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From: Tim Baker
Company: Otago Regional Council
SLR Consulting New Zealand
cc: Samantha Iles
Date: 24 October 2024
Project No. 820.V13556.00001

**RE: RM23.185 - Green Island Landfill
Groundwater Quantity and Quality Technical Memorandum 02**

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1.0 Introduction

SLR Consulting NZ (SLR) has been engaged by Otago Regional Council (ORC) to conduct a technical review of the resource consent application (including subsequent attachments and request for information (RFI) responses submitted by Dunedin City Council (DCC, the applicant) for the operation, expansion and closure of the Green Island Landfill.

DCC is proposing to continue to extend the life of the Green Island Landfill to allow acceptance of waste until between December 2029 and March 2031, following which closure operations and landfill aftercare will commence.

SLR prepared technical memorandums in late 2023 in response to the application. This included technical memorandums (hereinafter referred to as the 2023 Groundwater Memos) in relation to groundwater quantity (authored by Tim Baker) and quality (authored by Anna Lukey). The 2023 Groundwater Memos raised a number of items requiring further clarification (Section 92). In October 2024, further information was provided by the applicant in response to the SLR technical memorandums. The information supplied included new memorandums, new reports, updated reports, responses to specific queries and proposed consent conditions.

The further information provided has been reviewed. This technical memorandum (herein referred to as the 2024 Groundwater Memo) details the reviewers (Tim Baker) opinion as to whether the recently provided information addresses the items raised with respect to groundwater quantity and quality. Additionally, the 2024 Groundwater Memo also details any other items from the recently provided information that require further clarification.

2.0 Scope of Review

2.1 Scope

The scope of this review included;

- Re-familiarisation with the findings of the review that informed the original technical memorandums.
- Review of sections of the documents listed in Section 2.2 considered relevant to the questions posed by ORC with respect to groundwater quantity and quality.
- Consideration of the relevant operational aspects against the requirements of WasteMINZ 2023. Referred to herein as the WasteMinz Guidelines.
- Preparation of this technical memorandum.

2.2 Key Documents Reviewed

2.2.1 Original Resource Consent Application

The following key documents, which were submitted as part of the application in 2023, were reviewed in the development of the 2023 Groundwater Memorandums:

- Boffa Miskell Limited, *Green Island Landfill Closure, Assessment of Environmental Effects*, Dated March 2023. Referred to herein as the 2023 AEE.
- GHD Limited, *Waste Futures – Green Island Landfill Closure Design Report*, Dated 29 September 2023. Referred to herein as the 2023 Design Report.
- GHD Limited, *Waste Futures – Green Island Landfill Closure Groundwater Technical Assessment*, Dated 09 March 2023. Referred to herein as the 2023 GW Report.
- GHD Limited, *Waste Futures – Green Island Landfill Closure Surface Water Report*, Dated 7 March 2023. Referred to herein as the 2023 SW Report.
- Stantec New Zealand, *Green Island Landfill, Development and Management Plan*, Dated September 2023. Referred to herein as the 2023 LDMP.

2.2.2 Section 92 Responses

The following key documents, have been reviewed as part of the 2024 Groundwater Memo to assess if the items requiring clarification from the 2023 Groundwater Memorandums have been addressed;

- Boffa Miskell Limited, *Green Island Landfill Closure, Assessment of Environmental Effects*, March 2023 (Updated October 2024). Referred to herein as the 2024 AEE.
- GHD Limited, *Green Island Landfill Interim Human Health and Environmental Risk Assessment*, Dated 20 June 2024. Referred to herein as the HHERA.
- GHD Limited, *Waste Futures – Green Island Landfill Closure Groundwater Technical Assessment – October 2024 Update*, Dated 18 July 2024. Referred to herein as the 2024 GW Report.
- GHD Limited, *Waste Futures – Green Island Landfill Closure Surface Water Report – October 2024 Update*, Dated 18 July 2024. Referred to herein as the 2024 SW Report.
- Dateless excel file without letter head with eleven worksheets with filename “MASTER_RM23.185 GILF RFI Jan 2024-Tranche5-6.xlsx” provided to SLR by Shay McDonald of ORC on 10 October 2024. Referred to herein as DCC Comments Response Spreadsheet.
- Dateless PDF document without letter head titled “*Green Island Landfill Closure – Draft ORC Conditions of Consent*” provided to SLR by Shay McDonald of ORC on 10 October 2024. Referred to herein as Existing Consent Conditions.
- Dateless and unnamed PDF document without letter head with the filename “*LDMP Recommended Changes*” provided to SLR by Shay McDonald of ORC on 10 October 2024. Referred to herein as Proposed LDMP.



3.0 Assessment

The comments from the 2023 Groundwater Memos are included along with a summary of the findings from the updated review (the 2024 Groundwater Memo findings). Even though there is significant overlap, the original spit of groundwater quantity and quality has been retained.

3.1 Groundwater Quantity

3.1.1 Is the technical information provided in support of the application robust, including being clear about uncertainties and any assumptions? Yes, or no. If not, what are the flaws?

2023 Groundwater Memo Commentary

In reviewing the geological and hydrogeological conceptual model prepared by the applicant, I found several areas where there are limitations in the information provided regarding groundwater flow direction and groundwater levels – this propagates to uncertainty in the adequacy of existing monitoring locations. These issues have been discussed with Anna Lukey, author of the groundwater quality assessment, and are presented in her report, however for completeness, I summarise them below:

- A fundamental assumption of the hydrogeological model is that the leachate collection trench intercepts all groundwater and prevents offsite migration. While the trench intercepts the more permeable estuarine silts and sands, I disagree that it would prevent offsite migration because trench does not extend to the depth of the Abbotsford Mudstone (basement) and therefore there remains potential for groundwater flow beneath the trench, above the low permeability mudstone.

The applicant states that upward hydraulic gradients are a form of control on downward and offsite migration (Both Appendix 3 and 5 refer to artesian conditions preventing downward migration of contaminants). However, as I discuss below, there is very limited evidence of upward hydraulic gradients.

- The historical stream diversion, and historical evidence of channels on the estuarine mudflats (beneath the footprint of the landfill) increases the potential for preferential flow paths beneath the landfill (noting it is unlined). It is my view that the monitoring network around the boundary is currently insufficient to adequately represent off-site groundwater discharges.
 - Recommendation: Additional monitoring locations, particularly of deeper groundwater should be added to the network. Locations should include consideration of former estuarine and stream channels. Please refer to Technical Memo of Anna Lukey for more information on the proposed locations of these.
- There is very limited information on groundwater levels and flows beyond the landfill footprint, and because of this no piezometric contour maps of flow direction outside of the landfill has been able to be generated. The Applicant notes that this is due to the lack of private wells around the landfill, which is understandable, but not a reason to limit further investigation or information gathering.
 - Recommendation: All historical monitoring wells on the site should be surveyed in, allowing accurate representation of groundwater flow direction/elevation at the site.



- Recommendation: the applicant should consider adding to the network of monitoring wells with additional wells at the property boundary around the landfill.
- While the 'typical monitoring cross-section' shown on Figure 2.4 (Appendix 5) shows a deep well (labelled D), the D wells only exist on Lines 2, 4 and 7 and there are no borelogs available for these wells. This means monitoring of the groundwater in the Lower Kaikorai Estuary Member (LKEM) is limited to those three transects. It is my opinion, that a Deep well should exist on every transect and that they be screened immediately above (they need to tag) the Abbotsford Mudstone layer.
 - Recommendation: Addition of a D well to each transect.
- There is limited information on hydraulic gradients between the different geological units at the site, or demonstration of the 'artesian' gradient referred to in Appendix 3 and 5.

The Applicant, in the s92 Response (Question 69) states that the levels recorded in monitoring wells C & D at Transect 2 & 4 indicate an upward hydraulic gradient between from the lower to upper Kaikorai Estuary Member. I remain uncertain whether this is an upward hydraulic gradient, or just a reflection of the drawdown caused by the leachate interception trench. Furthermore, without wells in the Abbotsford Mudstone, there is no knowledge of what, if any, gradient exists between the mudstone and the estuarine deposit.

- Recommendation: further demonstration of hydraulic gradient between all geological units is required. This assessment needs to ensure that the effects of groundwater drawdown from the trench are considered when making any conclusions. I would be comfortable seeing this work done as part of an adaptive groundwater monitoring plan, should ORC decide to issue consent.
- Recommendation: Include one or two new wells in the Abbotsford Mudstone to prove hydraulic gradients

2024 Review and Commentary

The 2024 GW Report includes updates through-out, with the main conceptual updates being:

- Renaming of the 'Leachate Interception Trench' as 'Leachate Trench'.
- Further explanation of the geological setting that assists with improving understanding of the geological controls on groundwater movement. Of note is the demonstration that to the southeast, a Mudstone ridge prevents groundwater flow in a southeasterly direction.
- Further explanation for the observed increasing groundwater levels at MW4D, now attributed to compression of the underlying estuarine sediments. It is also noted that this compression is likely to have occurred across the footprint of the landfill.
- New information in the conceptual model section, providing details on the pre-landfill setting, particularly the historic stream alignment. This indicates the stream had been diverted/constrained prior to landfilling, but also shows that there was a straightening of a stream loop in the northeast corner, located close to where the northern stormwater pond is now.



- It is also acknowledged that the southwest of the landfill, where historic estuarine channels are located, is considered the down-gradient side of the landfill. In response to this, an additional well has been added to the monitoring programme, MW103 (D).
- A new groundwater contour map of the landfill. However, this is limited to onsite groundwater, and does not include off-site piezometric contours.

The 2024 GW Report retains the fundamental assumption that the leachate trench intercepts all groundwater and prevents offsite migration. I remain of the opinion that there is insufficient off-site (being outside of the leachate trench) groundwater quality and groundwater level data to be confident in this conclusion. Furthermore, the absence of borelogs for the historic wells means there is uncertainty in what part of the formation the C and D wells are screened in. I believe that there remains potential for leachate to be moving in groundwater beneath the leachate trench and beyond the site boundary. Observation from Fairfield Landfill, located across the Estuary from Green Island where leachate has been recorded to be present in groundwater within the wetland end estuary, are discussed in Section 3.2.6.

The addition of BH103 to the monitoring programme is supported. However, I would like to see further deep wells added, at a minimum, to monitoring lines 1 and 3. This would provide a continuous network of deeper wells around the 'down-gradient' side of the landfill.

A further set of monitoring wells covering the three main geological units (including the Abbotsford formation), in the southwest corner of the property, is also recommended. A suggested location is shown below on Figure 1. This location would provide more information on the potential for off-site migration of leachate, and is aligned with the historic estuarine channel locations, which may form preferential flow paths.

Further discussion on the justification for additional monitoring based on the monitoring of the adjacent Fairfield Landfill is provided below, in the recommendations section.

All other recommendations from the 2023 Groundwater Memos remain valid.

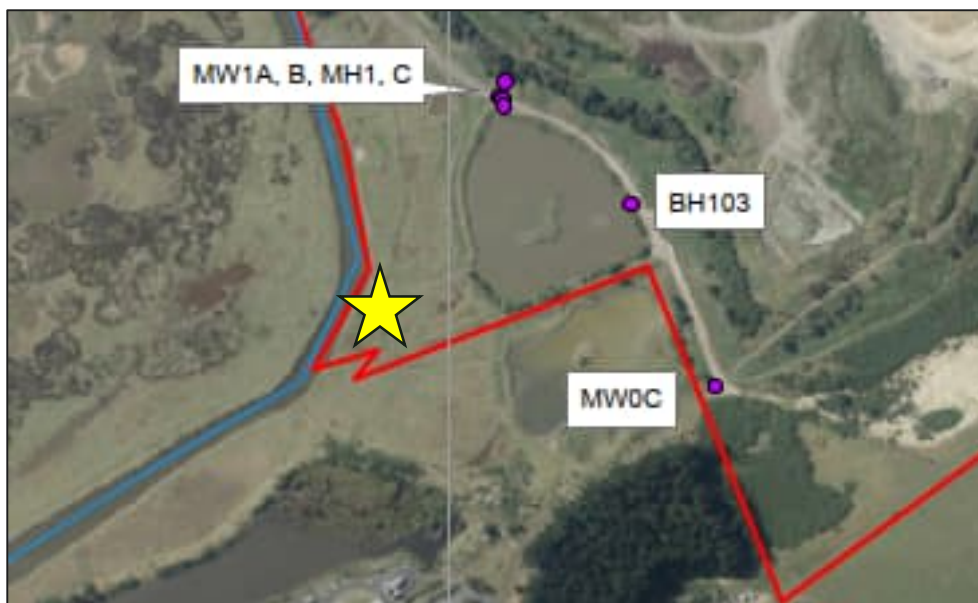


Figure 1 Recommendation for the location of the new monitoring well cluster



3.1.2 Are there any other matters that appear relevant to you that have not been included? Or is additional information needed? Please specify what additional info you require and why [please explain]

2023 Groundwater Memo Commentary

Addressed by the response to the above question.

2024 Review and Commentary

No further matters other than those addressed in the 2023 Groundwater Memos.

3.1.3 If granted, are there any specific conditions that you recommend should be included in the consent?

2023 Groundwater Memo Commentary

With regards to groundwater levels and flow direction, I would request that a Groundwater Monitoring and Contingency Plan is developed and is subject to ORC approval. The plan should include:

- Details of all monitoring well construction (depth, elevation, material, logs)
- A sampling and analysis plan, including the sampling methodology to be followed.
- A plan for the installation of additional boundary wells, and new deep transect wells, including the proposed depths, construction, and timing of installation.
- Other items as addressed in the Groundwater Quality memo.

2024 Review and Commentary

Existing Consent Conditions (reference conditions 38 to 51) have been updated and generally provide a good framework for management of groundwater at the site. I recommend the following additions/changes:

- Addition of the new wells as described in Section 3.1.1.
- Addition of a requirement to survey all wells and collect, where possible information on well construction.
- Condition 41. This would benefit from specifying the groundwater sampling methodology i.e., the National Environmental Monitoring Standards describe multiple appropriate methodologies.

3.1.4 Has the applicant appropriately assessed the effects of the groundwater take on the hydrological functioning of the nearby Regionally Significant/Natural Wetland?

2023 Groundwater Memo Commentary

The assessment of the stream depletion effects resulting from the groundwater take have been assessed using the results of SEEP/W model which predicts inflow into the leachate drain.

The modelling results (presented in Appendix G of the 2023 GW Report) align relatively well with the observed leachate pumping record and indicate that inflows into the leachate trench are in the order of 1 to 2 L/s (inflow rates are very low).



The relative proportion of flow from each side of the trench was estimated using the model with 70% sourced from the landfill, 30% from the stream. Along the 1674 m trench length, this equates to ~0.5 L/s sourced from the stream side.

As a proportion of the Kaikorai mean flow (368 L/s) and mean annual low flow (81 L/s) the applicant considers this is insignificant and I agree with that conclusion.

2024 Review and Commentary

The comments above remain unchanged.

3.1.5 Is the SEEP/W 2D groundwater model appropriate for use in this context? Has it been applied appropriately?

2023 Groundwater Memo Commentary

Two models were used for the assessment:

- The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate rainfall infiltration through the landfill cap.
- SEEP/W was then used to estimate groundwater seepage from the landfill into the leachate collection drain. The SEEP/W model used the HELP outputs as the recharge input.

Overall, I consider the application of both models to be appropriate. I have some minor reservations about the consideration of climate change effects in the HELP model rainfall data series, and whether the assumptions around hydraulic gradients across the main geological units are valid. However, overall, the models appear to be a fair representation of long-term leachate/seepage process. The validation of the model outputs to measured abstraction rates supports the validity of the models, although the ability of the model to represent storm conditions is poor (leachate pumping rates following rainfall are 7-9 L/s, compared to 1-2 L/s under normal conditions).

I questioned whether the predicted 10% increase in rainfall for the Otago region had been considered in the HELP modelling. The Applicants response (Q70) suggests that it was, however, it is still not clear to me that the stochastic modelling input does consider this. I believe the stochastic rainfall model considered current variability (which would include >10% variability from the mean), but it does not account for a 10% increase in overall average rainfall.

The SEEP/W modelling did consider the effects of sea level rise on the inflow into the leachate trench (Scenario 2C). Across all scenarios, there was negligible change in inflows between scenarios. I have no reason to disagree with the results presented, however recommend that the modelling outputs, and inherent uncertainty, are validated through a robust long-term monitoring programme of groundwater levels and leachate trench outflow rates.

2024 Review and Commentary

The comments above remain unchanged.



3.1.6 Have the cumulative effects of the activity been appropriately assessed?

2023 Groundwater Memo Commentary

With regards to groundwater abstraction from the leachate trench, I do not consider there to be any cumulative effects because the long-term abstraction volumes are very small compared to surface water flows, the tidal influence on estuary levels, and likely regional groundwater flows.

2024 Review and Commentary

The comments above remain unchanged.

3.1.7 Have the effects of the defence against water been adequately assessed including: effects on existing defences? Correctly identified any diversion or secondary flow paths because of the defence/ alteration to the defence?

2023 Groundwater Memo Commentary

The land adjacent to the landfill is low lying between 1.5 and 2.0 m msl. It is situated within a flood plain and is subject to a moderate risk of flooding from storm surge and fluvial flooding in the Kakorai Stream.

The 2023 Design Report indicates that estimates that flood flows will increase by approximately 9% by 2050. The report concludes that *'this would be expected to increase flood levels by between 60 -100 mm and will not significantly impact the flooding extent in the area of the landfill or day-to-day operations'*. I agree with this.

Sea level rise is assessed to increase estuary water levels by 0.25 to 0.5 m. The planned response to this risk is to raise the level of the perimeter road berm that runs around the landfill between the adjacent Kaikorai Stream and leachate trench by approximately 1.0 m to minimise the risk of inundation by surface waters.

Raising the perimeter road (stop bank) may reduce the cross-sectional area of the floodplain, and result in higher flood levels as the same (or greater with climate change) amount of water must flow through a smaller area. However, it is important to note that in this case, that only a very small part of the flood plain area sites on the landward side of the existing stop bank. Furthermore, it is my understanding that the proposed increase is of an existing stop bank (road) and therefore does not change any existing stormwater flow paths.

A part of the s92 request (q76), an assessment on the change in flood levels because of the increase stop bank height was carried out. This assessment was done using a simple analytical approach (not a model) and indicated the change in flood level height to be in the order of 3.0 to 4.0 cm. I consider this negligible.

2024 Review and Commentary

The comments above remain unchanged.



3.2 Groundwater Quality

3.2.1 Is the technical information provided in support of the application robust, including being clear about uncertainties and any assumptions? Yes, or no. If not, what are the flaws?

2023 Groundwater Memo Commentary

Yes - the technical information provided in the 2023 application documents is generally robust. The data that has been presented is clear and discussed. However, there are numerous assumptions made and assumptions of note are highlighted below:

- The historical data from the groundwater monitoring wells is not comprehensive and some assumptions are required based on well construction.
- The introduction section sets out a number of assumptions about the landfill life expectancy, which is based on filling volumes and the establishment of Smooth Hill landfill.
- There is an assumption of the site being commercial/industrial land use until closure, and thereafter will be used for recreational purposes.
- When the landfill closes completely, there will be opportunities for environmental enhancements and public recreational use around the edge of the site. Examples could be planting restoration projects and new walking and biking tracks beside the Kaikorai Estuary. Long term use and public access to the landfill site post closure will be determined in consultation with Te Runanga o Otakou, the local community and key stakeholders.

There is no discussion presented regarding what impact groundwater quality will have on the expected recreational land use. The proposed recreational use does not include water use, however it would be expected that this should be discussed in the context of potential future receptors.

2024 Review and Commentary

A new section (reference Section 4.4.1) has been added to the 2024 GW Report which assesses the effects on recreational users. It states that the applicant does not intend to apply leachate to land, (via irrigation) and therefore the groundwater quality will not impact and future land use and surrounding area. I agree with this statement.

However, leachate breakout remains a risk to future land uses, and the risk could be reduced though management of leachate head. This is discussed further in the 2024 Landfill Design Review Technical Memo, authored by James Elliot.

3.2.2 Are there any other matters that appear relevant to you that have not been included? Or is additional information needed? Please specify what additional info you require and why [please explain]

2023 Groundwater Memo Commentary

The level of detail regarding historic well construction, including screen details are not available through the reports. This would assist in understanding the conceptual site model further.

A limited contaminated soil investigation was conducted based on opportunistic geotechnical investigation and it does not seem that there was a dedicated contaminated soils/groundwater investigation. The geotechnical works included the installation of six



piezometers which bore logs included indicate submerged screens. It is understood these wells are used for water level gauging, not groundwater quality. Further discussion should be provided with respect to applicants plans for these wells, and if they will form any part of the future groundwater quality monitoring.

The 2023 SW Report notes in Section 3.4: the Kaikorai Stream historically ran through where the landfill is now. However, the stream was diverted along the western boundary of the landfill to run in a southwest and southerly direction, towards the Kaikorai Estuary and ultimately the sea. The potential for the former drainage channel(s) to be acting as a preferential pathway has not been addressed. Furthermore, there is the potential that the leachate interception trench is located above the former channel(s). In addition, there is also a gap in the leachate trench to the southern side of the landfill, which may result in leachate not being captured and ultimately discharging through the former drainage channel(s). As such, there needs to be further investigation into the previous drainage channels and how these relate to the landfill conceptual site model.

Installation of downgradient of monitoring wells screened in the Upper Kaikorai Estuary Member (UKEM) and the Lower Kaikorai Estuary Member (LKEM) will assist in determining impact on groundwater quality. It would also be expected that deeper groundwater, in the Abbotford formation would also be monitored to confirm understanding of the aquitard function as stated in the application. At least three well locations (sets of wells in each unit should be considered to understand impact on underlying units) should be installed to cover off the former drainage channels and the impact of the landfill as a whole. These wells are to be installed outside of the leachate interception trench well system in a downgradient position before the estuary. There are limited locations based on surface water locations, however these can be installed in the southern to southwestern area of the landfill.

2024 Review and Commentary

The above concerns have largely been discussed in Section 3.1 above, but in summary:

- One of the geotechnical investigation bores, BH103, has been added to the monitoring programme. It is possible that BH101 may also be suitable, and beneficial, as a deep well on the monitoring line 3.
- Additional monitoring to address the risk of former stream and mudflat channels, and understanding of off-site migration, is still required and has been recommended in Section 3.1.1.

3.2.3 If granted, are there any specific conditions that you recommend should be included in the consent?

2023 Groundwater Memo Commentary

Further downgradient groundwater monitoring network is required in order to assess any impact on groundwater outside of the leachate inception trench system. There are no deep wells through the lines in the southern “half” of the landfill, which is within the area which is expected to be downgradient. There is no groundwater flow direction presented in the Report, however the Kaikorai Stream ran in a southwest and southern direction, prior to diversion, it is expected that this is the regional groundwater flow direction, towards the estuary and ultimately the coast. Long term monitoring post closure needs to be established in detail at this stage.

2024 Review and Commentary

The comments above remain unchanged and are discussed earlier in this memo.



3.2.4 Does the application appropriately identify sensitive areas including affected water bodies (surface, ground and coastal water), wetlands, bores, drinking water supplies? Yes/no.

2023 Groundwater Memo Commentary

The application notes the following:

- Kaikorai Stream and estuary to north and west are identified as Regionally Significant Wetland in the Regional Plan and an Area of Significant Biodiversity Value and a Wahi Tupuna of cultural significance to mana whenua in the 2GP.
- The site is not within a Groundwater Protection Zone or Seawater Intrusion Risk Zone. However, it is adjacent to a Regionally Significant Wetland as defined in the ORC Regional Plan (ORC, 2018).
- The former Kaikorai Stream channel is potentially a sensitive area.

Through the Section 92 process, 49 bores were identified within the area of interest. Drinking water bores in the site vicinity were not specifically identified in the application. There was reference to no groundwater use in the vicinity throughout the application, however further discussion is required based on the identified bores.

2024 Review and Commentary

The 2024 GW Report has updated the assessment of neighbouring groundwater use and I am satisfied that the effects are now adequately addressed (it will have negligible, and potentially no, effects on neighbouring groundwater users).

3.2.5 Is the description of the sensitive areas attributes potentially affected by the activity accurate?

2023 Groundwater Memo Commentary

Water bodies are identified however very limited discussion regarding attributes (refer to ecology technical memo). The underlying groundwater requires further review and investigation; with appropriate attention given to the principles of Te Mana o te Wai.

2024 Review and Commentary

The comments above remain unchanged and are discussed earlier in this memo.

3.2.6 Has the Applicant adequately assessed the adverse effects on groundwater quality of the discharge of waste and leachate to land?

2023 Groundwater Memo Commentary

Section 4 of the 2023 GW Report and Section 8.3.5 of the 2023 AEE discuss the effects. In my view the applicant has not provided sufficient detail regarding the assessment of adverse effects, other than reiterating the performance and reliance on the leachate interception trench noting surface water is not indicating adverse effects from groundwater impacts.



2024 Review and Commentary

The 2024 GW Report provides no update on groundwater quality other than some new discussion regarding presence of PFOS/PFAS in groundwater. However, the HHERA does include new and useful discussion on groundwater quality. Interestingly, the HHERA (Table 3.4) appears to acknowledge that there is at least the potential for offsite migration of landfill leachate, noting that concentrations of Zinc and PFAS “*were detected in groundwater samples at concentrations above ambient levels, which suggests that groundwater is a source of these chemicals*”. This acknowledgement seems to differ from the stance of the 2024 GW Report which hold to the view that the leachate trench prevents any offsite migration. Zinc has not been discussed or presented in the 2024 GW Report.

Furthermore, since January this year, I have been involved in the review, for ORC, of the Fairfield Landfill (closed). The Fairfield landfill is located opposite the Green Island landfill, across the Kaikorai Estuary. This closed landfill is similar to Green Island in that it is an unlined landfill founded on estuarine deposits. Leachate is controlled with a perimeter leachate drain that is pumped to minimise the offsite migration of leachate. Fairfield has multiple wells beyond the site boundary that contain elevated ammoniacal-nitrogen, zinc and boron, which the authors of their groundwater assessment, PDP, attribute to landfill leachate. The applicant acknowledges the potential for leachate to travel up to 1.2 km through the estuarine sediments. The same leachate indicators have been observed in the Green Island C and D wells; however, in this case they have been attributed to reduced conditions in organic estuarine sediments. The similarity in chemical constituents, but apparent discrepancy in source, warrants further investigation.

3.2.7 Has the applicant proposed appropriate methods to limit contaminants, particularly leachate, entering groundwater?

2023 Groundwater Memo Commentary

The application is based on the successful operation of the leachate interception trench. The groundwater results indicate that leachate is in the wells outside of the trench, however the hydraulic gradient is pulling impacted groundwater towards the trench and away from surface waters through continuous pumping.

The trench is currently not present along the southern side of the landfill and is planned to be extended with this work. The landfill engineer memorandum will comment on the expected performance following extension. The application notes the trench is not tied to the Abbotsford Formation mudstone which is inferred to be an aquitard due to the very low permeability of the mudstone and effectively an impermeable barrier for any downward seepage.

It is also expected the improved landfill capping will result in less leachate being generated and requiring treatment, following closure.

2024 Review and Commentary

The comments above remain unchanged.



3.2.8 Have the cumulative effects of the activity been appropriately assessed?

2023 Groundwater Memo Commentary

Cumulative effects have not been specifically assessed in the 2023 AEE with respect to groundwater quality.

2024 Review and Commentary

The 2024 GW Report and 2024 AEE have not addressed the potential for cumulative effects to adversely impact groundwater quality. There are no further updates to the above assessment.

3.2.9 Do you consider that the proposed improvements to the leachate system will be effective in improving groundwater quality?

Refer to the landfill engineering memorandum.

3.2.10 Has the Applicant proposed appropriate groundwater monitoring for the duration of the consent?

2023 Groundwater Memo Commentary

Section 5.1 of the 2023 GW Report recommends that groundwater monitoring is continued in line with the current consent conditions, (with some exceptions). The exceptions are valid. The monitoring parameters have been compared with Table 8-2 of the WasteMINZ Guidelines and it is noted that parameters are generally consistent with recommended parameters with the exception of copper, which should be included.

There is also note that PFAS is to be included in future monitoring.

The 2023 AEE, Section 8.3.6 sets out the proposed groundwater monitoring, which is an extension of the existing monitoring regime with some reduction of frequency for quarterly parameter monitoring.

The 2023 LDMP recommends that the monitoring programme is reviewed and updated to reflect the changes to the landfill post closure.

As this consent includes the post closure management, it would be expected that groundwater monitoring is set out at this stage and this includes installing new downgradient wells in both upper and lower Kaikorai formations and the Abbotsford mudstone, included in this monitoring to determine discharge and impact to groundwater.

2024 Review and Commentary

The comments above remain unchanged.

3.2.11 Do you agree with the Applicant's conclusions as to the level of adverse effects on groundwater?

2023 Groundwater Memo Commentary

The applicant has based their conclusions on the performance and reliability of the leachate trench and the low permeability of the Abbotsford mudstone and the surface water quality. In my view there is not enough site-specific downgradient groundwater data to determine the level of adverse effects on groundwater.



In my view further data is required in the form of downgradient groundwater monitoring wells which are screened within the 3 units to assess impact to groundwater at these different depths. These wells need to be located outside of the leachate interception trench.

2024 Review and Commentary

Additional monitoring to address the risk of former stream and mudflat channels, and understanding of off-site migration, is still required and has been recommended in Section 3.1.1.

4.0 Closure

In summary, the application with regards to groundwater quantity and quality covers the broad considerations but there remains broad levels of concern around:

- Whether the conceptual site model which is based on the leachate trench intercepting all leachate before it migrates off-site in groundwater is valid.
- Whether the current (and proposed) monitoring well network sufficiently covers the areas of highest risk to groundwater (down-gradient of the landfill, and adjacent to area of high leachate head and/or stream diversions)
- Whether the elevated concentrations of ammoniacal-nitrogen, boron and zinc (all leachate indicators) are attributable to natural estuarine conditions, or another source of these constituents.

Regards,

SLR Consulting New Zealand



Tim Baker
Principal Hydrogeologist



Emma Trembath
Technical Director – Environmental Services

