Technical Memorandum

To:	Rebecca Jackson	**From:**	James Elliott
Company:	Otago Regional Council	**SLR Consulting NZ**	
cc:	Samantha Iles (SLR)	**Date:**	5 December 2023
		Project No.	13556

RE: RM23.185 - Green Island Landfill Design and Management Technical Review

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 (the applicant, or DCC) for the operation, expansion and closure of the Green Island Landfill (referred to herein as the site).

The applicant is proposing to extend the life of the site allow acceptance of waste until sometime between December 2029 and March 2031, following which closure operations and landfill aftercare will commence.

SLR has prepared a number of Technical Memorandums in relation to the application. The Technical memorandum herein relates to Landfill Design and Management.

2.0 Scope of Review

2.1 Items Considered in this Review

The review considers landfill design and management only, as detailed in the documents listed later in this section, and as relevant to the questions posed by ORC (refer section 3.0). The design and management aspects considered as part of this review are summarised as;

- Proposed landfill cap.
- Leachate management.
- Landfill gas (LFG) management.
- Stormwater management.
- Landfill fires.

2.2 Key Documents Reviewed

The following key documents, which were submitted as part of the application, have been reviewed in the development of this technical review:

- Boffa Miskell Limited, *Green Island Landfill Closure, Assessment of Environmental Effects*, Dated March 2023. Referred to herein as the AEE.
- GHD Limited, *Waste Futures – Green Island Landfill Closure Design Report*, Dated 29 September 2023. Referred to herein as the Design Report.

- GHD Limited, *Waste Futures – Green Island Landfill Closure Surface Water Report*, Dated 7 March 2023. Referred to herein as the SW Report.
- Stantec New Zealand, *Green Island Landfill, Development and Management Plan*, Dated September 2023. Referred to herein as the LDMP.
- Tonkin and Taylor Limited, *Landfill Gas Masterplan, Green Island Landfill,* Dated September 2023. Referred to herein as the LFG Masterplan.
- Tonkin and Taylor Limited, *Green Island Landfill, LFG Management Letter Report*, Dated 21 September 2023. Referred to herein as the LFG Letter.
- GHD Limited, *Fire Management Plan, Green Island Landfill*, Dated 13 March 2023. Referred to herein as the FMP.

2.3 Scope

The scope of this review included;

- Review of the questions provided by ORC as detailed in Section 3.0 of this memorandum.
- Review of sections of the documents listed in Section 2.2 considered relevant to the questions posed by ORC (refer Section 3.0) for landfill design and landfill management.
- Considered the relevant landfill design and management aspects against the requirements of WasteMINZ 2018[1] (referred to herein as the WasteMinz Guidelines).
- Submitted a Section 92 request for Information to the applicant and reviewed associated responses.
- Prepared this technical memorandum.

2.4 Exclusions and Assumptions

The following assumptions and exclusions apply to the information provided herein.

- Discussion with respect to potential adverse human health and environmental effects associated with water and air discharges from the landfill are covered by other technical memorandums. Other technical memorandums should be read in conjunction with this technical memorandum.
- The entire contents of the documents listed in Section 2.2 were not necessarily reviewed. The review focussed on the areas described in Section 2.1.
- A detailed analysis of LFG modelling, LFG pipe sizing, HELP modelling etc. was not undertaken, and models were not rerun as part of this review.
- No site inspection was undertaken as part of this review. However, photos of the site were provided, and a SLR colleague inspected the site and provided verbal details of key site information.
- The design elements considered in this review are considered to be conceptual designs at this stage and are subject to detailed design at a later date.

[1] As of September 2023, the guideline document has been updated and reissued. However, given that the updates relate to waste acceptance criteria for landfills, and not landfill design matters, reference to the 2018 document is acceptable.

- The landfill has been operating for almost 30 years, and pre dates current landfill guidance including the WasteMINZ Guidelines. Some of the existing engineering controls do not conform to current guidance e.g. there is no engineered liner or leachate collection system on the landfill floor. This is a significant constraint for older landfills, including the site.

3.0 Response

3.1 General Matters

3.1.1 Question 1 - Is the technical information provided in support of the application robust, including being clear about uncertainties and any assumptions?

The technical information provided in support of the application is generally robust, and clear about uncertainties and assumptions. However there are some items that require further clarification. A summary of these items is provided in the following, with a reference to other relevant sections of this technical memorandum where further information is provided.

- The classification and fate of runoff from the intermediate cap (referred to herein as intermediate cover). Refer response to Question 5 (Section 3.2.2.2, bullet point 1) for more details.
- The frequency and associated impacts to the environment of leachate overflowing from the northern leachate pond in prolonged rainfall events. Refer to response to Question 5 (Section 3.2.2.3, bullet point 6) for more details.
- The lining of the northern leachate pond. Refer to response to Question 5 (Section 3.2.2.3, bullet point 3) for more details.
- The exact timing of LFG well installation for the LFG capture system. Refer to response to Question 6 (Section 3.2.3, bullet point 6) for more details.
- The potential use of a piggyback liner. Refer to response to Question 7 (Section 3.2.4.1) for more details.
- Potential impacts from subsurface landfill migration. Refer response to Question 2 (Section 3.1.2).

3.1.2 Question 2 - Are there any other matters that appear relevant to you that have not been included? Or is additional information needed?

3.1.2.1 Landfill Gas Assessment

There is limited information provided in relation to the assessment of potential environmental impacts from landfill gas in the subsurface. There appears to be potential for LFG to migrate laterally from the waste mass through the surrounding geology and buried services, particularly given the low volumes of LFG being captured by the LFG collection system (refer response to Question 6), and the absence of a landfill base or sidewall liner.

There is some information provided in the AEE regarding LFG in the subsurface, including;

- Three LFG bores are located at or near the Site to enable monitoring of subsurface LFG.
- Periodic LFG monitoring of three LFG bores is undertaken.

A maximum carbon dioxide concentration of 10.9% has been recorded from LFG bore monitoring. There are no CO_2 trigger values included in the WasteMINZ Guidelines. The AEE states that the recorded "*concentrations* (of) *CO_2 are not considered to pose a risk*".

Based on the limited information provided on subsurface LFG, the following comments are made;

- A subsurface CO_2 concentration of 10.9% may not be insignificant, and could be an indicator of migration of LFG away from the waste mass through preferential pathways like the natural geology and buried services (e.g. leachate interception trench (LIT)).
- In the absence of trigger levels for CO_2 provided by the WasteMINZ Guidelines, values from other jurisdictions could be consulted to enable an assessment of CO_2. It is noted that other nearby jurisdictions overseas have action/trigger values of 1.5% CO_2.
- Statements about the risk from LFG should be based on a site specific LFG risk assessment (LFGRA), which should in turn be based on a robust conceptual site model, and associated data set.

Based on the above comments, it is recommended that a LFGRA is undertaken for the Site, or if a LFGRA has already been completed, this is provided for review. Refer also to the response to Question 6 which is related to LFG management at the site.

3.1.2.2 Assessment of Potential Leachate Impacts

A key input to the design elements of the application is that leachate is not impacting the surrounding environment. Whilst review of leachate impacts is outside the scope of this review, further assessment has been recommended in other technical memorandums (prepared by SLR) related to groundwater quality and surface water quality. The outcomes of further assessment could influence the comments provided herein.

3.1.3 Question 3 - If granted, are there any specific conditions that you recommend should be included in the consent?

Based on the information provided to date, and considering the comments provided herein, it is recommended that specific conditions are included. A summary of the key items that should be addressed by specific conditions are provided in the following. Note that the below are not intended to be the actual conditions. Further consideration, including review of any additional information that is provided after issue of this technical memorandum, would be required before the exact conditions are confirmed.

- The need for further assessment of potential impacts, particularly from leachate, to the surrounding environment from the landfill, to help inform the need for, if any, additional management measures such as active leachate extraction (refer Section 3.2.2.3 for more details) and enhancements to the landfill cap profile and grades (refer Section 3.2.4.2 for more details).
- Improvements to be made to leachate management, such as active leachate extraction from the existing LFG wells, in an effort to reduce leachate head within the waste mass (refer Section 3.2.2.3 for more details).
- A site specific LFGRA based on a robust conceptual site model and data set to assess potential impacts from LFG on nearby sensitive receptors (refer Section 3.1.2.1 for more details).

- Implementation and timing, and where required additional details/detailed design, of proposed remedial activities, which include construction of the final cap in specific areas, installation of additional LFG wells and potentially LFG flares/engines, extension of the LIT, and eastern culvert works where leachate seepage has previously occurred.
- Surface water management, including the need to reduce the mixing of different water types; and to be clear about the fate of all water types, including intermediate cover runoff (refer Section 3.2.2.2 for more details).
- Details regarding assessment of fire risk, and associated additional mitigation, monitoring and management requirements and reviews as detailed in section 3.2.5.

3.2 Landfill Design and Management

3.2.1 Question 4 - Is the landfill design and management fit for purpose with regards to the Technical Guidelines for Disposal to Land (WasteMINZ, 2018)?

The landfill has been operating for almost 30 years, and pre-dates current landfill guidance including the WasteMINZ Guidelines. Some of the existing engineering controls do not conform to current guidance e.g. there is no engineered liner or leachate collection system on the landfill floor. This is a significant constraint for older landfills, including the site.

In considering if the landfill design and management was fit for purpose in relation to the WasteMINZ Guidelines, the application documents were compared to the requirements, recommendations and objectives of the WasteMINZ Guidelines. Notwithstanding the legacy of no liner or leachate collection system on the landfill floor, the proposed landfill design and management is generally in line with requirements specified in the WasteMINZ Guidelines, with the following exceptions;

- Section 5.6 of the WasteMINZ Guidelines includes objectives of surface water and stormwater management. One of these objectives is to "*maintain separation of stormwater from waste/leachate*". Based on the application documents, leachate is combined with runoff from areas that aren't considered leachate, and also leachate will overflow from the northern leachate pond during prolonged rainfall events. Both of these scenarios result in leachate combining with stormwater, which does not align with the aforementioned objective. Refer response to Question 5 for more detail.
- The landfill does not include a base liner and leachate collection system. Due to the age of the landfill, and the guidance at the time, this is not considered to contravene the WasteMINZ Guidelines relevant to this review. However the leachate head in the landfill is over 10 m in some parts. This is a considerable head of leachate and is not in line with the WasteMINZ Guidelines objective to minimise leachate head. Refer response to Question 5 for more details.
- Further to the above, the WasteMINZ Guidelines states that leachate needs to be controlled to influence the biodegradation of the waste and consequently the generation of landfill gas. The elevated leachate head is expected to be inhibiting the performance of the LFG collection system and is therefore not considered to meet the requirements of the WasteMINZ Guidelines.
- The proposed grades and material thickness' of the landfill cap profile are not considered to meet the recommendations of the WasteMINZ Guidelines. Refer response to Question 7 for more detail.

The aforementioned items do not strictly mean that changes are required to landfill design and management. However further assessment is considered necessary to demonstrate the suitability of the proposed design and management elements that don't conform to the WasteMINZ Guidelines. This is detailed further in subsequent responses.

3.2.2 Question 5 - Is the leachate and stormwater management appropriate for the site, including the changes proposed by the Applicant as part of this application?

3.2.2.1 Background

The water management systems at the landfill are described in various reports, including the SW Report. Surface water runoff is split into three category types as follows;

- *Clean: Non-contaminated or potentially low concentrations of sediment. Can flow directly to the natural environment.* The AEE states that currently the "clean" runoff flows either to Kaikorai Stream, via one or more of either perimeter drains, open swales, culverts and existing sedimentation ponds.
- *Stormwater: Non-contaminated water, but potentially containing elevated sediment concentrations. Requires directing to a sedimentation pond for treatment prior to discharging to the natural environment*. Stormwater runoff goes to a sedimentation pond, prior to discharge to the natural environment.
- *Leachate: Contaminated stormwater or has the potential to be contaminated from contact with waste or leachate. This contaminated water must be directed to a leachate pond, or a leachate drain or channel/swale which then goes to a leachate pump station, hence is pumped to the Green Island Waste Water Treatment Plant (GIWTTP).* Leachate will be allowed to either infiltrate into the waste, or it will be collected and diverted to a leachate drain or channel which is served by a leachate pump station.

Further to the type of water described above, the landfill is divided into specific surface water catchment areas. Each catchment is intended to only include one of the three types of water defined for the site (i.e. clean, stormwater, leachate). However, some of the catchment areas are combined before being directed to the relevant location. This includes combining clean water with stormwater and or leachate.

The AEE also states that "*if necessary, it is acceptable for cleaner waters to either flow to, or be directed to a sedimentation pond, or clean and sediment laden water to be directed to the leachate collection system*".

The landfill contains two sedimentation ponds, one in the east, and one in the west.

There is one leachate pond (Northern Leachate Pond) used to store runoff that is considered Leachate. The landfill includes a leachate interception trench around much of the landfill boundary (which also accepts water from the Northern Leachate Pond), which directs leachate to the Green Island Wastewater Treatment Plant (GIWWTP).

Horizontal leachate collection drains are proposed to be installed in new areas of waste.

The three categories of water described in the AEE, and the proposed management measures for each category, in principal, are generally considered to be appropriate. However the following comments are made in relation to stormwater and leachate management.

3.2.2.2 Stormwater Management

In relation to stormwater management, the following comments are made;

- Runoff from intermediate cover areas is not clearly defined in the documentation. The SW Report indicates that areas of intermediate cover are treated as leachate. However, the LDMP indicates that intermediate cover runoff can be considered as sediment laden water (which is interpreted to mean “stormwater”) that can be discharged to the environment via a sedimentation pond. The Design Report indicates that runoff from some areas of intermediate cover will be treated as leachate, and from other areas will be treated as stormwater. The classification, and fate, of runoff from intermediate cover areas should be confirmed and be made consistent across all application documents.
- Some of the catchment areas include a combination of water categories. However, effort should be made to avoid mixing higher quality water with lower quality (as described in Section 5.6 of the WasteMINZ Guidelines). Mixing various water types increases the volume of water needing management via the sedimentation ponds and/or GIWWTP. This is particularly evident in the Catchments 2, 2a and 5a which are from areas of final capping but are directed to the northern leachate pond and treated as leachate. Similarly for catchment 4a, 6a, 7a, 7b and 10, where potentially sediment laden waters (i.e. stormwater) are treated as leachate. It is noted that there are constraints to keeping water types separated (e.g. where “Clean” water flows downwards onto a “Stormwater” area), which may limit the possibility of separating all water types.
- It is acknowledged that where water categories are combined, the water is considered to be the lower quality water of the two categories being combined (i.e. if clean and leachate are combined, the water will be treated as leachate), which is also considered appropriate if combining waters is unavoidable.
- Further to the above, it is noted that the SW Report (Section 4.1) states that “*it is acceptable for clean and sediment laden waters to be directed to the leachate system. The high proportion of catchments currently being directed to the leachate system without causing issues is proof of this*”. It is unclear what *“without causing issues”* is referring to. This statement should be supported with definition of what an *“issue”* is and provide the relevant evidence that an *“issue”* hasn’t occurred.
- There is reference to runoff being allowed to soak into waste mass. Whilst this is acceptable for rainfall in the active tipping area, it should not apply to runoff from areas up stream of the active tipping face. Care needs to be taken to ensure that water does not pool on the landfill, where it could generate odours or become a hindrance to landfill operations. Given the significant head in the landfill, where possible, water considered to be leachate should be directed to the GIWWTP via the quickest route, rather than be allowed to seep into the waste mass.
- It is noted in Section 4.1.3 of the SW Report, *“in prolonged high rainfall events water from this pond (northern leachate pond) will overflow to perimeter swales and discharge to Kaikorai Stream*”. It is not clear what a prolonged high rainfall event is, however, leachate should not be allowed to discharge to the environment without treatment. This needs further assessment in relation to the potential frequency of leachate overflow and associated potential impacts to the surrounding environment.

- The discharge of water from the final vegetated cap direct to the environment is considered acceptable, provided the cap is sufficiently vegetated to prevent both erosion of the cap, and sediment laden water from discharging directly to the environment.

3.2.2.3 Leachate Management

In relation to leachate management, the following comments are made;

- Some parts of the landfill have leachate head of 10 m or more. It is acknowledged that due to the age of the landfill, and the guidance at the time, a base liner and leachate collection system were not incorporated into the landfill design. Therefore it is difficult to manage leachate levels in the waste mass, and to address the WasteMINZ Guidelines objective to "*minimise head of leachate above the liner*". However, a 10 m leachate head is considered to be significant, and is not in line with WasteMINZ Guidelines. There is no active extraction of leachate at the site. The Design Report states that active extraction from the existing LFG wells is an option for leachate removal. It is recommended that leachate is actively pumped from the waste mass, on a trial basis as a minimum, to assess if extraction can reduce the leachate head in the cells, and in turn reduce the potential for leachate migration offsite to occur. A reduction in leachate head at the site would also be expected to improve the LFG collection rates (refer response to Question 6). Active extraction, even a trial, should be based on a thorough understanding of the landfill, and take into account any effects the extraction may have at the site, such as fate of removed leachate, potential for increased LFG generation, possible rebound of leachate after extraction etc.
- Further to the above, the Design Report refers to extracted leachate being transferred to the perimeter leachate collection system and ultimately the GIWWTP. It is recommended that any leachate actively extracted from the landfill is transported to the GIWWTP via enclosed drains that do not allow for potential loss of leachate to the environment such as in the LIT or surface drains.
- The lining of the northern leachate pond is not entirely clear. An unlined, or poorly lined pond has the potential to allow migration of leachate into the underlying geology. It is noted that the landfill itself is not lined, and that the northern leachate pond is within the LIT catchment area. Therefore if leachate did leak through the northern pond base it may not necessarily have any noticeable, or significant impact on the environment. However, the suitability of the liner should be considered in relation to potential for leachate to impact the environment.
- The proposed horizontal leachate collection drains in the waste mass, where waste will be placed atop the existing waste mass, are considered appropriate and should be used wherever possible to help improve leachate removal and therefore reduce leachate head within the waste mass.
- Remedial measures to address the leachate seepage from the eastern culvert should be implemented at the earliest opportunity to reduce potential for more leachate seepage from the waste mass.
- The LIT allows for mixing of leachate and groundwater within the trench. This increases the volume of leachate. Similar to the comments made about the stormwater management system, the mixing of leachate with other water types, including groundwater, should be avoided.

However, the LIT appears to provide a preferred flow path for leachate where it can be extracted and sent to the GIWWTP. This is expected to reduce the volume of leachate entering the water table, which would be expected to reduce the impact of leachate on the surrounding environment. Therefore, whilst the mixing of leachate and groundwater should be avoided, the use of the LIT to reduce potential impact of leachate on the surrounding environment is considered to be acceptable. This is of particular importance given the absence of a liner and leachate collection system at the base of the landfill.

Furthermore, the extension of the LIT as proposed in the application is considered appropriate to further reduce the potential for leachate migration offsite. The extension of the LIT should be subject to detailed design, in particular noting that the drawings provided in the application show;

a. A direct connection between leachate and groundwater.
b. The materials to be placed on either side of the trench following excavation are not defined.
c. The horizontal component of the trench extends into existing waste.
d. The trench is founded in the natural underlying geology.
e. The existing trench is understood to include a High-density Polyethylene (HDPE) layer, and its unclear if this will be incorporated into the LIT extension.

- Regardless of the above, further assessment of the potential for leachate to impact groundwater and surface water should be undertaken to assess the effectiveness of the LIT in preventing impacts to the environment, and to inform if additional measures to manage leachate are required.

3.2.3 Question 6 - Is the landfill gas management appropriate for the site, including the changes proposed by the Applicant as part of this application?

The LFG Masterplan provides details of expected LFG generation and collection at the landfill based on site specific modelling. The forecast LFG production rate peaks at 903 m^3/hr , and the forecast LFG collection rate is 80% of the generation rate, which equates to 722 m^3/hr.

The existing landfill gas management system, as summarised in the LFG Masterplan is as follows;

- A total of 38 vertical LFG extraction wells, with approximate spacing of 40 m.
- LFG collection and header pipework and ring main for transmission of LFG
- One LFG engine with 350 m^3/hr capacity, and one candlestick LFG flare with 450 m^3/hr capacity

The LFG Masterplan details proposed improvements to the LFG management system which are summarised as follows;

- Extension of existing LFG management system (including wells, lines, and ring main) across the proposed future filling area.
- "*Discussion of replacing the existing backup flare with a new enclosed flare*", and "*other …options could be considered for the site* (which)*..could include installation of additional electricity generators*".

In principle the proposed LFG management system, once installed and on the assumption it performs as per the design expectations, would appear to be appropriate for the longer term management of LFG at the landfill. However, I have some reservations about the LFG management system, particularly in the period before the entire system is installed, which are summarised in the following.

- The leachate level in the waste mass is more than 10 m above the base of the landfill in some areas. Leachate build up within the waste mass would be inhibiting the generation of LFG, and would also be expected to be reducing the effectiveness of LFG wells where leachate is present at a level above the base of the LFG well. A reduction of leachate levels (refer response to Question 5) would be expected to increase LFG generation rates, and may improve LFG collection efficiency also.
- The modelled LFG generation rates and associated modelled LFG capture rates presented in the LFG Masterplan are much higher than recent LFG capture rates. For example, in 2022, a total of 2M m^3 LFG was captured, which equates to about 228 m^3/hr. This is compared to modelled 80% and 50% capture rates of 646 m^3/hr and 404 m^3/hr respectively. This indicates the system is performing poorly. It is noted that the modelled rates are based on a lower leachate level, than what is present at the site. This may result in LFG generation estimates being overestimated. Improvements to leachate level management (refer response to Question 5) may improve LFG collection rates. The LFG Masterplan offers some reasoning for the discrepancy between captured and modelled LFG rates, however leachate level is not mentioned, which is curious.
- It is also noted that the LFG utilisation and treatment systems (engine and flare) have significant downtime. This results in the landfill having extended periods of lower capacity for LFG utilisation/treatment. The maximum recorded LFG flow was 493 m^3/hr in January 2021, which exceeds the capacity of the flare and the engine if one was operating without the other. Furthermore, the maximum future predicted LFG collection rate is over 800 m^3/hr, which exceeds the capacity of the flare and engine operating together. It is therefore surmised that;
    f. Even with the relatively low LFG collection rates, the system could potentially have extensive periods where treatment capacity is less than the LFG capture rate due to regular downtime of the flare/engine.
    g. If the capture rates improve (as predicted in the LFG Masterplan), the above issue will be exacerbated further.
    h. If LFG collection rates improve to predicted rates (i.e. 80% capture), the treatment capacity, even if both the engine and flare are operating at full capacity, will still not be sufficient.
- The above is expected to become more critical if the LFG generation rates increase over time, which the LFG Masterplan predicts will occur. It is noted that the installation of a replacement flare has been “discussed”. It is recommended that treatment capacity is improved to ensure that all captured LFG can be treated, even during periods of downtime of the flare/engine, and that treatment capacity is sufficient for the expected increased capture rates in the future.
- It is understood that existing wells in areas where waste is to be placed will be extended over time to the top of final waste height. This is supported, although noting that wells that are located in operating areas are at risk of damage from landfill operations (e.g. waste placement and compaction), as well as from settlement. The detailed design of such wells will need to account for this hazards.

- The exact timing of installation of new LFG extraction wells is not clear. Typically this would be done at the time that waste reaches final height. The period in which areas of waste are without LFG extraction capability should be minimised. It is recommended that more detailed timing of LFG well installation compared to waste placement in each area is provided, to provide an understanding of waste volumes that may be left untreated.
- The LFG Masterplan considers the use of horizontal LFG wells for LFG collection. However, the LFG Masterplan recommends that horizontal LFG wells are not installed due to the "sporadic nature of filling and the varied waste depth". Whilst it is agreed that horizontal wells may not be as effective in this type of landfill, they may still provide some collection capacity in areas where LFG may remain uncollected for a significant period of time whilst the waste mass reaches full height.

3.2.4 Question 7 - Is the landfill closure concept design appropriate as described in section 4 of the Design Report (Appendix 3)?

The landfill closure concept design is generally considered appropriate. However, some specific comments on the landfill closure are provided in the following;

3.2.4.1 Piggyback Liner

Section 4.4.3 of the Design Report is titled *"Proposed Approach to Landfill Liner Absence".* This section identifies that a piggyback synthetic liner (piggyback liner) is an option for the landfill development. This section seems to indicate that a piggyback liner will not be adopted, although it is not explicitly stated. Three key risks in relation to a piggyback liner are identified. Whilst a piggyback liner may not necessarily be warranted for this site, the following comments are made;

- A piggyback liner could include a number of layers and materials and shouldn't necessarily be limited to synthetic materials only.
- Two key risks highlighted by the Design Report in the application of a piggyback liner include differential settlement and performance during seismic events. These two factors apply to a number of engineering controls at the landfill (base liner, cap, leachate and LFG management systems), and the design of the piggyback liner needs to take account of such factors. The fact that these risks exist doesn't necessarily mean that the option shouldn't be considered further.
- A third risk highlighted by the Design Report in the application of a piggyback liner relates to complications in the installation and operation of the LFG system. It is agreed that it may complicate things, but similar to the above, the design would need to account for this, and the fact that things may become complicated shouldn't necessarily be the reason not to proceed.
- The Design Report states that the existing leachate collection trench (this is assumed to mean the LIT) meets the required environmental outcomes, and the addition of a piggyback liner was assessed as not providing any additional benefits. The assessment referred to above should be provided. Additionally, confirmation that the current LIT is meeting environment outcomes should also be provided, noting recommendations relating to further assessment in Section 3.2.2.3 and in other SLR Tech Memos.

3.2.4.2 Landfill Cap Profile

The existing landfill cap profile is not described in Section 4, however it is described in Section 3.3 of the Design Report, which from top to bottom consists of;

- 350 mm topsoil.
- 600 mm compacted low permeability (<1x10^{-7}) clay.
- 300 mm compacted intermediate cover soils.

Section 4.3 of AEE states that final capping profile across the remainder of the site will meet these same requirements as the existing cap. Assessment of the cap profile layers against the requirements of WasteMINZ Guidelines (Table 5-8) is summarised below;

- The cap profile includes a topsoil layer of 350 mm, which is greater than the 150 mm thickness recommended in the WasteMINZ Guidelines. The increased thickness is considered acceptable.
- The cap profile includes a 300 mm intermediate cover layer above the waste. This is less than the 500 mm combination of soil cover and gas dispersion layers recommended in the WasteMINZ Guidelines .
- It is also noted that WasteMINZ Guidelines includes a 500 mm “subsoil layer”. There is no subsoil layer included in the cap profile.
- The WasteMINZ Guidelines state that “where the final cover is designed to minimise infiltration of water into waste, a combination of flexible membrane liner….or geosynthetic clay liner with compacted soil…is typically used". The proposed cap profile does not include a membrane or geosynthetic clay liner (GCL).

It appears that the cap profile does not strictly meet the minimum recommended final cover requirements detailed in the WasteMINZ Guidelines. However, the reduced thickness of the intermediate cover layer, and the absence of a subsoil layer and a membrane/GCL, may still be appropriate, subject to further assessment of potential for leachate to impact the surrounding environment. If leachate is found to be impacting the surrounding environment such that additional mitigation/remedial measures are required, then the cap profile may need enhancement to further reduce the potential leachate generation rates, and reduce potential impacts of leachate on the surrounding environment.

3.2.4.3 Landfill Cap Grade

The proposed landfill cap includes grades as low as 2%. This is well below the minimum grade recommended by the WasteMINZ Guidelines of 5%. It is understood this grade is proposed due to existing landscape and physical site constraints

The intent of the minimum grade of 5% specified in the WasteMINZ Guidelines is to promote rainfall runoff, and to allow for some changes in the final grade due to differential settlement. The flatter grade increases the potential for flat spots to occur due to differential settlement, which creates the potential for increased seepage through the final landfill cap.

The grade is therefore not considered appropriate at this time, but may be reconsidered based on further information, such as details of the physical and landscape constraints, further assessment related to potential impacts of leachate on the surrounding environment (which the landfill cap is primarily intended to reduce/prevent), and any other measures taken to manage leachate (e.g. active extraction from the waste mass).

It is noted that Section 1.3.1 of the Design Report states that the consent conditions do not impose any specific limit on height of the landfill, and therefore it may be possible to increase the cap grade without reducing the volume of airspace available for waste placement.

3.2.5 Question - 8 Has the risk of landfill fire been adequately assessed? Please explain.

To provide an answer to this question, The Fire Management Plan (FMP) was reviewed. It is noted that in section 1.2 of the FMP, it is referred to as a "*fire management assessment report*", with one report objective being to "*assess the potential and associated risks of a fire occurring on site*..". Whilst there is discussion about potential sources of fires, there does not appear to be an assessment of risk in relation to the identified hazards. Rather, the report details the expected fire hazards, and then provides details of mitigation, monitoring and management requirements for the potential fire hazards. It is recommended that a fire risk assessment is prepared, or if it has been completed already, it is provided for review, and is detailed in the FMP to assist in assessment of the suitability of the mitigation, monitoring and management requirements.

Regardless of the above, the mitigation, monitoring and management requirements detailed in the FMP generally appear acceptable, noting the following;

- Battery fires are becoming an ever increasing issue for waste collection and disposal. Vigilance at the tipping face and weighbridge are needed to detect these in incoming loads in particular. A plan for managing these is critical, including provision for such a fire to be extinguished typically by dumping in a dedicated fire safe area away from the waste mass and other infrastructure.
- Further to the above, as the occurrence of such fires increases, so too does the need to enhance mitigation, monitoring and management requirements. Therefore regular reviews, and potentially updates, to the FMP are warranted.
- Table 4 states that "monitoring of oxygen…and carbon monoxide…in the collected gas" will be undertaken. The details of the monitoring (i.e. frequency, location, method etc..) should be documented in a LFG monitoring program, and results reviewed after each event and reported periodically to help assess the potential for a landfill fire to occur or have occurred.
- Table 5 states that a "*thermal imagery camera will be purchased*" and a "*review will be undertaken by 1st January 2024 with the aim to setup a fixed mount thermal imaging camera which is capable of scanning the active landfill area and vegetated surface of the landfill*". I agree with this measure, and support its implementation. Full details should be provided, including the results of the proposed review by Council.
- Section 5.6 of the report details fire risk mitigation and readiness. There is reference to water sources, in section 5.6.3, including fire extinguishers. Other types of fire fighting methods apart from water may be needed, dependant on the type of fire. For example a chemical fire maybe inadvertently provoked by the addition of water.
- A key environmental impact from a subsurface landfill fire is odour. Odour should be a key part of monitoring for a landfill fire, along with other items that are proposed for monitoring including presence of smoke, increased carbon monoxide in the LFG system etc..

4.0 Closure

SLR trusts that this technical memorandum is adequate for its purpose. We are happy to discuss any aspects of our assessment and work collaboratively with you to undertake additional revisions if required.

Regards,

SLR Consulting Limited

pp

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