019 section 2.2  
<https://crecwebcom.files.wordpress.com/2019/03/waterline-resources-inc.-report-feb-25-2019-2.pdf>

“The recommended environmental monitoring program is presented in Section 14 of GHD’s DOCP. Given the lack of continuous baseline groundwater monitoring, the mis-characterization of groundwater in the fractured bedrock (i.e.: water levels in bedrock wells indicated to be higher than in sand and gravel wells), and observed ponding in the pit area, the proposed groundwater monitoring program will need to be re-considered.”

Source: Waterline Hydrogeological Review of the Proposed Upland Landfill, February 25, 2019, section 2.2  
<https://crecwebcom.files.wordpress.com/2019/03/waterline-resources-inc.-report-feb-25-2019-2.pdf>

### 2. Drainage from Rico Lake to Mclvor Lake, our drinking water supply

“Water flows from Rico Lake to Mclvor Lake.”

Source GHD Hydrogeology and Hydrology Characterization Report, May 31, 2017, Page 17  
<https://crecwebcom.files.wordpress.com/2019/03/2017-05-31-ghd-hhcr.pdf>

CREC Video, April 8, 2016

<https://crecweb.com/>

### 3. Insufficient knowledge of the fractured bedrock hydraulic connection between Rico Lake and the pit

“GHD appears to have repeatedly mischaracterised the hydraulic connection between the bedrock aquifer and the sand and gravel aquifer in the pit area.”

Source: Waterline Hydrogeological Review of the Proposed Upland Landfill, February 25, 2019, section 2.3  
<https://crecwebcom.files.wordpress.com/2019/03/waterline-resources-inc.-report-feb-25-2019-2.pdf>

“The key initial assumption that the landfill was separated from Rico Lake, which is part of the regional drinking water supply, by a bedrock ridge has now been refuted. The fact that there is likely a direct hydraulic connection between Rico Lake and the Landfill site drastically changes the perspective and foundation of the project.”

Source: GW Solutions Review of GHD Technical Responses Task 7 and Task 8 - Upland Landfill-Key Concerns, p.19  
<https://crecwebcom.files.wordpress.com/2019/03/2019jan02-uplands-review-gws-1-1.pdf>

“In my view, GHD’s assessment understates the relevance of the fractured bedrock in conveying groundwater from Rico Lake to the Sand and Gravel Aquifer beneath the Site.”

Source: Patrick Consulting Inc November 6, 2018, Peer Review of Additional Information, Proposed Upland Landfill, Campbell River, BC. P.9  
<https://crecwebcom.files.wordpress.com/2019/03/patrick-consult-inc-final-let-6nov2018-1.pdf>

### 4. Groundwater flow between Rico Lake and the pit

“Groundwater flow from Rico Lake towards the Pit occurs through the shallow sand and gravel aquifer and fractured bedrock. The groundwater contours shown on Figure 5.1 illustrates the hydraulic connection between Rico Lake and the Pit.” Source: GHD-Technical Response to ENV Review Task 7 – Additional Bedrock Characterization Upland Landfill, Conclusions, p.11

<https://crecwebcom.files.wordpress.com/2019/03/2018-10-01-ghd-addtl-bedrock-characterization-task-7.pdf>

“Based on the information reviewed, a hydraulic connection likely exists between the lakes and the aquifers beneath the proposed landfill, however insufficient data has been collected to fully understand this connection.

“February 25, 2019 Waterline Hydrogeological Review of the Proposed Upland Landfill, section 2.1

<https://crecwebcom.files.wordpress.com/2019/03/waterline-resources-inc.-report-feb-25-2019-2.pdf>

“The role played by the groundwater regime in the fractured bedrock aquifer still needs to be defined. This should particularly be taken into account in case of a catastrophic accidental event (e.g., resulting from a large earthquake) that would cause movement of landfilled waste and interruption of the drainage system (in addition to loss of integrity of the liner system). This scenario should be addressed (taking into account the time it would take to address and remediate the situation under such circumstances) and illustrated to confirm that the water quality of both Rico Lake and the receiving environment east of the landfill would not be affected.”

Source: GW Solutions Review of GHD Technical Responses Task 7 and Task 8 - Upland Landfill, p.20

<https://crecwebcom.files.wordpress.com/2019/03/2019jan02-uplands-review-gws-1-1.pdf>

## 5. Current water-ponding in the pit and groundwater levels beneath the pit

“Insufficient water level data has been collected to demonstrate that groundwater levels will remain 1.5 m below the base of landfill. In fact, groundwater levels at MW4A-15 was measured at 165.9 m AMSL on the 6 April 2017, and at 165.2 m AMSL in MW4B-1 5 on the 11 September 2015 which are above the design elevation of the sump and likely do not meet the ENV landfill criteria.”

Source: February 25, 2019 Waterline Hydrogeological Review of the Proposed Upland Landfill, section 2.2

<https://crecwebcom.files.wordpress.com/2019/03/waterline-resources-inc.-report-feb-25-2019-2.pdf>

“The bedrock groundwater level data do not appear to have been considered by GHD in relation to the ENV landfill criteria requirement of that groundwater levels be maintained 1.5 m below the base of the landfill.”

February 25, 2019 Waterline Hydrogeological Review of the Proposed Upland Landfill, p.12

<https://crecwebcom.files.wordpress.com/2019/03/waterline-resources-inc.-report-feb-25-2019-2.pdf>

“According to GHD, the sand and gravel is thick under the pit (Figure 4), and its hydraulic conductivity  $2 \times 10^{-2}$  cm/s (Technical Response to ENV Review (Auth. No.:Pr-10807) Task 8). With such a high hydraulic conductivity, water should not be ponding, and surface water is expected to infiltrate very rapidly through the pit floor.”

Source: GW Solutions Review of GHD Technical Responses Task 7 and Task 8 - Upland Landfill, following December 11, 2018 Site Visit, P.15

<https://crecwebcom.files.wordpress.com/2019/03/2019jan02-uplands-review-gws-1-1.pdf>

## 6. Unexplained source of high levels of metals (aluminum, barium, calcium, iron, magnesium, sulphur, zinc) currently found in Rico Lake sediment

Leilane Barbosa Ronqui, PhD, found Aluminum, Barium, Calcium, Iron, Magnesium, Sulphur and Zinc all significantly greater in recent Rico Lake sediment sampling conducted by Upland (1 sample) than in adjacent control lakes. Source:

Leilane Ronqui, Ph.D., Rico Lake – Sediment and Water Surface assessment, Nov. 1, 2018

[https://crecwebcom.files.wordpress.com/2019/03/rico-lake-assessment\\_leilanonqui-2.pdf](https://crecwebcom.files.wordpress.com/2019/03/rico-lake-assessment_leilanonqui-2.pdf)

In February 2017, CREC sampled water flowing from Rico Lake to McIvor and found elevated Aluminum levels.

Source: 2017/02/07 Maxxam Sampling Results

<https://crecwebcom.files.wordpress.com/2019/03/maxxam-sample-results-drainage-from-rico-to-mcivor-lake.pdf>

## 7. Drainage from the site east to Lost Lake, Cold Creek and the Quinsam River Hatchery unresolved

“GWS modelled the hydraulic gradient using all available groundwater elevations. Our analysis does NOT match that of GHD.” Source: GWS Uplands-review- 7/6/2016 presentation, slide 3

<https://crecwebcom.files.wordpress.com/2019/03/gws-presentation-of-upland-application-7-6-2016.pdf>

“GW Solutions has completed a preliminary conceptual model of the subsurface. It has used the data provided by GHD to map the piezometric conditions. **GW Solutions interpretation of the data does not match GHD’s interpretation. GW Solutions estimates that groundwater moves in an east -northeast direction.**

Source: GW Solution October 17, 2016 Review of Upland Excavating Landfill Application Technical Assessment Reporting, p. 2

<https://crecwebcom.files.wordpress.com/2019/03/gws-review-of-upland-excavating-landfill-application-technical-assessment-reporting.pdf>

“The observed flow to the east and southeast is consistent with the anticipated regional flow system in the Sand and Gravel Aquifer and in bedrock. Regional flow is to the east and southeast, with groundwater discharge into the Quinsam River watershed or beyond with discharge to the sea.”

Source: Patrick Consulting Inc. November 6, 2018, Peer Review of Additional Information, Proposed Upland Landfill, Campbell River, BC, p.11  
<https://crecwebcom.files.wordpress.com/2019/03/patrick-consult-inc-final-let-6nov2018-1.pdf>

## 8. No baseline groundwater sampling to the east and northeast

“The groundwater monitoring program should include locations along the eastern property boundary, in particular along the northeastern boundary.” Source: Dec. 21, 2018 GW Solutions Review of GHD Technical Responses Task 7 and 8 p.21

<https://crecwebcom.files.wordpress.com/2019/03/2019jan02-uplands-review-gws-1-1.pdf>

## 9. Definition of the Campbell River Watershed Boundary

“According to the BC Water Resource Atlas (2017) the Site is located on the watershed divide between the Campbell River and Quinsam River Watersheds.” Source: GHD 2017 Design, Operations, and Closure Plan. P.6

<https://crecwebcom.files.wordpress.com/2019/03/2017-05-31-ghd-hhcr.pdf>

“Based on the elevation differences between the lakes and the overburden sand and gravel flow zone, and the large difference in static water elevations between these two waters bearing zones, it is likely that any hydraulic connection between the lakes and the overburden sand and gravel aquifer is a muted connection (**weak connection**)” (*emphasis added*). Source: GHD Hydrogeology and Hydrology Characterization Report, May 27, 2016, p.13

<https://crecwebcom.files.wordpress.com/2019/03/2016-05-27-ghd-hhcr-part-1-of-2.pdf>

“The hydraulic conductivity of the sand and gravel aquifer and measured hydraulic gradients between Mclvor Lake and the Pit area are sufficiently high that drainage from the lake is **very fast** (*emphasis added*).” *Mclvor Lake* recharges the sand and gravel aquifer near the Site.”

Source: GHD Hydrogeology and Hydrology Characterization Report, May 31, 2017, Page 14

<https://crecwebcom.files.wordpress.com/2019/03/2017-05-31-ghd-hhcr.pdf>

## 10. Proposed final elevation of landfill above Rico and Mclvor Lakes

“The top final cover will have a crest elevation of 192 meters above Sea Level (AMSL), and a peak elevation of 195 m AMSL.” Source: GHD 2017 Design, Operations, and Closure Plan. P.15

<https://crecwebcom.files.wordpress.com/2019/03/2017-05-31-ghd-docp.pdf>

Mclvor lake surface is 177m above sea Level and Rico Lake surface is 178 to 181m AMSL.

Source: Upland, City of Campbell River January 28, 2019 Council Meeting, delegation 4

[http://archive.isiglobal.ca/vod/campbell/archive\\_2019-01-28.mp4.html](http://archive.isiglobal.ca/vod/campbell/archive_2019-01-28.mp4.html)

“The maximum elevation of the landfill should be reduced to minimize the risk of any leachate originating from the landfill to reach a drinking water source, in particular following a catastrophic scenario. The maximum height could be selected based on the estimated groundwater regimes both in the fractured bedrock and the sand and gravel aquifer following a catastrophic scenario.”

Source: Dec. 21, 2018 GW Solutions Review of GHD Technical Responses Task 7 and 8 p.21

<https://crecwebcom.files.wordpress.com/2019/03/2019jan02-uplands-review-gws-1-1.pdf>

Link to Full Reports: <https://crecweb.com/2016/05/14/the-campbell-river-environmental-comittee/>