REPORT

Auckland Regional Landfill

Compiled further information responses

Prepared for
Waste Management NZ Ltd

Prepared by
Tonkin & Taylor Ltd

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Table of contents

Overview

Resource consent application

Auckland Council requested further information pursuant to section 92 of the Resource Management Act 1991 (RMA) on Waste Management NZ Ltd's (WMNZ) application for resource consent to construct and operate the Auckland Regional Landfill. These requests were included in a letter sent through on 18 September 2019 and the subsequent addendum sent through on 24 September 2019. In addition, some further clarification matters were raised by Auckland Council in response to the further information provided by WMNZ and its consultants.

Responses to these questions have been provided to Council in five tranches, between November 2019 and February 2020. This document compiles all of the information provided to Council by technical area for ease of reference. We have retained the numbering used in Council's requests.

Private Plan Change request

WMNZ also lodged a request for a Private Plan Change with Auckland Council on 17 July 2019 for the Auckland Regional Landfill precinct. Auckland Council requested further information pursuant to Clause 23 of Schedule 1 of the Resource Management Act 1991 (RMA) on WMNZ's Private Plan Change request. These requests were included in letters sent through on:

- 30 September 2019
- 24 December 2019
- 3 March 2020.

Responses to these questions are collated in Appendix AA.

1 Engineering

Questions relating to engineering and hydrogeology were set out in the memorandum from Pattle Delamore Partners Limited, dated 28 June 2018.

1 ***The assessment has a paucity of ground investigation data from within the Valley landfill footprint. The applicant provides data from six (6) hand augers drilled to 4 m depth inside the Valley 1 footprint. All other intrusive investigations have been completed either on the boundary or outside of the proposed landfill, and the majority of these do not penetrate to the invert of landfill. The basegrade design involves depths of cut up to 45m with cut over most of the landfill footprint deeper than 10m, well below the depth of the investigations carried out to date. The report acknowledges that the form of the basegrades may be modified during detailed design based on further geotechnical information. Given that a number of key issues are dependent on the assumed basegrade configuration (groundwater contamination, liner and leachate system design, material balance and soil borrow and storage and stormwater control) provide an assessment of the potential envelope of uncertainty for the basegrade configuration and the implications for the dependent issues.***

Investigations on site have been limited to test pits within the footprint of the landfill and machine boreholes around the perimeter of the main landfill valley. This was because of the difficult terrain in the main landfill valley making access very difficult and the need for tree removal from a production forest if access tracks were to be cut. The depth of residual soils within the landfill has been inferred from this information. Residual soils were encountered throughout the site at depths ranging from 0.8 to 12.5 m below ground level. The geological sections included in the Geotechnical Interpretive Report[1] show an inferred depth of residual soils generally in the order of 10 m, thinning out towards the base of the valley. The geometric design of the landfill basegrade shown in the Engineering Report[2] has been designed to:

- Provide a planar and uniform landform to facilitate geosynthetic liner installation.
- Provide a surplus of cut over fill sufficient for the operational needs of the landfill over its lifetime.

The shape was determined primarily based on geometric considerations, but with the objective of restricting the depth of excavation to in the order of 10 m so that most of the excavation would be in residual soils. This objective was achieved over much of the footprint (refer to the cut-fill isopach shown on Drawing ENG-11), however there are some notable exceptions where a much greater depth of excavation is required, particularly to remove the large spur at the south eastern end of the valley.

Once the pine trees have been removed from the valley it will be possible to undertake a more extensive geotechnical investigation within the landfill footprint to inform the detailed design of the landfill basegrade. It is expected that the final design will follow the general form of the basegrade shown in the consent application drawings. However, some changes are likely to be made to:

- Avoid areas of hard rock if this can be accommodated without adversely affecting other aspects of the design.
- Possibly increase the depth of excavation in areas where the depth of residual soils is greater than expected, if required to improve the overall soil balance, and if this can be accommodated to meet other design objectives.

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[1] Auckland Regional Landfill, Geotechnical Interpretive Report, Tonkin & Taylor Ltd, May 2019
[2] Auckland Regional Landfill, Engineering Report, Tonkin & Taylor Ltd, May 2019

We expect that over most of the footprint the final design for the basegrade will be generally in accordance with the concept design and generally will vary no more than 2 to 5 m vertically from the concept design except in isolated areas. Any detailed design changes will be made with the overall soil balance in mind.

The issues raised in the question relate to the effect of such changes on groundwater contamination; liner and leachate system design; material balance and soil borrow; and storage and stormwater control. These are addressed separated below:

Groundwater contamination

Changes to the base grade levels will not affect potential groundwater contamination compared with the concept design on the basis that:

- The overall landfill footprint will remain unchanged so the potential contaminant source remains unchanged.
- Any small change in the proportion of flatter areas vs sloping areas will not materially affect the potential leakage of contaminants to groundwater.
- The liner design will remain unchanged so the potential for leakage through the liner will remain unchanged.
- Any small difference in elevation of the basegrade will not affect the transport of contaminants from the site via groundwater given the long travel distances to any receptor.

Liner design

Small changes in elevation of the liner will not affect the liner design. Any changes that may be made will be made in accordance with best practice for liner design and will not change the principles described for the consent design.

Leachate system design

Small changes in elevation and shape of the liner will not affect the leachate system design. The design is already strongly influenced by the high proportion of side wall liner areas. Minimum slopes (2 % gradient) will be maintained on all benches and floor areas, and collection pipes designed accordingly, so that the overall design objectives for the leachate collection system are met. Any changes to the basegrade design will not affect leachate generation.

Material balance

This is the factor most likely to be influenced by any changes to the basegrade design. However, the intent of any changes would be to better match the design with the subsurface conditions to yield soils that are suitable for landfill construction and operation. Overall, with a footprint of approximately 60 ha, an average depth of cut about 8 m is required to provide sufficient materials for the landfill operation. Indications to date are that this is achievable. In the event that there is more excavated material than required for landfill operation then surplus material would remain in the stockpiles on site, with appropriate contouring. Should there be a deficit of soils required for landfill operation then further fill would need to be sourced from elsewhere on site or brought in from off site. Any additional approvals required, or variations to existing approvals, can be sought at that time.

Stormwater control

Any small changes to the basegrade design will have no effect on stormwater control. Stormwater systems will be designed in accordance with the overall concepts and best practice to convey water to the western end of the valley for treatment in the proposed stormwater ponds prior to discharge.

2 ***During the early refuse placement stages the management of stormwater upstream of the refuse is proposed to occur by two stormwater pipes; one passing beneath the liner to carry the full up valley stormwater flows and one above the liner to carry runoff from new construction areas. This presents a risk of washout of the completed downstream landfill stages, other ancillary facilities and downstream natural assets should the pipes have insufficient capacity, become blocked or are unable to access and freely discharge the flows. While design storm flow standards have been provided a fuller assessment is needed given the significance of the consequences should failure of this system occurs. Provide a more detailed assessment that considers the range of risks that may develop and the responses that will be available to address those risks. This should include risks that may be associated with the long-term resilience of these pipes over the life of the landfill and after care period.***

As described in the consent application, the construction of Phase 1 of the landfill will block off the catchment upstream of Phase 1 at the eastern extent of the valley. Runoff from this catchment will discharge into a pond upstream of Phase 1 and from there into a pipe beneath Phase 1. The pond will provide for flow attenuation and sediment removal. The pipe beneath the landfill will be approximately 1350 mm internal diameter designed to carry the 10 % AEP flow, with a design attenuation volume in the pond to hold a 1 % AEP event. This pipe will need to remain operational while Phase 1 and 2 are being filled and while Phase 3 is being constructed. Once the upper benches of Phase 3 are completed the upper portions of the catchment will be drained to the benches around the downstream waste fill, reducing the catchment discharging through the main pipe. Also, a second stormwater pipe will be installed above the liner level to allow drainage from above liner level while Phase 3 is being constructed.

The pipe beneath the landfill will be installed only beneath Phase 1, a length of approximately 600 m beneath the landfill, but it will be extended further downstream of the landfill to Stormwater Pond 3A. It will need to be operational for approximately six years. Once Phase 3 construction is complete the pipe will be decommissioned. All downstream sections of pipeline will be removed prior to any landfill construction in these areas. Both ends of the pipe remaining beneath the landfill will be sealed to prevent water ingress or discharge. If the pipe is considered to pose a long-term risk of structural collapse it will be either fully or partially backfilled to minimise this risk.

Potential risks associated with the pipe during operation comprise:

- Blockage of the pipe reducing capacity such that the pipe will not carry the design flows.
- Rainfall exceeding the design rainfall event.
- Live storage in the attenuation pond being full at the time a further significant rainfall event occurs.

Pipe blockage

The most likely cause of any blockage would be forest debris from the catchment above, including branches, tree trunks and similar. Water from the pond will discharge through decant structures to allow removal of water from the pond surface for sediment removal. No large debris can enter these devices because of the small apertures. A bar screen will be installed on the main outlet pipe to prevent any large debris entering the pipeline. This screen will need to be inspected regularly to check for and remove any debris accumulation and, at the same time any large floating debris would be removed from the pond surface as far as this is possible.

High flows

Details of the pond have not yet been designed. However, the outlet for the pond will comprise:

- Decant T-bars to discharge low flows from the surface of the pond to the pipeline, providing for sediment removal while drawing down the water level between rain events to maintain the live storage volume.
- A higher level main discharge pipeline, again taking water from the surface of the pond, designed to convey the 10% AEP event from Pond 5 to Pond 3[3].
- A second, higher level discharge pipe to discharge pond water to the pipeline should the main outlet structure become blocked.
- A valve controlled low level outlet in the pond that can be manually opened to rapidly drain down the pond level prior to a predicted significant rain event to provide additional live storage.

The original hydrological assessment of Pond 5 was based on rainfall depths from HIRDS V4 with an allowance for climate change in accordance with Auckland Council's Stormwater Code of Practice (16.8% increase in storm rainfall to 2090 based on AIB middle of the road scenario from IPCC 4th Assessment Report of 2.1°C projected temperature increase and 8 % increase in storm rainfall per °C). This was a conservative approach as Pond 5 is intended to be active for only six years therefore climate change to 2090 is not required.

The Ministry for the Environment (MfE) published climate change projections for New Zealand in 2016, updated in 2018 and NIWA published updated HIRDS storm rainfall (HIRDS V4) in 2018 based on the IPCC 5th Assessment Report. These documents refer to four future Representative Concentration Pathways (RCP). RCP 2.6 mitigation pathway with removal of some CO_2 presently in the atmosphere, two middle of the road scenarios (RCP 4.5 and RCP 6.0) and an extreme scenario (RCP 8.5) with very high greenhouse gas concentrations. Based on the proposed life of the ponds and the latest MfE climate change projections, it is considered more realistic to consider a middle of the road scenario (RCP 4.5) with climate change projected to 2031 to 2050. Projected temperature increases for RCP 4.5 are 0.74°C.The design peak inflow presented above (13.3 m^3/s for 1 % AEP) thus differs from the flow of 14.9 m^3/s presented in Section 4.7.2 of the Engineering Report accompanying the application.

In addition:

- A large freeboard will be provided above the 100 year flow attenuation level (approximately 1.0 m to spillway level), providing additional storage prior to an overflow occurring from the pond. This will effectively store a 0.2 % AEP (500 year ARI) storm event.

It will be necessary to install a spillway from the pond to protect the dam structure in the unlikely event that there was an overflow, either due to a much larger rainfall event or other factors such as pipe blockage. This would discharge into a stilling basin at the toe of the slope, and upstream of the landfill. The outlet from this pond would discharge through the pipe laid above the landfill liner, but this would not have sufficient capacity for the full flow and water would pond immediately upstream of the landfill. The potential consequences of this are:

- If filling of the landfill has progressed sufficiently, the water would pond against the intermediate cover placed on the upstream face of the landfill. A typical detail for an upstream bund on a landfill is to line the external face of the bund with geomembrane to prevent any ingress of stormwater. Should flooding exceed the level of the bund then water could potentially seep into the landfill. With a landfill floor area in the order of 600 m in length there is no risk of this short term event causing a stability failure of the landfill. There may be

[3] Storage requirement in Pond 5 was determined by simulation using a HEC-HMS model to simulate inflow and outflow from the pond when passing a 1% AEP event, with a pipeline designed to convey a 10 % AEP event. During this event, the peak inflow is 13.3 m3/s and simulated peak outflow from the 1.35 m diameter pond outlet pipe is in the order of 11 m3/s. Pond 5 is designed to store the difference between the simulated inflow and outflow (approximately 5,000 m3)

a short term increase in the quantity of leachate generated and collected if this ponded water seeps into the waste.

- If in the early stages of operation of Phase 1 of the landfill, the depth of the waste/starter bund at the upstream end will be much lower. In this case it is possible the starter bund would be overtopped and water could flow into the waste and leachate collection system. This will necessitate contingency actions to remove surplus leachate but, because of the large floor area of Stage 1 the overall depth of flooding will be small and no downstream discharges would be expected. Any stormwater that did flow into the leachate collection system would be treated as leachate and disposed of appropriately.

The likelihood of a significant event (<0.2% AEP) occurring over the operating life of 6 years is rare.

In summary:

- Pond storage volumes and discharge pipes will be conservatively designed to ensure that the risk of any overflow from the pond is minimised, such that no overflow would be expected.
- Additional safeguards will be provided in the form of:
  - An additional pond outlet to allow discharge should the primary outlet become blocked.
  - A low-level valve controlled outlet to allow for rapidly draining the pond prior to predicted large storm events, to provide additional attenuation volume.
  - A constructed spillway and stilling basin for the dam to ensure that if an overflow did occur, it could do so without damaging the dam.
- In the unlikely event that such an overflow was to occur, because of the large distance to the downstream extent of Phase 1 and corresponding large floor area, no discharge of contaminated stormwater would be expected. Some action by the landfill operator may be required to repair any damage and to manage possible additional leachate quantities.

3 ***The leachate collection system relies on a longitudinal system of leachate collection pipes that feed into a central leachate collection pipe extending along the floor of the landfill for up to one kilometre from the toe of the eastern batter. It is acknowledged that cleaning of this pipe is feasible for up to 200m from the leachate collection sump leaving some +800m of line not accessible. Some redundancy for this main collector will be provided by the repurposed stormwater pipe used in Phase 1, however it is not clear to what extent this will address the risk of leachate collection system blockage. Provide a more detailed assessment of the risk of blockage or failure of the leachate collection so that the design nominal leachate head on the liner of 300mm will be achieved over the life of the landfill.***

The general concept for the leachate collection system layout is shown on Drawing ENG-14. The concept arrangement shows:

- A leachate collection pipe on each bench to collect leachate from the side-slope above each bench.
- A dropper pipe from each bench collector pipe at the end of the bench at each stage to convey leachate to the collector pipe on the bench below, and ultimately to the floor collector pipes.
- A collection pipe at the toe of each side slope on the floor.
- A collector pipe at the centre low point on the floor. Towards the toe of the landfill the floor is only 25 to 30 m wide so the three main collector pipes will be installed in close proximity providing a high level of redundancy.

- The main leachate pipes all installed in a coarse aggregate surround, allowing for a significant flow outside the pipe through the porous aggregate should blockage of the pipe occur. This flow could then re-enter the pipe further downstream.
- Provision for cleaning access at the ends of the three main floor leachate pipes, although it is acknowledged that cleaning may not be totally effective over such long lengths of pipe.
- A separation geotextile above the drainage blanket layer on the floor of the landfill to reduce the risk of the leachate drainage aggregate becoming blocked by finer material filtering down from the overlying waste.

This arrangement of collector pipes provides a significant level of redundancy and safeguards as follows:

- Should blockage occur in one of the bench pipes, and leachate is not adequately conveyed in the coarse aggregate surrounding the pipe, it will overflow from the bench and be collected in the bench pipe on the bench below.
- Should the pipe at the bottom of the slope become blocked, and leachate is not adequately conveyed in the coarse aggregate surrounding the pipe, leachate will overflow to be collected by the main leachate pipe at the centre of the floor.
- As the centre pipe in the floor is the ultimate collection point, this needs to be taken into account in design, and consideration given to providing redundancy, either through an over-sized pipe or duplicate pipes.

During later stages of operation of the landfill, if concerns were held regarding the integrity of the floor pipes, the opportunity exists to divert flow from the bench pipes at the lower (western) end of each bench to a collector pipe laid beside the landfill footprint. This would divert all leachate generated at the upper levels of the landfill from the floor leachate collection system.

12 Empirical estimates for a similar composite liner provided within Rowe (2012) indicate that leachate seepage rate estimates for the 5 defects/ha assumption are closer to 2 lphd – when geomembrane is in direct contact with a clay liner (e.g. a composite liner of similar specification). This would equate to an estimated leachate seepage rate of approx. 40 m3/yr, which is over one order of magnitude higher than currently presented. Provide further justification for the appropriateness of the calculated 3 m3/year maximum estimated leachate seepage rate – or – provide an updated leachate seepage estimate.

Theoretical calculations based on a uniform leachate head of 300 mm are not representative of what happens in a landfill. The actual leachate head will vary:

- Depending on the location and hydraulic conditions within the landfill (e.g. the distance between leachate collectors, the slope, the permeability of the gravel and the position along the flow path), and
- Depending on leachate generation, which is influenced by the climate, so the head will change seasonally, weekly and daily, depending on rainfall patterns.

For Auckland Regional Landfill the floor area of the landfill will be approximately 6.8 ha compared with a total landfill liner area of 58.5 ha. It is proposed that a gravel leachate collection blanket layer be placed over the entire landfill liner area. This will have a permeability in the order of 1×10^{-3} m/s or better. With such a layer at a slope of 1V:3H the leachate head will be no more than a few mm (50 year average from the HELP model is 2 mm). Because of the steep gradient and high permeability of the leachate blanket layer it is impossible that a significant leachate head could ever be experienced on the high proportion of the landfill area covered by the side slopes.

An increase in leachate head to greater than design values, while unlikely, is more of a possibility on the small landfill floor area. In order to respond more fully to this question and other questions related to leachate seepage, we have undertaken a sensitivity analysis to provide a range of possible leachate seepage rates. This is presented below in response to question 16.

13 ***Other landfills in NZ and overseas have been observed to develop leachate head levels in excess of 0.3 m, due to blockages within the leachate collection system, or by other means. It is considered foreseeable that leachate head could increase to above the assumed 0.3 m over appreciable areas of the proposed landfill. Provide a higher-end leachate leakage estimate that assumes a higher leachate head level, and provide discussion/evaluation on how this may affect leachate seepage through the liner.***

As described above, there is little potential for a high leachate head to build up over the majority of the landfill footprint, which is on side slopes. A sensitivity analysis is provided below, in response to Question 16, to consider a range of possible leachate head conditions.

14 ***The effectiveness of the liner system is inherently governed by the proficiency of liner installation, whereby numerous opportunities for liner degradation are possible, even under careful construction management. Rowe, 2012 displays field evidence of theoretical/calculated leachate seepage rates vs actual seepage rates for North American composite liners with leakage detection systems. The actual leachate seepage rates are significantly higher than the theoretical/calculated rates, with Rowe proposing that the formation of winkles during the installation of the geomembrane is likely to explain the discrepancy. Provide further justification and comparison of composite liner performance for New Zealand based examples (or overseas if no NZ examples are available) which demonstrate that the presented leachate seepage rates can be achieved in practice.***

Measurement of actual leachate leakage through liners is rare as there is generally no opportunity to do this. The cases cited by Rowe relate to situations where a double liner system has been installed, including a leakage detection layer below the primary liner, where it has been possible to measure leakage. No landfills in New Zealand, other than one small example that we are aware of, have double liner systems, so such information is not available for NZ.

The work by Rowe explains increased leachate leakage, compared with theoretical calculations, on the basis of wrinkles being present in the geomembrane when covered. His paper considers affected wrinkles to be those greater than 30 mm high. Wrinkles less than this will flatten with placement of the leachate collection layer. His design approach considers different lengths of connected wrinkles for different degrees of wrinkling of the geomembrane.

Rowe's work was based on drone photography of the Queens University Environmental Liner Test Site (QUELTS), Ontario, Canada, trial cell in the heat of the day when a large number of wrinkles were present. Wrinkling can be controlled by careful selection of the time of day when cover materials are placed over the geomembrane. Typically, in the cold of morning, no wrinkles or very few wrinkles are present. The number and size of wrinkles increases as air and geomembrane temperatures increase throughout the day. The amount of wrinkles exposed to potential leakage can thus be controlled by only installing cover materials during suitable climatic conditions such as early in the day. This is well recognised in New Zealand and T+T has been involved in the installation of a large number of lining systems in New Zealand where permanent wrinkling has been minimised or even eliminated in this way. This is aided by the installation of a white protection geotextile, placed over the geomembrane prior to covering, and which controls the rise in temperature of the geomembrane.

The primary design case presented in the Engineering Report for leachate leakage through the lining system is based on a liner comprising:

- Geomembrane (HDPE) with:

- 2 x manufacturing defects per ha (pinholes 1 mm in diameter)
- 4 x installation defects per ha (1 cm^2 in area)
- Good installation quality

- Clay layer with k = 1 x 10-9 m/s

We comment on these selected parameters as follows:

- The HELP manual recommends typical manufacturing defects for geomembranes between 1 and 2 per ha. We have selected the upper end of this range (i.e. 2 per ha).
- The HELP manual recommends 2.5 to 10 installation defects per ha for good installation quality and up to 2.5 per ha for excellent installation quality. Because of the high level of QA that will be applied to the geomembrane installation, we have selected 4 installation defects per ha as providing a conservative estimate of potential defects.
- Good installation quality assumes good field installation with well-prepared, smooth soil surface and geomembrane wrinkle control to ensure good contact between geomembrane and adjacent soil that limits the drainage rate. This is typical of installation conditions achieved in New Zealand with a high level of QA as proposed.
- The HELP model will not model two barrier layers together. Therefore, it cannot easily model the proposed Type 2 lining system comprising a GCL overlying a clay layer. Therefore, we had conservatively assumed the permeability for the underlying layer of 1 x 10-9 m/s, essentially a Type 1 lining system described in the Engineering Report. However, the leakage through a geomembrane defect is controlled to a large extent by the permeability of the underlying layer, so a much lower leakage would be expected if the underlying layer permeability was reduced to 3 x 10-11 m/s, the typical permeability for a GCL.

In order to consider the sensitivity of the selected parameters above, and to also address the earlier questions, potential seepage rates for a range of different scenarios were calculated. The cases considered comprise:

1 The base case presented in the Engineering Report and described above.

2 The base case but modelling a GCL beneath the geomembrane rather than a compacted clay layer (with the underlying clay layer input as a vertical percolation layer).

3 The base case but assuming poor installation quality. Poor installation quality assumes poor field installation with less well-prepared soil surface and/or geomembrane wrinkling providing poor contact between geomembrane and adjacent soil that limits drainage rate, resulting in a large gap for spreading and greater leakage. For this case the poor quality is applied to both the side slopes and the base liner.

4 As for Case 2 but with poor installation quality.

5 The side slopes as per the HELP analysis with GCL (on the basis that a head cannot build up on the side slopes) but with a uniform head of 300 mm on the base liner (6.8 ha) for 100% of the time. Leakage through floor defects based on calculations in accordance with Giroud 1998[4] with good installation quality.

6 As for 5 but with poor installation quality.

7 As for 5 but with 1 m head of leachate on the floor liner. This is not a realistic scenario as the floor rises approximately 18 m from the west to the east.

8 As for 6 but with 1 m head of leachate over the entire floor liner.

Results are presented in Table 1.1

[4] Giroud J.P. Soderman K.L. Khire M.V. Badu-Tweneboah K. (1998) New Developments in Liner Leakage Evaluation

Table 1.1: Annual Leachate see page for different scenarios

Scenario	Leachate seepage (m3/yr)
1. Base case: HELP model — HDPE over clay: good installation (as 3.014presented in the Engineering Report)	3.014
2. HELP model — HDPE over GCL: good installation	0.778
3. HELP model — HDPE over clay: poor installation	16.694
4. HELP model — HDPE over GCL: poor installation	2.255
5. 300 mm leachate on floor (Giroud) and Scenario 2 on side walls: good installation	2.854
6. 300 mm leachate on floor (Giroud) and Scenario 3 on side walls: poor installation	14.813
7. 1000 mm leachate on floor (Giroud) and Scenario 2 on side walls: good installation	19.812
8. 1000 mm leachate on floor (Giroud) and Scenario 3 on side walls: poor installation	107.680

A potential leakage rate of 3.01 m^3/year was used in the assessment of potential effects on groundwater[5].

A sensitivity analysis was undertaken as part of that assessment as described in Table 8.5 of the Hydrogeological Report. The analysis considered an increase in leachate seepage by 3 orders of magnitude, and even this significantly greater modelled leakage did not result in unacceptable risks to receptors. The maximum (unlikely) worst case considered as part of the liner leakage sensitivity analysis presented above is approximately 35 times the base case considered. This is well within the sensitivity analysis considered as part of the Hydrogeological Assessment.

15 ***Actual effectiveness of the liner is also related to liner design, liner selection, and liner suitability for the site conditions and waste type/leachate chemical composition. Provide further information / supporting evidence on the effectiveness (over entire life-span) of the proposed liner with respect to:***

- ***The site's natural soil and pore water chemistry conditions, and suitability to proposed type of GCL chemistry***
- ***Suitability of GCL chemistry to that of the expected leachate chemistry***
- ***Suitability of the composite liner to the expected temperature that the liner will be exposed to during its operational lifetime***
- ***The potential for wetting and drying of the clay liner beneath the geomembrane due to the proposed sub-liner drainage, and/or other temporal effects.***

<u>**Leachate chemistry and GCL performance**</u>

The proposed Auckland Regional Landfill will be a municipal solid waste landfill constructed with the lining system components that are commonly used for municipal solid waste landfill lining systems. Thus it is expected that, subject to the details of design, the lining system will perform as for any other municipal solid waste landfill.

The first two questions above related to the compatibility of the GCL with the groundwater chemistry and leachate chemistry. The background to this is that most GCLs are manufactured using sodium bentonite. Sodium bentonites are prone to cation exchange when permeated with solutions containing divalent or trivalent ions, for example Ca2+, which can lead to increases in the permeability of the GCL. This can be a significant factor when a GCL is used to contain waste that

[5] Auckland Regional Landfill Hydrogeological Assessment, Tonkin & Taylor Ltd, May 2019

produces particularly aggressive leachate. Johns and Shamrock[6] provided a literature review of research into this matter and described further experimental work to provide a correlation between the relatively simple swell index test (ASTM D 5890) and permeability. Determining the effects of cation exchange by permeability testing can be difficult to achieve and must be undertaken over a long period of time. The swell index test shows a good correlation with hydraulic conductivity, with the conductivity not affected to any great extent for a swell index greater than approximately 15 mL/2g, refer Figure 1 below.

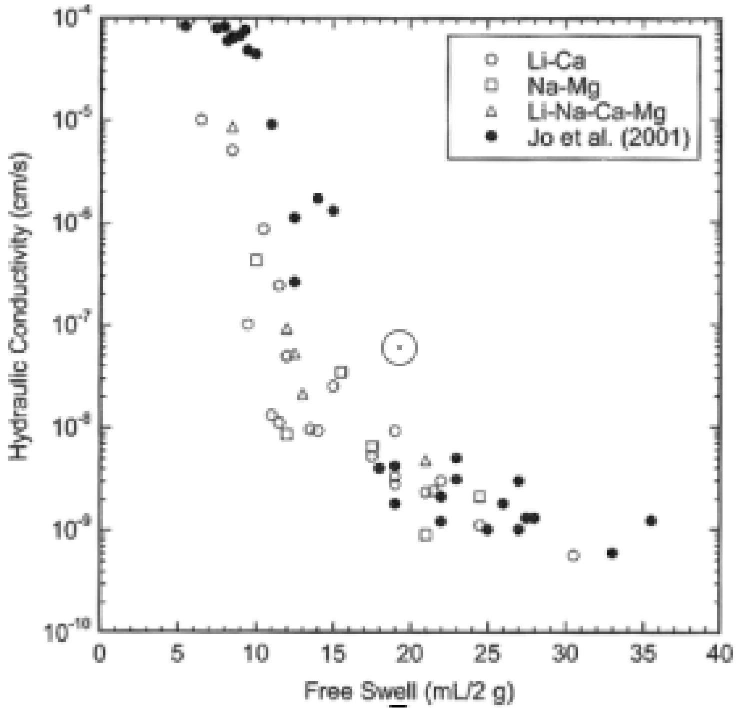

Figure 1.1: Hydraulic Conductivity of GCL as a function of free swell of bentonite from Kolstad et al.[7]

As the ARL is not yet operational it is not possible to undertake any testing using actual leachate from the landfill. Similarly, we do not know precisely what GCL will be used, although it will be specified in accordance with standards current at the time, e.g. GRI-GCL3. However, we have provided leachate data for Redvale Landfill to Geofabrics in Australia (who provide Elcoseal GCL). Geofabrics have a database of test results for their products for a range of leachate strengths and have provided the report included in Appendix A.

This report shows results of swell index testing and permeability testing for Elcoseal X2000 GCL for a leachate similar to Redvale landfill. The results show:

- A bentonite swell index of 19.0 mL/2g, which is well above the minimum of 15 at which significant changes in permeability are expected.
- A permeability similar to (better than) the standard permeability of a GCL (2.03 x 10-11 m/s).

Chemical analysis of groundwater found on site, as presented in Appendix D of the Hydrogeological Report[8] shows that the concentration of ions that would affect permeability, such as magnesium and calcium are low (magnesium typically around 5 mg/L and Calcium around 12 mg/L. This compares

[6] Swell Index Testing of GCL Bentonites with General and Hazardous Waste Leachates, D. G. Johns and J. S. Shamrock, GIGSA GeoAfrica 2009.
[7] Kolstad D.C Benson C.H. & Edil T. (2004) Hydraulic Conductivity and Swell of Nonprehydrated Geosynthetc Clay liners Permeated with Multispecies Inorganic Solutions. J, Geotechnical and Geoenvironmental Engineering, Vol 130, No. 12, pp 1236 – 1249.
[8] Auckland Regional Landfill Hydrogeological Assessment, Tonkin & Taylor Ltd, May 2019.

with a mean of 129 mg/L for magnesium and 169 mg/L for calcium in Redvale leachate. Therefore, groundwater is not expected to adversely affect the permeability of the GCL.

While ion exchange has the potential to increase the permeability of GCL, Rowe[9] notes that there is also potential for the permeability to decrease. In a landfill situation, the GCL is subject to higher applied stress compared with the reference laboratory test. For a GCL with a permeability of 3×10^{-11} m/s specified by the manufacturer, the permeability under actual landfill stresses could be as low as 7×10^{-12} m/s. Rowe concludes *"Based on a review of available data, the "typical" or "base case" value of kL for consideration in this paper was taken to be the typically specified kL = 5×10^{-11} m/s as it represents a reasonable value for GCLs permeated with water at low (3 to 4 kPa) stress levels, but also closely approximates the values obtained for GCLs permeated with a realistically simulated MSW at stresses of 25 to 35 kPa."*

Temperature

The temperatures of liners in landfills have been reported by a number of researchers, as summarised by Rowe (2012)[10]. Typically the temperature of a liner in a MSW landfill will be between 30 and 40 °C, and this temperature range is expected at ARL. (The temperature of leachate is measured at Whitford Landfill with an average of 27.5 °C and a high of 31.9 °C) Higher temperatures can be experienced for specific waste types and where there is a significant leachate mound. To avoid the latter Rowe (2005)[11] recommends that the service life of the leachate collection system can be extended by:

a The use of uniform coarse gravel drainage blanket

b Minimising the flow in critical regions

c Increasing the thickness of gravel in critical areas and having alternative drainage paths

d Using a suitable filter between the waste and the coarse gravel

e Appropriate sequencing of waste placement

f Regularly cleaning the leachate collection pipes.

These will be implemented in the design and operation of ARL.

The expected service life of a HDPE liner has been investigated by a number of researchers. A comprehensive study is reported in the Geosynthetics Institute (GRI) White Paper #6[12]. The paper describes three distinct lifetime stages:

Stage A - Antioxidant depletion time

Stage B – Induction time to onset of degradation

Stage C – Time to reach 50 % degradation (i.e. half-life)

In summary, based on research, the White paper predicts a half-life for HDPE of 446 years at 20 C, 166 years at 30 °C, 106 years at 35 °C and 69 years at 40 °C. The half-life is based on a 50 % reduction in specific design properties. The paper notes that even at half-life, the material still exists and can function, albeit at a decreased performance level with a factor of safety lower than the initial design value.

The tests at the GRI were undertaken with a sand layer on either side of the geomembrane. Hsuan at al[13] notes that where the top surface of the geomembrane was exposed to leachate while the

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[9] Rowe R.K. (2012) Short and long-term leakage through liners. The 7th Arthur Casagrande Lecture.

[10] Rowe R.K. (2012) Short and long-term leakage through liners. The 7th Arthur Casagrande Lecture.

[11] Rowe R.K. (2005) Long-term performance of contaminant barrier systems. Geotechnique 55, No 9, 631-678

[12] Koerner R.M. Hsuan Y.G. Koerner G.R. (2005, updated 2011) Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions, GRI Whit Paper #6, Geosynthetic Institute.

[13] Hsuan Y.G Schroeder H.F. Rowe K. Muller W. Greenwood J. Cazzuffi D. Koerner R.M. Long-term performance and lifetime

bottom surface is exposed to hydrated GCL the OIT (oxidative induction time – or effectively Stage A described above) values of the geomembrane were about 2.2 to 4.8 times slower for the same geomembrane immersed in the same leachate. Therefore, a composite liner with a GCL could be expected to have a significantly longer life than predicted by the White Paper.

Wetting and drying of clay liner

This question is asked specifically in relation to wetting and drying of the clay liner due to the proposed subliner drainage, and/or other temporal effects.

Drying and desiccation of the clay liner prior to GCL/geomembrane placement is a well-recognised risk and is addressed by QC and QA of liner placement. Control methods include:

- Over-filling the liner and trimming to the required level just prior to deploying the covering geosynthetic material.
- Keeping the surface damp with the use of fabrics (hessian/geotextile) and water sprays.
- Only doing the work during appropriate weather conditions.

High plasticity clays are more susceptible to desiccation than soils with a higher silt content/lower clay content. The soils found at the ARL site fall into the latter category and we expect that desiccation will be relatively easy to control during construction.

The sub-liner drainage system to be installed is not proposed to be a comprehensive subsoil drainage system. Its intent is to intercept any concentrated groundwater flows/springs to minimise potential for damage to the constructed liner. The valley is relatively narrow and steep sided. There is little potential for the compacted clay liner beneath the landfill to dry out, and it is our experience that any liner exposed subsequent to construction has been wet.

16 ***We note the proposed methodology to overcut areas where fractured rock is encountered at <2 m below basegrade level, and then re-instate with 2 m thickness of 'compacted soil excavated from site to provide an additional attenuation layer'. Please provide further information / supporting evidence on:***

- ***How the assessment of whether an area requires overcut and re-instatement will be undertaken e.g. what investigations and rock mass criteria will be adopted to classify the need or not.***
- ***The surface area that is expected to encounter the need for overcut and re-instatement.***
- ***The volume of fill material that is expected to be required, and where the fill material is to be sourced from.***
- ***How does this impact the cut-fill balance presented in Technical Report N***

The detailed basegrade design will be determined following further geotechnical investigations within the landfill footprint. The overall concepts for the basegrade will remain as shown on the consent drawings, but levels may change in places to avoid excavation to/below rock level if this is practicably achievable.

However, there will be areas where excavation into rock is unavoidable, particularly in the deep excavations proposed towards the eastern extent of the footprint.

Sub-excavation and backfill below the rock level does not affect the overall materials balance shown in the Engineering Report. Materials from the sub-excavation will be replaced by materials excavated elsewhere. Rock that is removed will be used on site to the extent possible, with likely

prediction of geosynthetics, EuroGeo4 Keynote Paper uses being as basecourse for permanent site roading, to provide a running surface for access to the tip face, for rip-rap in drains, etc. The sub-excavation will be backfilled with suitable materials excavated from the site that form part of the overall materials balance.

A cut-fill isopach for the consent basegrade design is shown on drawing ENG-11. We have assessed the likely area over which sub-excavation will be required to be where excavation exceeds 10 m. This covers a total area of approximately 195,000m^2 (19.5 ha) or approximately one third of the overall footprint, with most of this occurring within the eastern half of the footprint.

Depth to rock will be determined by scale penetrometer or similar to confirm the need for the proposed sub-excavation and backfill. Where the rock is sufficiently "tight" as to not fall under the general description of "fractured rock" in the Technical Guidelines for Disposal to Land then the rock will not be sub-excavated. A suitable methodology will be developed early during construction to help identify zones of suitable rock. This may be based on a flooded basin type soakage test (say a 2 x 2 m basin). If the rock permeability is demonstrated to be less than or equal to 1×10^{-7} m/s by such a test it would be considered suitable. Once an understanding is gained of what suitable rock looks like, decisions on future rock suitability will be based on visual inspections.

Rock permeability testing, also known as lugeon testing, was undertaken within the boreholes drilled during the site investigations. Of particular relevance in this case is BH7, drilled in the base of the proposed landfill valley, which achieved no water flow during all lugeon tests indicating very low permeability.

1.1 Development Engineering

Additional engineering questions from Auckland Council's Development Engineer were included in a letter from Sentinel Planning on 24 September 2019. Further clarification of the original responses provided to Council was subsequently sought by email from Steve Cavanagh on 8 January 2020. The further clarification is provided below the original question and response.

1 ***Please advise what the difference is between the Access Road and the Site Road? They are not labelled on the submitted plans so it cannot be determined which is which and it appears that they are designed to different standards***

The term Access Road is used in the Engineering Report and elsewhere in the application to be the road from SH1 through the Southern Block to where it enters the main landfill site at the landfill facilities area. It is described in Section 7.2.1 of the Engineering Report.

Site roads are all other roads required on the site for operation of the landfill and includes:

- The perimeter road around the landfill footprint
- Access to the Energy Centre
- Access to stockpiles
- Access to the stormwater ponds
- Access to site facilities

Any other roads that may be required from time to time for effective operation of the site.

Further clarification sought - You agreed to send a few sentences on the different standards for site roads in terms of grade, width and materials. I understand the Access road is to be sealed and two way. While I agree the placement of culverts would likely be better covered in covered in the consent process, I do think it is necessary to be able to highlight where any increase in concentrations of runoff are likely to occur so effects on streams and watercourses can be more easily assessed. I will discuss with the Ecologist and confirm with you. The dust would be covered by construction methodology so yes a consent/condition approach would be taken. The Safety would be covered by the same but the grades would play a large part in any required mitigation.

Site roading is described generally in Section 7.2 of the Engineering Report. In summary of the items discussed, and to address your specific question below.

Essentially the roads fall into two general categories: the main access road and site roads

Access Road:

The access road is the road through the Southern Block from SH1 to where it crosses the ridge into the main landfill site at the site facilities area. This will be a permanent road operational over the life of the landfill to carry all traffic, including waste vehicles, accessing the landfill. It will be a sealed two way road with a maximum grade of 8% (to suit the haulage of full refuse vehicles uphill) with lane width of 3.6 to 4.0 m.

Site Roads.

Roads are required within the landfill site to provide general access within the site for waste haulage, construction, operation of the landfill and maintenance. Different roads will be built to different standards based on their use. Generally, the roads will be unsealed as they often have a shorter operating life, being moved as the landfill develops. Where a road will be in place for a long period of time with heavy usage consideration may be given to sealing it. The design of the road will suit its intended use, e.g.

- Roads for waste haulage will generally have a maximum grade of 8% but up to 10% over short distances. The width of the road will depend on the overall layout – e.g. they may be one-way roads if a one-way ring layout is adopted at any one time, two lane if it is an in/out road, or possibly a single lane with passing bays if this suits the operation at that particular time of the landfill development.
- Haul roads between the site and stockpile areas, where these will only be accessed by site vehicles (dump trucks) may be steeper – up to 15%. If required to be accessed by road vehicles the target maximum grade will be 10%. The width will depend on the proposed operation, whether one-way or two-way operation.
- Other site access roads will be constructed generally in accordance with the standards above to suit their design intent. There will be some roads that are required for light four wheel drive vehicle access for monitoring/maintenance in remote parts of the site that may be built to a lesser standard.

Your clarification question below also mentions culverts. Stream crossings on the main access road are described in Section 7.2.1.2 of the Engineering Report. These are discussed in further detail in response to ecology s92 questions, in particular in response to the ecologists question 18.

Within the landfill site the landfill formation is based on constructing benches at 20 m height intervals. These benches will be used for construction and sometimes for access. A stormwater drain will be constructed on each bench to divert upstream stormwater around the landfill and to collect any run-off from covered areas of the landfill. Any road crossings of the drain benches will be culverted.

2 ***Further detail is required with respect to the process for installing the principal culvert within the overland flow path under the proposed fill site. Staged sections should address this request.***

The detailed methodology for installing the culvert under the landfill can only be determined when more topographical, geotechnical and other site information is available once good access to this part of the site is available. Any staged drawings prepared at this time are unlikely to depict the actual situation and could be inaccurate.

However, we have prepared a separate drawing, ENG-48 (refer to Appendix B) that shows the proposed pipe alignment, the outline of the landfill floor and the existing stream alignment. This drawing shows that the proposed pipeline route is away from the existing channel location over nearly all of its length so that construction of the pipeline can generally proceed without impacting on the stream. It will be preferable to have the pipeline in place early during construction so that further construction can proceed without impacting on the stream and without the presence of the stream affecting the works.

The general principles that will be followed are:

- Downstream sediment ponds will be constructed prior to any works being undertaken.
- Temporary sediment control measures will be put in place to minimise erosion and sediment transport from earthworks areas.
- Preparatory earthworks will be undertaken to prepare the pipeline route, away from the stream channel.
- The pipeline will be installed to the extent possible without impacting on the stream, i.e. over most of its length.
- A by-pass channel and/or over-pumping will be required to complete the section of pipe where it crosses the stream. The lower section near the future landfill toe, where the pipeline generally follows the stream alignment may be omitted and simply discharge into the existing

stream channel to flow to Pond 3A. This will be determined at detailed design when more detailed topographical information is available.

With this methodology it is expected that all of the pipe could be installed while the existing stream flows through its current channel, with water diverted into the pipe on completion. For any sections where this proves not to be possible then the pipeline will be constructed in sections. The stream flow will be diverted around all construction works. Where possible, this would be by way of a bypass channel or pipe, based on gravity flow. Where gravity diversion is not possible a pumping alternative may need to be implemented.

Further clarification sought - Again while this could be left to the consent stage, it is important to establish areas of potential environmental impact and in particular where SW needs to be separated from Leachate or comes in close contact to fresh landfill areas. We agreed you could send some simple sketches showing the progression of the commissioning, operational and decommissioning stages of the SW system, below and around the ongoing landfill.

As requested, attached are a series of marked up drawings showing the progression of development of the landfill stormwater system (Appendix C). These are described as follows: Sketch SW1: Phase 1 and 2 Construction and operation

- Catchment A, comprising the undeveloped catchment above the landfill footprint and covered areas of waste, will discharge into drains constructed on the benches and discharge to Pond 4 for treatment. Pond 4 in turn discharges to Pond 3A, Pond 2 and Pond 1.
- Catchment B, all of the catchment above Phases 1 and 2 will discharge into Pond 5. Pond 5 discharges into a pipe laid beneath the landfill liner, bypassing Pond 4 and discharging into Pond 3A, then Pond 2 and 1. Pond 3A is kept at a low level during this period to allow gravity flow through the pipe beneath the landfill.
- During this period earthworks will commence in catchment B for the development of Phase 3Sketch SW2: Phase 3 construction
- Phase 3 construction will commence from the top down. As the first 20 m bench is constructed all of the stormwater from above the bench will be diverted around the landfill on the bench to discharge to Pond 4. On the southern side, a drain will be constructed across covered landfill surfaces to convey stormwater to the bench drain on the northern side of the fill.
- Stormwater from below the bench will continue to be discharged to Pond 5 while this is available. However, Pond 5 will be progressively removed as the earthworks for Phase 3are completed. Once the Phase 3 landfill lining system has been constructed no flow to the main pipeline beneath the landfill will be possible and it will be decommissioned. All sections downstream of the Phase 1 landfill toe will be removed. At this time, all stormwater falling on the Phase 3 liner will be discharged through a smaller pipe laid above the lining system through Phase 1.
- As soon as waste is placed in Phase 3 no flow through this system can be discharged as stormwater and all flow will be diverted to the leachate system.
- At this time the water level in Pond 3A can be raised to provide additional storage/treatment volume as described for Pond 3B.

Sketch SW4: Phase 4 onwards

- Phase 4 will be constructed as a vertical extension above Phase 3. Once developed the storm water will be diverted around the landfill on the benches as shown.
- Similar stormwater diversion will occur along the benches and landfill perimeter for

subsequent Phase development

As described in the Engineering Report, all stormwater is kept separate from leachate. A bund is constructed at the extent of each operational phase of the landfill to contain leachate within the landfill leachate collection system. In the operational area of the landfill, any water that comes into contact with waste is treated as leachate and is diverted to the leachate system.

3 ***The culvert under the Landfill is stated as being temporary. Further information on this culvert is required to accurately assess associated effects. A staged long section of this culvert would be ideal.***

Please refer to our response to question 2.

4 ***Further detail on the proposed road drainage is required as the surrounding ground is particularly steep and the effects need to be fully assessed. It is noted that cross-sections have been provided but a detailed plan identifying collection and disposal points is required.***

We assume this question refers to the Access Road. Stormwater systems along the Access Road are described in sections 4.2 and 7.5 of the Stormwater and Industrial Trade Activity Report, and on Drawings ENG-31, 44 and 45.

5 ***There is a long culvert near the entry to the site (1200 diameter, 104m long as shown on drawing Eng. 30) incorporating a large amount of fill. Depending on the grade etc., it is unusual to construct a culvert instead of a bridge. In this instance, blockage due to upstream logging operations is a distinct concern and the effects of such in this terrain could result in a large volume of fill being transported downstream. Apart from a small scale pipe denoted on the above referenced plan, no detail has been provided. It looks as though the associated catchment is approximately 10-12 hectares. Noting that a bridge allows for freeboard / clearance to avoid obstruction, please confirm if a comparison between a bridge and culvert was undertaken and, if so, why a culvert was preferred. That notwithstanding, further details on the culvert in terms of sections, long sections etc. are required at an appropriate scale.***

Please refer to our response to question 18 in the Ecology section.

Further clarification sought - You had mentioned that there is still a culvert of some 60m uphill from the access bridge nearer the State Highway. This needs further clarification as to the reasons given around ongoing logging operations, construction etc.

This culvert is described in Section 7.2.1.2 of the Engineering Report and further detail on the extent of this, effects and options is described in response to the ecology s92 questions, in particular in response to ecology question 18.

6 ***The proposed soil stockpiles are large and vary through the life of the operation of the landfill. Please detail the protection measures that will be implemented to protect them from sediment and dust emissions, particularly during high wind and rain events.***

Note: an error has been identified on page 31 of the earthworks report, 'Earthworks volumes for roads' should be table 8.1 and not 7.1.

Details of erosion and sediment control for the development are described in the report "Erosion and Sediment Control Assessment" and will be managed in accordance with the Erosion and Sediment Control Plan. We understand that these documents are being reviewed by others and hence we will not repeat the details here. However, it is worthwhile noting that while the overall stockpile footprints are large they will be progressively developed in a way that most of the surface of any stockpile over most of the life of any stockpile will be typically grassed and stabilised.

7 ***It is stated within the application that the proposed works do not cover 1% AEP scenarios. Please explain why this is the case.***

We require a more specific reference to be able to respond to this question in any detail. The concept design has been based on 10 % AEP and 1 % AEP events as appropriate for the element being considered.

> ***Further clarification sought - My concern is purely around what additional effects could arise if an extreme event (i.e. above the 10%AEP) did occur. Again this may be better dealt with in discussion.***

As discussed, and as described in Section 4.7.2 of the Engineering Report, all permanent stormwater systems will be designed for a 1% AEP event. All temporary systems will be designed for a 10% AEP event. This higher exceedance probability is appropriate for temporary works due to the short period they will be operational, and is a practice adopted at all landfills we are associated with. Design will, of course, need to consider what happens should a design event be exceeded and appropriate provision made.

8 ***Some of the sections provided suggest that all stormwater is separated from leachate, with others stating it as being combined. Please provide further clarification as to what is proposed with respect to stormwater discharge.***

We do not understand what is being referenced in this question. The operation of this landfill, as with any landfill, is based on all leachate being separated from stormwater. There is no intention to discharge leachate to stormwater. This appears to be based on a misinterpretation of a plan.

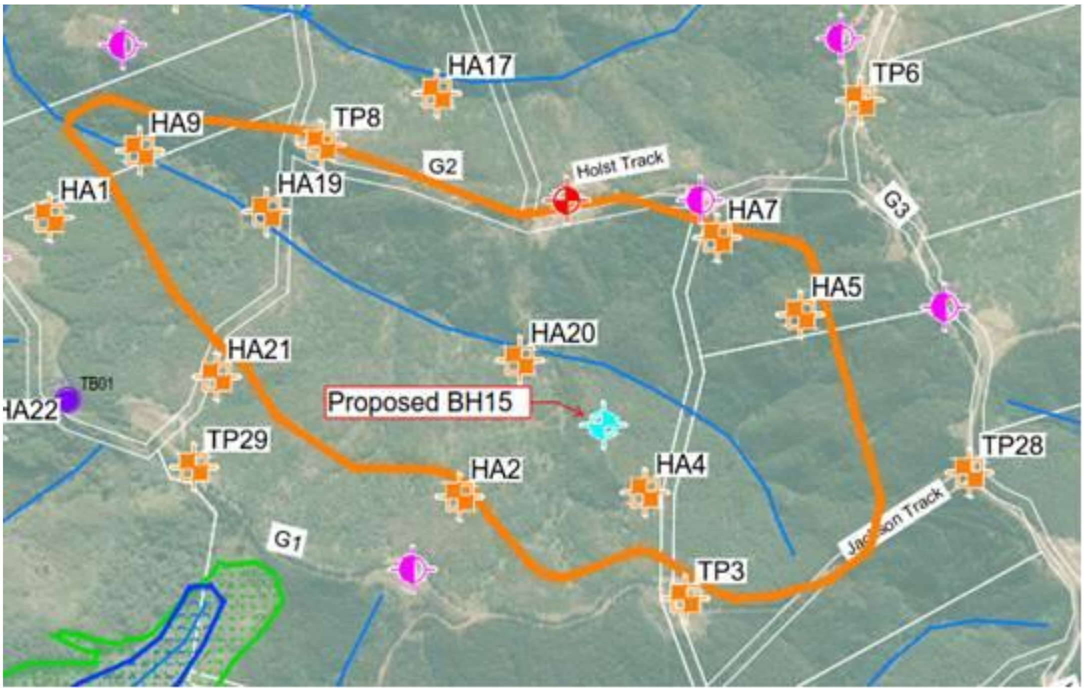
2 Hydrogeology

Questions relating to engineering and hydrogeology were set out in the memorandum from Pattle Delamore Partners Limited, dated 28 June 2018.

2.1 Additional drilling overview

We provide below our interim responses to the Pattle Delamore Partners (PDP) s92 questions from Auckland Council 18 September 2019. To address the s92 responses, Tonkin & Taylor Ltd (T+T) and Waste Management NZ Ltd (WMNZ) are proposing to collect additional site specific investigation data related to groundwater levels and aquifer characteristics.

Following the 9 October 2019 meeting between T+T, WMNZ and PDP the location of a new investigation bore within the proposed landfill footprint has been proposed by WMNZ and acknowledged by PDP as a “useful location” by way of email 6/12/19. The new location labelled BH15 is indicated below. WMNZ is currently working with the drilling contractor to explore alternative solutions to gaining access to a drilling platform for BH15 that is closer to the existing central axis of Valley 1.



The new investigation bore has three main purposes:

- To provide geological information about the Pakiri Formation (weathering and fracturing) beneath the proposed landfill footprint. The bore will be as close to the longitudinal axis of the footprint as access will allow.
- To supplement the existing shallow groundwater level and regional groundwater level information directly beneath the proposed landfill footprint.
- To further validate our current understanding of groundwater fate and transport and confirm our hydrogeological model.

The new investigation bore will be located on a ridgeline, at an approximate height of 140 mRL. Based on the regional groundwater level in TB01 being around 35 mRL, the proposed depth of the new bore will be at least 130 m. This bore will be drilled in a similar way to the existing investigation bores, which means it will be cored to the full depth, with packer testing carried out at selected intervals to determine the rock mass permeability. The new bore will be used to confirm the regional groundwater level directly beneath the landfill.

A shallower bore will be drilled adjacent to the deeper bore (within 5 m distance) to a depth that extends 20 m below the level of the base of the landfill to measure the shallow groundwater level. The depth drilled will be approximately 55 m below ground level. This drilling programme will allow a well pair to be created to establish the vertical pressure heads between the shallow and regional groundwater. The proposed installation specification is illustrated on Figure S92-HG-F2 attached (Appendix D).

WMNZ is considering an alternative installation to a standard well pair that will result in one bore being installed with multi-level instrumentation, such as vibrating wire piezometers or other similar systems. Details of any proposed change to the bore specification will be provided before drilling commences.

The regional groundwater level information from the new bore will be combined with the existing groundwater level data from TB01 and other groundwater bores where access has been granted in the wider regional setting. These include groundwater bores located on neighbouring land to the west of the WMNZ property, plus bores to the north and north-west of the proposed landfill within a 6km radius. The purpose of collecting the additional groundwater level data is to confirm the existing understanding of the regional groundwater flow direction and other parameters such as the hydraulic gradient of the regional groundwater surface. The additional information will be made available as soon as possible, and prior to the hearing on this consent application.

1 Provide a water budget for the existing hydrogeological system within the area of interest. This should at least include quantification of:

- ***All key groundwater inflows and their seasonal range.***
- ***Groundwater outflows to each key groundwater receptor/sink and their seasonal range e.g. Hoteo River discharge, relevant Valley 1 streams/springs discharge, Waiteraire Stream discharge, relevant wetlands, groundwater through/out flow, abstraction boreholes, etc.***
- ***Seasonal flow rates between the key hydrogeological units e.g. flow from Upper aquifer zones to Lower aquifer (where relevant), flow from the Lower aquifer zones into the Upper aquifer zones (where relevant), other relevant flow exchanges.***
- ***Seasonal groundwater storage volumes (for all key hydrogeological units).***
- ***Provide an assessment of hydraulic parameter uncertainty and how this is expected to alter all of the above e.g. what are the upper and lower ranges due to parameter uncertainty.***

T+T will use the additional site investigation information obtained progressively as indicated above and for the purposes of detailed design where necessary, plus other supporting information such as stream flows and climate information, to develop a water budget for the existing hydrogeological system prior to the landfill being constructed. The hydrogeological system will include the catchment of the landfill footprint and important downstream receptors including the Hoteo River and Waiteraire Stream.

The water budget will take into account seasonal fluctuations to demonstrate typical natural and man-made changes in water availability that may reasonably be expected throughout a year. This information will be provided to Council in advance of the hearing process.

2 Provide a groundwater pressure/head profile for the groundwater regime in:

- ***Plan view – for the Upper and Lower aquifer zones***

- ***Section view - along the longitudinal axis and transverse axis of Valley 1***

As requested, a groundwater pressure/head profile will be prepared in plan view and section view along the longitudinal and transverse axes of the proposed landfill (Valley 1). Additional shallow and regional groundwater level information will be collected from the new investigation bore and other off-site monitoring and water supply bores in the broader regional setting.

There is a sparsity of data points on the regional scale, which would rely on interpolation between data points to develop the regional groundwater surface. Given the uncertainty associated with the sparsity of data and interpolation, we will adopt a kriging interpolation approach to provide what we believe will be a more reliable regional groundwater surface. Kriging interpolation is a common geostatistical data-driven method applied to estimate the water table in unknown locations. When kriging interpolation is applied with an external drift, a statistically significant auxiliary variable, such as elevation, can more readily inform the prediction of the primary variable, namely unknown groundwater heads between monitoring points. This approach will result in a more accurate representation of the groundwater surface/contours where there is data scarcity. This information will be provided to Council in advance of the hearing process.

3 *Three-dimensional assessment of groundwater flow paths and fate within the area of interest, and specifically groundwater migrating from beneath the landfill. This should include assessment of 'average' travel as well as potential 'preferential' fracture flow travel*

Additional site investigation data collected from within the landfill footprint will be used to strengthen the existing hydrogeological model. We will create a leapfrog model and combine this with numerous cross-sectional models throughout the longitudinal and transverse axes of the proposed landfill to illustrate our three-dimensional characterisation of groundwater flow paths and fate and transport characteristics. The cross-sections will presented in two ways, the first will represent the existing hydrogeological conditions and the second will take into consideration the changes that are likely to occur as a result of the change in profile through Valley 1 when the proposed landfill is constructed.

Cross-sections on the broader regional scale will also be developed to add to the understanding of the extended hydrogeological model.

If there is any significant change to the hydrogeological model from that assumed and described in the consent application Technical Report E, then the existing fate and transport modelling will be updated accordingly, particularly with groundwater flow paths away from the proposed landfill footprint. This information will be provided to Council in advance of the hearing process.

4 Provide a water budget within the area of interest

- ***All key groundwater inflows and their seasonal range.***
- ***Groundwater outflows to each key groundwater receptor/sink and their seasonal range e.g. Hoteo River discharge, relevant Valley 1 streams/springs discharge, Waiteraire Stream discharge, relevant wetlands, groundwater through/out flow, abstraction boreholes, etc.***
- ***Seasonal flow rates between the key hydrogeological units e.g. flow from Upper aquifer zones to Lower aquifer (where relevant), flow from the Lower aquifer zones into the Upper aquifer zones (where relevant), other relevant flow exchanges.***
- ***Flow rates to be intercepted by the proposed landfill underdrain system.***
- ***Seasonal groundwater storage (for all key hydrogeological units)***

- ***Provide an assessment of hydraulic parameter uncertainty and how this is expected to alter all of the above e.g. what are the upper and lower ranges due to parameter uncertainty.***

The response to Q.1 above is directly relevant for the response to Q.4.

In addition, the water budget will provide further focus on how the local groundwater and surface water flow rates may be altered following construction of the proposed landfill and the underdrain system. Reasonable assumptions will have to be made at the time regarding the extent of the underdrain system beneath the proposed landfill. These assumptions will be clearly listed. This information will be provided to Council in advance of the hearing process.

5 Provide a groundwater pressure/head profile for the groundwater regime in:

- ***Plan view – for the Upper and Lower aquifer zones***
- ***Section view - along the longitudinal axis and transverse axis of Valley 1***

The response to Q.2 above is directly relevant for the response to Q.5.

6 Three-dimensional assessment of groundwater flow paths and fate within the area of interest, and specifically groundwater migrating from beneath the landfill. This should include assessment of 'average' travel as well as potential 'preferential' fracture flow travel

The response to Q.3 above is directly relevant for the response to Q.6.

7 If required, relevant aspects of the contaminant migration assessment should be updated if changes are required due to other s92 questions e.g. changes to assessment of groundwater hydraulics (flow patterns and flow rates), leachate seepage, and/or any other relevant aspect.

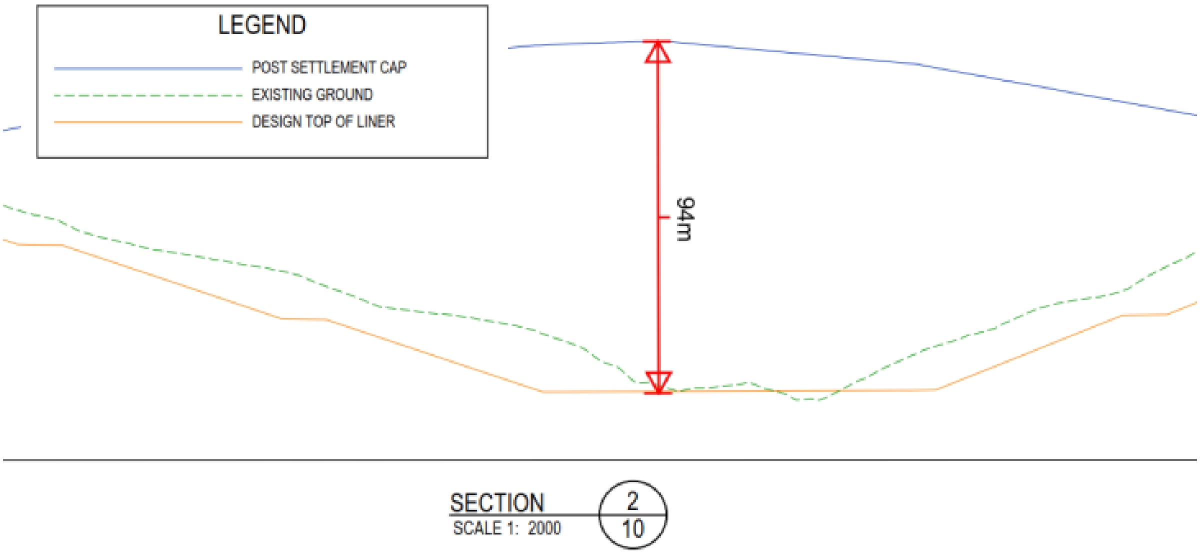
If required, this will be provided following completion of the drilling programme.

8 ***A number of parameters and model input assumptions within the RBCA model require further explanation on their; appropriateness, level of conservatism, and sensitivity - with respect to the hydrogeologic setting and the output results. Specific parameters for further explanation:***

- **Depth to Water Bearing zone**
- **Soil Column Thickness**
- **Groundwater Source Zone width**
- **Groundwater Source Zone mixing thickness.**
- **Groundwater Source Zone saturated thickness**
- **Hydraulic conductivity**
- **Hydraulic gradient**

Further explanations are provided for the model parameters below. The RBCA model input parameters will be reviewed and possibly updated following the collection of additional site investigation information and refinement of the hydrogeological model:

Depth to Water Bearing zone – This parameter is derived from the maximum design thickness of the landfill, which is estimated to be 94 m thick (refer figure below, and Figure ENG-16, Cross section 2).



For the shallow groundwater scenarios, we have assumed that the water-bearing zone to be 1 m below the base of the landfill, therefore the depth to the water-bearing zone from the top of the landfill is estimated to be 95 m below the final surface of the landfill (94 m landfill thickness + 1 m separation).

For the deep groundwater scenarios, we assume that the depth to the deep water-bearing zone is 36 m below the base of the landfill. This is equivalent to a depth to water-bearing zone of 130 m (94 m landfill thickness + 36 m separation). Modelling this zone as unsaturated is considered appropriate as contaminants would need to traverse this zone to reach the deeper groundwater.

These parameters (for both shallow and deep groundwater) are considered to be conservative as it assumes that contaminants will leach across the entire vertical thickness of the landfill. In practice, the soil column within the landfill will also comprise daily and interred intermediate cover material, which is expected to be relatively uncontaminated and able to absorb contaminants from waste.

Soil Column Thickness – This is the Depth to Water Bearing zone (95 m for the upper Pakiri Formation and 130 m for regional groundwater) less the thickness of the capillary fringe (negligible thickness). This is not a key parameter for the analysis, because it is largely influenced by the 'Depth to water-bearing unit' parameter.

Groundwater Source Zone width – This parameter is assumed to be the width of a hypothetical zone of liner affected by defects. A wider plume may be less conservative but a width of 10 m (across a total landfill width of 1,500 m for the regional groundwater and 560 m for the upper groundwater) is considered appropriate, as the cross-sectional area of Valley 1 is relatively steep, with subsurface flow expected to be concentrated along the centre of the valley. Further still, defects, if any, are likely to occur in isolated areas.

Groundwater Source Zone mixing thickness (and saturated thickness) – These parameters are based on the estimated seasonal fluctuation of the groundwater table. A greater source zone mixing thickness/saturated thickness will allow for greater dilution of leachate from incoming groundwater. Therefore, the small thickness of 1 m estimated in the assessment is considered conservative.

Hydraulic conductivity – This parameter has been adopted from aquifer testing undertaken in boreholes at the site. The sensitivity of the RBCA model outputs to this parameter is discussed in Section 8.9 of the report. The sensitivity analysis showed that an increase in hydraulic conductivity parameter leads to lower predicted contaminant concentrations at the receptors.

Hydraulic gradient – This parameter has been derived for both the shallow and the regional groundwater levels in the Pakiri formation (see Appendix G of the hydrogeological report).

Upper Pakiri formation: we have assumed that the shallow groundwater level in the formation is congruent with the topography of Valley 1. In the absence of information about the shallow groundwater surface, we consider that this assumption is appropriate for this hydrogeological setting. Although a higher gradient of 0.25 was calculated for cross-valley flow towards the valley centre, we consider it is more appropriate to use the average down-valley gradient of 0.03 as this is the expected direction of any migration of seeped leachate.

Regional groundwater levels: These are derived from the regional groundwater height recorded in TB01, BH13 and BH14 as well as the approximate height of the Hoteo River and Waiteraire Stream. The good agreement between the two calculated gradients indicates that they are consistent and therefore appropriate.

9 *Provide further explanation on how the contaminant assessment is commensurate with the primary groundwater flow mechanism of fracture flow, and whether potentially high transmissivity, low storage, and low attenuation flow pathways have been accounted for*

We have modelled the aquifer as an equivalent porous medium, rather than as discrete fractures. We consider this appropriate due to large size of the modelled area relative to the small spacing of fractures. The use of aquifer parameters derived from a pumping test (see Section 6 of the report) is appropriate as the pumping test integrates the effects of the fractures across the entire screened area, which again is large compared to the fracture spacing. In addition, an assessment of high hydraulic conductivity zones is included in the RBCA model sensitivity analysis (see Section 8.9). This sensitivity analysis indicated that even with maximum observed hydraulic conductivities, any adverse effects to potential receptors are highly unlikely.

10 *Provide further explanation on how the contaminant assessment incorporates the proposed sub -liner drainage system e.g. potential for leachate seepage to be captured and then discharged by the sub-liner drainage system.*

Subsoil drains will be used to manage shallow groundwater during the construction of the landfill lining system and will drain to stormwater ponds. Once placement of the entire landfill waste mass or significant portions of it are complete, then the long term options for the underlying subsoil drains are:

1. Grout and seal the drains to prevent any ongoing discharges as previously described (see Section 8.2.3).
2. Keep the subsoil drains permanently open and monitored as a form of leakage detection and as a way of collecting leakage, if any, and treating it.

Therefore, there are two potential pathways beneath the lining system for potential seepage, if any, that passes through the lining system.

1. If the subsoil drains are either not installed, or grouted, then any potential contaminant seepage will flow generally with groundwater and the potential effects of this have been described in Section 8.6 of Technical Report E.
2. While the drains are operational during the landfill's operating life, or remain ungrouted, the discharge from the drains will be into the stormwater ponds. This discharge will be monitored. If leachate contamination is detected (leachate contamination will be defined in the management plan for the purposes of assessment, and the definition will consider whether there would be any environmental consequence at the point of discharge after treatment through the stormwater ponds and wetland) then either:

- the flow will be diverted away from surface water and either treated or removed from site, or
- the option remains to grout and seal the pipe(s) with the affected flow.

The possibility, albeit remote, that some leachate might find its way through the lining system has been considered. The effect of that potential leachate seepage into the subsoil drains was assessed using mass conservation methods in Appendix N, Section N4 and summarised in Section 8.10 of Technical Report E. This assessment demonstrates that contaminants discharged from subsoil drains will be sufficiently diluted by groundwater, such that contaminant concentrations in the subsoil drain flow will be below ANZECC 2000 guideline values for the protection of 95 % of freshwater species at the point of discharge and before any further dilution into stormwater ponds.

11 ***Provide further explanation on how the proposed deep groundwater take from TB01 will be protected from potential leachate migration, including how the drawdown created by the proposed groundwater abstraction could influence contaminant migration towards the borehole.***

The drawdown within the regional groundwater system due to groundwater abstraction from TB01 is estimated to be approximately 7 m adjacent to the bore. Groundwater levels in the upper Pakiri formation are estimated to be perched approximately 100 m above the regional groundwater level at the location of TB01 (see Figure HG-F7) with an unsaturated zone between. Therefore, we consider it unlikely that the additional 7 m of drawdown within TB01 will significantly increase the rate of vertical migration of leachate through the unsaturated zone towards the borehole. In addition, a permanent casing will be installed within the bore and grouted to prevent ingress of surface water.

3 Stormwater ponds

One question relating to stormwater damming was included in the letter from Sentinel Planning on 18 September 2019. A report and accompanying Potential Impact Classification assessment is included in **Appendix E** in response to the s92 question.

4 Stormwater & Industrial & Trade Activities

Questions relating to Stormwater and Industrial & Trade Activities (ITA) were included in the letter from Sentinel Planning on 18 September 2019.

4.1 Stormwater

<u>Bin exchange area</u>

2 ***Section 4.3 of the submitted stormwater report states:***

"Runoff from the bin exchange area will be treated for quality via one or two raingardens and then discharged into the stream via a structured (rip rap) outlet. Flows exceeding the 95 percentile will bypass the treatment devices and discharge directly to the stream via the same outlet or a dedicated extreme-event rip-rap outlet".

While it is understood that the final size / locations of the proposed raingardens and the outlets will be finalised, dependant on the catchment, at a later stage, the information set out below is required to provide the necessary understanding of the proposed devices and to assess their appropriateness in respect of the objectives and policies contained in chapter E1.3 of the AUP(OP):

- ***Please clarify if the swale shown on engineering plan ENG 31 Rev 1 prior to the raingarden is to convey flow and is not for treatment purposes.***
- ***Please provide preliminary design calculations for the outlet.***
- ***Council's GIS shows that the bin exchange area is located within a wetland system. Please advise why this location was chosen.***

The swale shown is to provide conveyance only and has not been designed to provide treatment. Full treatment is to be achieved via the raingardens.

We have undertaken a preliminary design of the raingarden outlet, which is summarised below. The design will be subject to finalisation as part of the detailed design stage. Final design will be submitted to Council for verification of compliance with consents prior to any works commencing.

The outlet from the bin exchange area has been designed to convey a 10yr ARI storm event through the pipe network. Due to the difference in elevation between the bin exchange platform and outlet location, a drop manhole is proposed to assist in energy dissipation.

The outlet orifice will be at a higher level within the drop manhole to enable velocities to reduce prior to the point of discharge into the existing stream. A standard outlet structure (such as a culvert wingwall and riprap apron or similar) will be constructed to reduce the potential for erosion.

The size of the concrete outlet pipe is 525 mm. This pipe will be laid relatively flat. For now, we have assumed a grade of 1%.

The size of the riprap apron was calculated using FHWA HEC 14, 10.2: Riprap Apron. A summary of these results are shown in the Table below. The riprap apron will be underlain with geotextile to prevent sinking into the underlying soil.

Table 4.1: Downstream outlet HEC14 apron design

Apron average length	2.1 m
Apron start width	2.3 m
Apron end width	3.7 m
Riprap size (D_{50})	150 mm

Minimum riprap apron thickness	300 mm (2.0 x D_{50})

The overall concepts for the landfill were considered prior to land acquisition and again at an early stage of concept design, with progressive refinement as the site was inspected, with decisions made as to which part of the site would be developed for the landfill footprint, where the access should be, and other key decisions considering a broad range of engineering and potential environmental effects criteria. The reasoning behind these decisions is described generally in the Engineering Report and the AEE. It was decided that the main access to the landfill should be through the Southern Block and that the landfill would be in Valley 1.

The primary purpose of the Bin Exchange Area is for road vehicles to drop off full bins and pick up empty bins and leave the site as quickly as possible. Site haulage vehicles then pick up the full bins and take them to the tip face before returning them empty to the bin exchange area. Some of the key considerations for locating a Bin Exchange Area are thus:

- It needs to be conveniently located near the site entrance/public road to make it easily accessible by road vehicles, and ideally accessed immediately from a state highway which avoids landfill traffic needing to travel along local roads.
- It needs to be between the site entrance and the landfill disposal area – without increasing the overall haul distance to minimise fuel/energy consumption.
- It should be located in a manner that does not increase the vertical climb for vehicles – without increasing fuel/energy consumption.
- It requires a large flat area for the storage and manoeuvring of bins.

The selected area near the site entrance was the only suitable area available that met all of these criteria. All other parts of the site between the entrance and the landfill are on relatively steep terrain and all other locations on the landholdings considered for the bin exchange purpose would disproportionately increase effects in relation to other environmental aspects such as noise, visibility, vegetation clearance, fuel efficiency, traffic flow and neighbourhood disruption.

The bin exchange area is predominantly in an area of cut (the hillside to the east of the area), wattle forest and pasture. A small part of the Bin exchange area covers areas of wetland. The areas affected comprise 3,300 m^2 of "exotic wetland" as identified in the ecological report and 1,570 m^2 of indigenous wetland. The indigenous wetland affected comprises approximately 14% of the indigenous wetland at the location of the Bin Exchange Area. The extent of wetland affected is shown on the drawing ENG-30W appended (Appendix F). The effects on this wetland have been reduced as far as is practicable through the design of the access road/bridge, and the design of the bin exchange area. The wetlands affected are of relatively poor quality in the context of other wetlands on the ARL site, and are not classified as Significant Ecological Areas in the Auckland Unitary Plan.

__Access road__

3 ***The access road as shown on engineering plan ENG-44 Rev 1 is a typical detail. Specific locations along the entire length of the access way for the filters / outfalls is required along with the following details:***

- ***A plan showing the approximate location of the proposed filter strips.***
- ***Confirmation that three level spreaders will be installed within the access road (as shown on the plan).***
- ***Preliminary information on the proposed dispersal bars, including the distances from the bars into the stream.***
- ***Information regarding the outlet shown on the plan next to the southern channel drain.***
- ***Confirmation as to whether or not a speed rumble bar will be installed in the vicinity of the weighbridge.***

The plan provided with the application showed a high level design and layout of the filter strips. An updated site plan showing the total number and location of each filter strip is attached (Each filter strip will include a dispersal pipe to evenly distribute flows. This will be designed in accordance with the guidance in Auckland Council TR2013/18.

Dispersal bars will be constructed to disperse concentrated flows and promote low velocity sheet flow. Stormwater management along the landfill access road will likely comprise:

- Water quality flows from the landfill access road will be conveyed towards the northern road-side channel drain;
- These flows will pass through a distribution box. The distribution box will be designed to dissipate energy in the channel flow, and also to facilitate sucker truck access for removing silt.
- The flow from the distribution box will be piped to a PVC or PE dispersal bar (level spreader).

For the preliminary design, it is assumed that the dispersal bars will comprise of a perforated pipe. The pipe will be flexible to enable it to be laid level and parallel with the ground contour. To prevent concentrations of flows at low points, the dispersal pipe will be elevated slightly above the ground surface. The design of the dispersal bars and supporting structure will be similar to Figure 7 in Auckland Council Technical Report 2013/018.

Figure 7: Dispersal Bar with Suitable Supporting Structure and Outlet Holes

A concept level design of the landfill access road is shown on drawing ENG-30. Stormwater management along the access road is described in Section 7.2.1.3 of the engineering report (Technical Report N, Version 1). The culverts that convey stormwater under the road from the southern (higher) side of the road to the northern (lower) side of the road will be designed in accordance with Auckland Council Stormwater Code of Practice1. Pipes on the downstream side of the road will be sized to convey the 100 yr ARI event to existing flow paths. Energy dissipation/erosion protection will be provided at the outlet of each culvert in accordance with Auckland Council Technical Report 2013/0182.

A typical concept design scenario at Culvert #2 has been undertaken as described in the following paragraph to estimate the size of the rock apron required at the outlet of the culvert. A conservative approach has been undertaken by summing the flows from the road-side (south side) open channels and upstream catchments to determine the outlet discharge.

The riprap apron will be underlain with geotextile and the riprap will typically extend 300 mm around the outlet of the pipe in accordance with HeC14. A summary of the riprap apron around the culvert is summarised in the Table below.

Table 4.2: Downstream outlet HEC14 apron design

Apron average length	4.5 m
Apron start width	2.7 m
Apron end width	6.7 m
Riprap size (D_{50})	250 mm
Riprap apron thickness	500 mm (2.0 x D_{50})

Parking

4 ***The application states that 50 parking bays are proposed and that they will be located after passing the weighbridge. Engineering plan ENG-05 shows that parking is proposed around the main office. Accordingly, please confirm the location of all car parking areas and the total associated impervious area (m²) on-site.***

The proposed formal parking is detailed in the engineering report and includes:

- Bin exchange area: Parking for 10 light vehicles and 6 trucks. The light vehicle parking will be for mule drivers, any admin workers at the bin exchange and incidental servicing/maintenance. The truck parks allow for the drivers to stop to use the facilities/lunch room.
- Office area is described in the text as providing parking for 20 cars.
- Parking at the workshop and energy centres for up to 10 staff.

All formal carpark areas will be located within Industrial or Trade Activity areas with stormwater treatment in place. Treatment at the bin exchange area will be provided via raingardens and for the remaining areas stormwater will pass through the landfill pond system and the wetland.

<u>Energy centre</u>

5 ***Engineering plan ENG-41 shows three catchments for stormwater runoff from the energy centre. One catchment is to pond 1 and second is to pond 2b. It is not clear where pond 2b is. Is this part of pond 2? Please also clarify where the third portion will discharge.***

The Energy Centre will be constructed as a single stormwater sub-catchment with all stormwater draining to a single cesspit which will drain to Pond 3). Flows from Pond 3 will then flow through the wetland providing treatment prior to discharge.

<u>Engineering plan</u>

6 ***ENG-06 indicates that runoff from the energy centre will be piped into pond 3, but this is unclear. Accordingly, please confirm where the stormwater runoff from the energy centre will discharge. It is further understood that runoff from this area may contain potential contaminants like oil / grease, condensate and glycol coolant. Where will runoff from these outside modular self -bunded container units be directed to? Will it go to the treatment ponds? Please clarify.***

See response to Question 5 above. The runoff will pass through the wetland providing stormwater treatment prior to discharge. In addition, the generator units and leachate tanks will be bunded with no discharges of any contaminated water to the stormwater system. Any contaminated water will be either pumped into the leachate system or removed via sucker truck for off-site treatment.

<u>Gas generator area</u>

7 ***Please clarify how the gas generator area will be treated on-site***

Please find a copy of drawing (ENG-47) showing the proposed drainage for the Energy Centre in Appendix F. As shown on the plan, all stormwater will discharge via a single pipe to Pond 3 as part of the Surface Water Treatment System. The water within the bunded area below the leachate tanks will be visually inspected prior to release to the stormwater system. In the event that there is evidence of leachate within the bund, the water will be pumped into the leachate tanks or the landfill. The generator units themselves will be enclosed and have internal bunding isolated from rainfall.

<u>Landfill gas</u>

8 ***It is stated that landfill gas condensate will be directed to the leachate system. However, any spills will be directed to the on-site stormwater pond treatment system. As the proposed stormwater management system will not treat condensate contaminants, please demonstrate how the ponds will provide treatment for landfill condensate spills.***

As outlined above, the landfill gas condensate will be directed to the leachate system and treated as leachate. Therefore, in the event of a spill, the spill response plan procedures will be utilised. There is no intention to permit on-going discharges of landfill gas condensate to surface water. Spill response is described in the Emergency Spill Response Plan, Section 4, Appendix A, Technical Report P.

Assessment of thermal effects

9 ***Please provide an assessment of the thermal effects for the runoff from the ponds on the receiving environment during summer periods when the potential for thermal effects is greater***

Relative impact of temperature within the environment does depend on the fauna present and the values being protected. However, Macroinvertebrate indices in the downstream Valley 1 reach and Upper Waiteraire were indicative of excellent water and habitat quality, with more sensitive species dominant in the community. Western block indicative of poor water quality and community made up of more tolerant species.

Sensitive aquatic species such as those within Valley 1 and Upper Waiteraire prefer a maximum water temperature of 20 ^{o}C, however more tolerant species (such as those within the Western Block) can withstand up to 26^{o}C. Slight, moderate and severe adverse effects occur at water temperatures of 22^{o}C, 24°C and 26°C respectively. We have undertaken an assessment of the potential thermal effects associated with runoff from the ponds. The assessment has calculated the thermal increase within the stream immediately downstream of the discharge location. This includes the discharge from the wetland as well as the flows from the adjacent upstream catchment. The assessment has been undertaken based on 90th percentile rainfall events.

The assessment has made the following assumptions:

- The discharge temperature from the wetland is 25°C (based on summer temperatures from wetland3;)
- The temperature within the stream is 15°C (based on reported temperature of bush catchments4)
- The contributing stream catchment is 95 hectares.

The temperature downstream of the mixing zone has been calculated at 20°C. TR 2013/044 includes a study into the potential temperatures on different fish and macroinvertebrate species and reports that acute effects are limited to increases in temperature of 20 to 25°C.

In Valley 1 and the Upper Waiteraire, water temperatures of 20 degrees are expected to be tolerated by instream species. In the Western Block, the water may be warmer, but as the species in the Western block are more tolerant of temperature increases, the warmer water will not create adverse effects. Therefore, it is not considered that the discharge will have any thermal effects on the receiving environment.

Water Quality

10 ***Boron, titanium and semi-volatile organic compounds should be included within the monitoring parameters. Please address this.***

Boron and titanium will be included in the monitoring programme. These have both been included in the baseline monitoring programme going forward.

SVOCs have previously been monitored at existing landfills, and no samples have been recorded above the detection limits. It is understood from the meeting with Council staff that, while the Council agree with this absence of detections, they would like some initial sampling undertaken at the commencement of works. WMNZ therefore agrees to undertaken 4 rounds of monitoring during the first year of operation, with the results to be reviewed at the end of the initial monitoring period and testing to be discontinued if no significant detections are found.

11 *Please provide a draft surface water monitoring programme, including a table clarifying the different approaches for the trigger levels.*

A draft water monitoring programme has been provided in the draft Landfill Management Plan (Appendix T).

12 *There is concern relating to potential dust generation from the bag house. Total and dissolved Chromium III and VI will not be treated completely by the proposed stormwater devices. Please provide information regarding this matter.*

We understand from the meeting with Council staff on 8 August 2019 that the concern relates to the potential for dust released during the placement of baghouse dust into the landfill to be blown beyond the landfill area and contaminate stormwater. Baghouse dust would be received as an industrial waste subject to a commercial agreement and manifest system. The Waste Acceptance Criteria Report includes controls on the management and receipt of dusty material at the site (which would include baghouse dusts). This material will only be accepted with advance notice and appropriate controls will be implemented including the placement within the waste mass, the use of dust suppression, immediate covering and restrictions on disposal during windy conditions. With these dust control measures in place, the potential for contaminated dust, including baghouse dust, to be deposited beyond the landfill footprint and result in contamination of stormwater is considered to be negligible.

<u>General</u>

13 *Please clarify where the runoff from roof areas (office, covered areas around the energy centre, fuel bay canopy workshop etc) will drain to?*

The office, energy centre, fuel bay and workshop will drain to the main Stormwater Treatment system. All surface water from the project footprint will pass through at least one pond and the wetland prior to discharge.

14 *Please confirm if the landfill will accept semi-liquid waste*

The Waste Acceptance Criteria Report outlines the requirements for waste being accepted at the site. Liquid waste will not be accepted, and the waste must meet a set criteria for moisture content and ability to be handled at the working face, as described in draft consent condition 79, Appendix G, Assessment of Environmental Effects, T+T, May 2019, and in section 4.2.2, Technical Report O.

15 *Boron concentrations in previous landfill discharges exceeded leachability limits for Class A landfills. Please indicate if the landfill will accept waste with high boron levels, and whether pre-treatment is proposed for these waste streams to reduce the boron concentrations prior to landfilling of the wastes.*

Landfill leachate typically contains elevated boron concentrations. The predominant source of Boron is general municipal solid waste, and there is no readily available industrial process to remove it before it becomes part of the general waste stream. Pre-acceptance testing for Boron in special waste like contaminated soils will be undertaken at the site's discretion in accordance with the sites waste acceptance criteria. As leachate is kept separate from surface water, the potential for boron contamination of surface water is limited. Although the presence of elevated boron within the surface water discharge is unlikely, regular monitoring of boron will be undertaken as one of the potential indicators of leachate contamination.

16 *Please identify approximate spill kit locations on the industrial and trade activity plan.*

The spill kit locations will be confirmed as part of the development of the operational spill response plan, a draft of which appears in Section 4, Appendix A, Technical Report P. It would be appropriate to include a condition in the consent that requires the submission of a site plan showing all spill kit locations. The location of the spill kits will include all locations that use or store environmentally hazardous substances including the bin exchange area, the workshop, the energy centre and the wheel wash. An indicative spill kit location plan is attached on the ITA plan, but this will be subject to change.

17 *Please clarify what procedures will be in place for contractors who enter the site to ensure that compliance with environmental management plan requirements is achieved.*

WMNZ operates a comprehensive induction programme at all of their sites, which will include the ARL once works commence. This includes outlining the environmental responsibilities including requirements of resource consents, management plans and spill response procedures. All contractors are required to be inducted before coming onto site.

18 *Please confirm that the operation and maintenance responsibilities of the stormwater management devices will remain with the applicant.*

WMNZ will be responsible for the operation and maintenance of all stormwater management devices within the project.

19 *Please clarify if the landfill will accept road sweepings for disposal*

The criteria for acceptance of wastes at the site are described in the Waste Acceptance Criteria Report. Road sweepings would be accepted if they meet the waste acceptance criteria, which may include requiring pre-treatment.

20 *Will storage bins or containers be stored at the site? The environmental management plan should address the storage bin / container locations.*

The bin exchange area will include the storage of both full and empty waste bins. Only sealed or covered bins will be stored within the bin exchange area. It is possible, that waste bins may also be temporarily be stored within the landfill footprint, as already indicated in the draft ITA EMP, Section 3.3, Appendix A, Technical Report P. The EMP will provide more detail in due course.

21 *Please clarify if the site will have a small-scale laboratory. If so, further details are required regarding chemicals / quantities and whether there will be any discharges, and if so, to where.*

There will be a small laboratory on-site for the purposes of water sampling, earth fill testing and waste screen testing. Only small volumes of chemicals will be used within the laboratory and stored within the building. Any wash-water from the laboratory will be discharged into a holding tank and removed via sucker truck for off-site disposal and treatment, and residual solids, sludges and sample discards will be taken in wheelie bins to the landfill.

22 *Please provide information regarding the on-going maintenance requirements of the stormwater pipe under the landfill (from ponds 4 & 5).*

The stormwater pipe under the landfill will only be needed for approximately 6-10 years and therefore it is not expected that any significant maintenance will be required. Inlet controls will be included in the design to minimise any gross debris from the entering the pipe.

In the unlikely event that maintenance of the pipe is required, provision for the use of a pig will be included in the design to clear any debris or blockages.

23 *General site roading described in the engineering report states that the wetlands on site will having road crossings. It is not clear how these areas will be crossed. If reclamation will be required, please provide more information regarding this statement, noting that this may overlap with some of the responses on ecological issues.*

The section 92 response on the ecological issues outlines the proposed road crossings of any wetlands. While the plans do show the roads crossing the edges of wetlands on-site, the need to cross wetlands will be avoided where possible through the detailed design. Crossing points are required to be wide enough only for motor vehicles and to be located only where essential to reach inaccessible terrain. Where it is not possible to avoid crossing wetland areas, culverts will most likely be provided.

24 ***The numbering and naming of the stormwater ponds is inconsistent between the stormwater report, the submitted AEE and the engineering plans. Please address this.***

The correct naming is shown on Drawing SW1 (Appendix F). The initial stormwater calculations were undertaken based on early versions of the drawings which used different pond names, which is the cause of the differences in pond numbering.

25 ***Stormwater runoff will be directed around the landfill to pond 3. This is shown on engineering plan ENG-42 Rev 1. It is assumed that bunds will be formed to direct the flow of surface water. Please advise whether or not this is correct. If not, please provided further details as to how surface flows will be directed***

Stormwater will be collected in open drains upstream of the landfill and directed around the waste on the benches during the landfill's operating life and on the exterior access roads around the edge of the final cap towards the end of the landfill's operating life.

4.2 Industrial and Trade Activity

<u>General</u>

26 ***The landfill is assessed as a moderate risk area, however Table E33.4.3 of the AUP(OP) identifies landfill activities as a high-risk activity. Please address this inconsistency***

We confirm that we consider that Landfills are a high risk activity under Table E33.4.3. The landfill activities are also identified as high risk without controls in the assessment

<u>Refuelling area</u>

27 ***Please provide information regarding the type of oil interceptor proposed to treat runoff from the refuelling bunded area.***

An API Oil/ Water Separator will be used to treat surface water runoff from the refuelling area. It is likely that a proprietary unit will be used. Attached is typical details for Humes proprietary 'API Oil Interceptor' (Appendix G). The refuelling area and catchment will be designed to ensure it does not exceed the capacity of the Separator.

28 ***Please provide design sizing calculations for the proposed oil interceptor device.***

As above, please find attached a product data sheet for the Humes device proposed (see Appendix G).

<u>Compressor room</u>

29 ***Please clarify where the condensate from this room will discharge.***

The proposed compressors will be oil-free compressors, which do not result in any oil contamination of the condensate.

<u>Wash-bay</u>

30 ***Please provide information regarding the grit chamber proposed to manage wash area runoff prior to discharging into the ponds and demonstrated that it is fit for purpose.***

Runoff from the wash bay area will drain to a Humes proprietary Oil and Grit Interceptor (see Appendix G) (. The oil and grit interceptor has a capacity of 3,000 L. The maximum washing volume is

40 L/min with a typical wash duration of 10 mins which gives a maximum volume of 400 L per wash which is well below the capacity of the interceptor.

Environmental management plan

31 ***Please provide a site plan showing the industrial and trade activity areas in square metres (workshop, the energy component, the generator area, wheel wash area etc).***

See attached plan (SW-1) (Appendix F) showing all of the industrial and trade activity areas. The total ITA Activity Area has been calculated as 632, 429 m^2.

32 ***Please confirm the areas in square metres of the high-risk areas size showing the direction of stormwater runoff flow (piping system) from these areas.***

See attached plan (SW-1) (Appendix F) showing all of the industrial and trade activity areas and drainage pathways.

33 ***Please provide details of the proposed oil separator (treatment) devices.***

The only oil/water separator proposed is at the refuelling area which is detailed above. No other oil/water separators are proposed.

34 ***The emergency and spill plan states that unacceptable loads and leaking bins will be moved and stockpiled within the landfill footprint. Please detail the locations within the footprint where identified unacceptable materials and leaking bins will be placed. Please also detail how often trucks will be tested to meet the proposed acceptability criteria for truck loads.***

Any leaking loads or bins will be taken for immediate disposal or relocated to a holding area within the active working footprint of the landfill where leaking liquid can be collected and/or allowed to soak away into the landfill.

5 Water take from stormwater ponds

35 *Please specify the annual quantity sought*

The quantity of water sought for dust suppression, road washing and other non-potable site uses is described in Section 7.4.2 of the Engineering report as 150 m^3/d. This is an average daily use. Therefore, on average the annual quantity of water required for this purpose is 54,750 m^3.

36 ***Please explain how it has been determined that 150m³/day and the annual quantity sought from the stormwater dams, or any specified lessor quantity, for dust suppression, road washing and wheel wash, would be an efficient allocation and use of water.***

The quantity of water for dust suppression, road washing and other non-potable site uses has been estimated by WMNZ on the basis of actual water usage at Redvale Landfill. Redvale Landfill currently uses an average of 169 m^3/d for site water. With some efficiencies, WMNZ considers that this could be reduced to 150 m^3/d at the Auckland Regional Landfill.

The use of water has been shown to be an effective means for dust control which is required for worker safety and control of environmental effects. The use of water is proposed at ARL for this purpose. Water will only be applied when required for dust control. The higher rainfall at the ARL site may result in less water being required than at Redvale, and this would be reflected in the actual water used.

The other significant use of non-potable is for wheel washing. During wet conditions vehicles travelling across the site, particularly at the tip face, will collect dirt around and between their wheels. If not removed this will drop off as it dries while travelling along site roads or public roads, creating a nuisance and even dangerous conditions for other drivers, and potentially resulting in sediment runoff to streams. A wheel wash is provided at the exit from the "dirty" area of the site to remove dirt from wheels. This is in the form of a drive-through pond with rumble bars to help shake off the dirt, and water jets and/or hand held water blasters to help remove more persistent deposits. Water will discharge to a settling pond and decanted water will be returned to the main wheel wash to conserve water.

37 ***Please demonstrate that the daily quantity sought will be available from the stormwater ponds in a 1:20 year drought.***

A spreadsheet water balance model was set up to test performance of the proposed ponds to supply water required for dust control and site water. For the analysis we have assumed that water would be extracted from Ponds 2 and 3B as these have the longest life on site. In practice Pond 4 would also be available. Daily rainfall data from NIWA's virtual climate station network (VCSN) from 1960 to 2017 were input to the model with average monthly evaporation estimated from the climate data for the Warkworth climate station (-36.43435 latitude, 174.66766 longitude).

In the simulations water for dust control was only supplied on days with less than 5 mm of rainfall on the assumption that water would not be applied during wet conditions. Our analysis takes into account evaporation loss due to a constant potential evapotranspiration (PET) area. For the basis of this analysis, we have assumed the PET area is the sum of the average area of both Ponds 2 and Pond 3B, assuming a pond average area at 2/3rds of the pond height. The compensation release was assumed to be 0 m^3/day and we have taken the minimum total working storage volume as 31,000 m^3. In reality the Ponds are capable of storing approximately 40,000 m^3 as shown in Table 2.

Data is presented for a period of 56 years therefore, if designing for a 1:20 year drought, it could be expected that there would be a maximum of 2 to 3 shortfalls in supply over this period.

Simulated working storage in the ponds with a dust control demand of 150 m^3/day is shown in Figure 2.This model was based on the total working storage volume of 31,000 m^3, available from

Pond 2 and Pond 3B combined. The results shown in the graph below indicate that there are no shortfalls within the 56 years of data analysed.

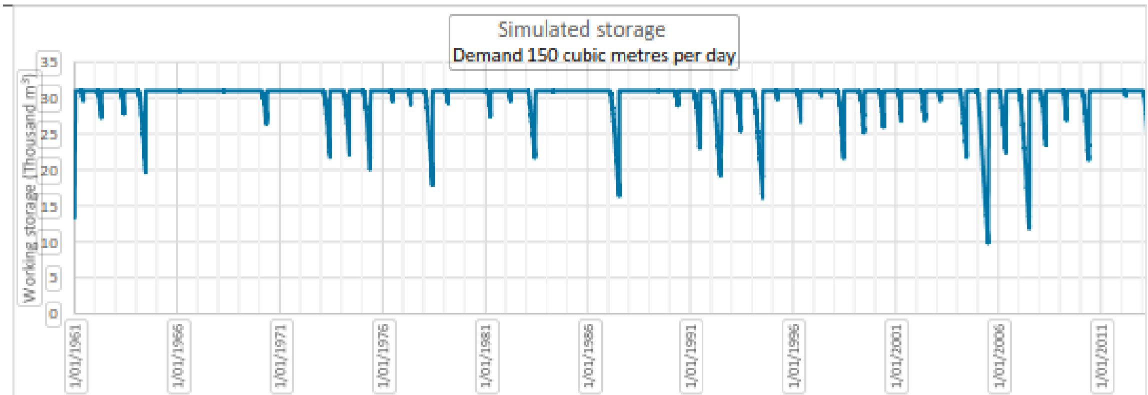


Figure 2-Simulated working storage with 150 m³/day demand

A second scenario was tested by reducing the simulated working storage until two shortfalls were observed. This correlated to a total working storage volume of approximately 20,000 m³ in Ponds 2 and Pond 3B (i.e. with this storage volume the supply would meet the 1:20 year criteria).

The simulated working storage results for this scenario are shown in Figure 3 below.

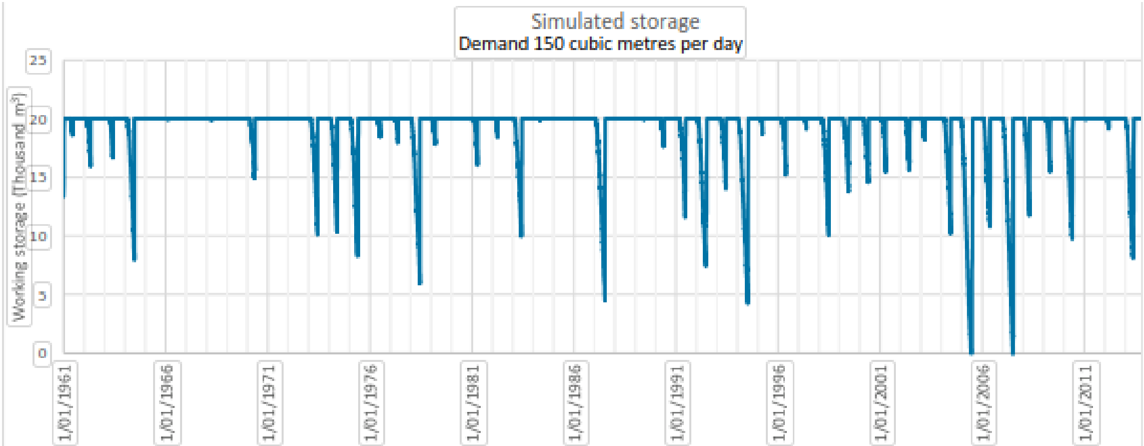


Figure 3-Scenario 2 simulated working storage with 150m3/day demand and 20,000 m3 live storage

38 ***Please specify how many of the stormwater ponds it is proposed to take water from and provide the pond name(s) and a map showing the pond locations.***

Details of the main stormwater ponds are described in Table 7.12 of the Stormwater and Industrial Trade Activity report. That table is repeated below

Table 5.1: Stormwater pond volumes

Ponds	Total maximum volume (m³)
Pond 2	15,600
Pond 3A	4,500
Pond 3B	24,400
Pond 4	44,000
Pond 5: Upstream pond	8,700

In addition to the above, Pond 1 is the name given to the wetland downstream of Pond 2.

The names and location of these ponds are shown on the Engineering Drawings, in particular drawings ENG-40 and ENG 41. Drawing ENG-40 shows Pond 3A and drawing ENG-41 Pond 3B with an increased water level after decommissioning of the pipe beneath Phase 1 of the landfill.

It is proposed that water be taken mainly from Pond 4 during the early stages of operation on the basis that:

- This is the largest of the ponds.
- It is most conveniently located in relation to operational activities.
- Being upstream, it will preferentially fill before the downstream ponds.

However, this pond will be removed for the final phase of development of the landfill. At that time Pond 3 will be used as the primary source for site water. Also, Ponds 2 and 3 will be used from time to time should there be a shortage of water in Pond 4 (initially) or Pond 3 (during that latter stage of operation).

39 *Please describe the day-to-day operation of the take. For example, is it proposed that the total daily requirement may be taken from just one pond on a day, but different ponds may be utilised from week to week depending on how full they are or other operational requirements?*

The actual operation of the take will be determined as part of detailed design. However, the most likely mode of operation is described as follows.

One of two methods will be used for taking water from the ponds. In the most simple form the water carts will drive up beside the pond and fill the cart by inserting their suction hose into the pond and pumping into the cart. However, because of the relative remoteness of the ponds from operational activities a more convenient method would comprise a fixed pumping arrangement in Pond 4 (initially) or Pond 3. This may be a pump mounted on a floating pontoon to only draw water from the surface. This would be pumped to water tanks located at a convenient location to allow filling the water carts by gravity, possibly with a quick fill option.

With such an arrangement water would be taken from Pond 4 in the normal course of events. Should water levels in the pond drop so that sediment was being removed with the water from the pond, then the take would move to the next pond downstream. If it was found that this was required on a regular basis consideration would be given to installing a fixed pumping system in that pond as well.

40 *Please provide the NZTM map reference(s) of the location of the takes from the dams*

NZTM map references are given for the centre of each of the ponds from which water will be abstracted as follows (note, these precise locations may be updated as the design/layout of the footprint is refined):

- Pond 4: 1741683 mE, 5978064 mN
- Pond 3: 174 1471 mE 5978165 mN
- Pond 2: 1741440 mE 5978305 mN

41 *Please specify and justify the reliability of supply that is sought, e.g. 95% or 19 years in twenty.*

Please refer to our response to question 37 above. In the unlikely event of no water storage on site, and no availability of water from the bore, water could be brought onto site in tankers.

42 *Please respond to AUP(OP) policy E2.3 (9) and provide details of any monitoring proposed to be undertaken e.g. metering of the take.*

In accordance with AUP(OP) policy E2.3 (9) it is proposed to measure and record the daily volume of water removed from the ponds. If practicable measurement will be achieved using a water meter. If not practicable to use a water meter the volume used would be measured by tankers filled, pump run hours or similar. The remaining requirements of this policy are not relevant to a water take from a stormwater pond.

6 Geotechnical

There were two geotechnical s92 requests included in the letter from Sentinel Planning dated 18 September 2019. Requests for further clarification of the Geotechnical s92 responses were received by email from Warwick Pascoe on 3 December 2019. Responses to these questions are provided below the original s92 response provided.

43 ***Reference is made to the design life being 50 or 100 years (section 2.3). Which elements of the design will have a 50 year design life, and which will have a 100 year design life, and on what basis have these design life choices been made bearing in mind that the landfill and associated permanent infrastructure will need to last significantly longer than this?***

Based on the expected operational design life of the Auckland Regional Landfill, operational facilities such as the site infrastructure, access roads and all works outside of the landfill footprint are considered to have a design life of 50 years. Based on the operational life and standard aftercare period for the landfill, permanent works relating to landfill stability are considered to have a design life of 100 years.

As a probabilistic seismic hazard analysis (PSHA) requires a return period rather than design life as input, a number of return periods were considered for the PSHA. An appropriate return period for site infrastructure can be obtained from NZS1170.0 based on the structure's design life and importance level. A design life of an element is not directly used in a PSHA.

To the best of our understanding, currently there are no New Zealand standards or guidance documents that specify the earthquake return periods that need to be considered for a seismic hazard assessment of a landfill. As such, return periods up to that suggested in RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities by United States Environmental Protection Agency has been considered for this PSHA (i.e. up to an approximate return period of 2500 years corresponding to a 10% probability of exceedance over a 250 year time period).

It is important to note that the design life described above has been used to describe the period over which the components of the landfill are required to be operational including aftercare (by the end of which the environmental consequence of an event will have greatly reduced), and this has been used to determine the appropriate design seismic return period. In practice, aspects of design such as stability, are designed with a specific factor of safety. Provided the design load case is not exceeded then slopes are expected to remain intact permanently.

44a ***Table 6.6.4, parameters for soil and rock fill. It is unclear whether these design parameters are based on source testing of the proposed fill materials, or if they are specifications to be met. Please clarify, and add comment on whether the proposed sources contain sufficient material for the concept design.***

The fill parameters provided in table 6.6.4 are based on a combination of source testing and experience working with similar materials on nearby projects. They are not specifications to be met. These fill parameters are considered appropriate for feasibility level (concept) design in support of Resource Consent applications. The Geotechnical Interpretive Report section 7.5 identifies two instances where further geotechnical investigation will be needed prior to final design, and draft consent condition 30 requires independent confirmation of all earthworks design (which would include parameters) prior to construction.

44b **Section 7, please define the SLS/ULS/high groundwater load cases in more detail. I wasn't able to ascertain from the report what the design life assumptions were, or how conservative the high groundwater case was relative to available data**

SLS: 100 year design life (including operations and aftercare), Assumed IL3, Site Class C, 25 years return period, 0.05g PGA as defined in AS/NZS 1170.0:2002 section 3 and New Zealand Bridge Manual section 6.2.

ULS: 100 year design life (including operations and aftercare), Assumed IL3, Site Class C, 2500 return period, 0.19g PGA as defined in AS/NZS 1170.0:2002 section 3 and New Zealand Bridge Manual section 6.2. Please note that the New Zealand Bridge Manual recommended minimum peak ground accelerations and earthquake magnitudes were adopted instead of the Probabilistic Seismic Hazard Assessment (PSHA) magnitudes because the PSHA produced accelerations less than the minimum from the Bridge Manual.

High GWL: The high groundwater case included a 2 m increase in the static perched GWL found along the soil rock interface. This high groundwater case is based on engineering judgement and is considered to be appropriately conservative. We do not currently have groundwater monitoring instruments (piezometers) monitoring groundwater level/pressure within the upper soil profile. Soil piezometers should be installed as part of the detailed design site investigation phase.

44c Table 7.1, properties of landfill components. What was the source of information to generate these properties?

The material parameters for refuse material is highly variable due to compaction, depth and composition of the refuse. We have adopted the unit weight of 14 kN/m3 for refuse with typical compaction effort and soil cover based on Figure 11 from Ed Kavazanjian et al. (1995) provided below.

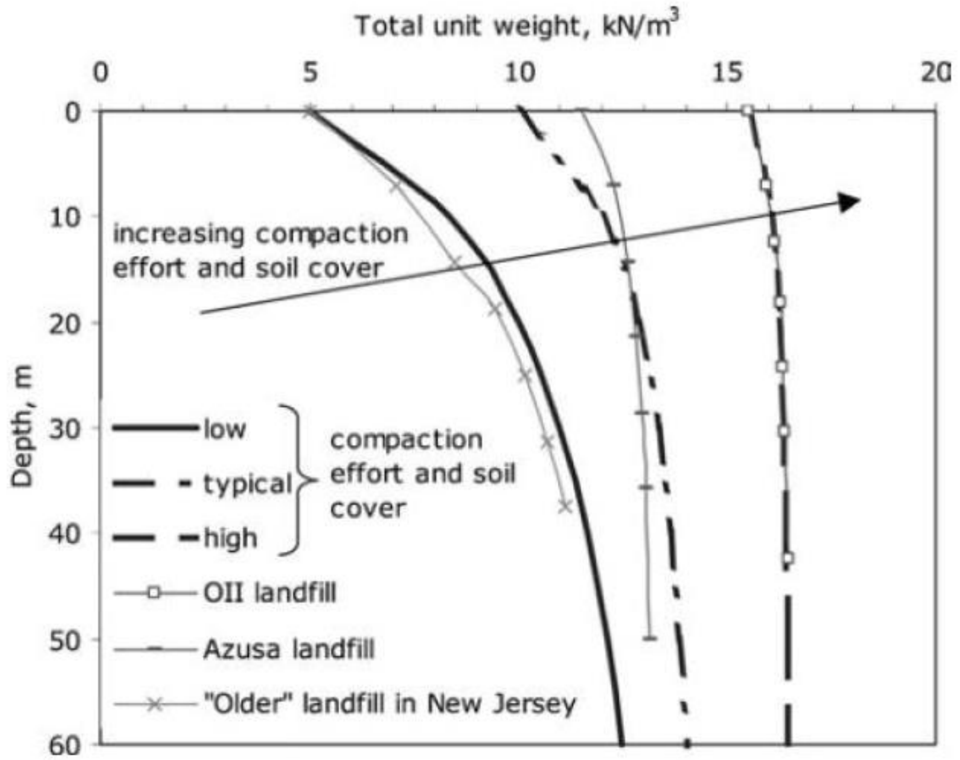


Fig. 11. Recommended unit weight profiles for conventional municipal solid-waste landfills. The near-surface in-place unit weight depends on waste composition (including moisture content) in addition to compaction effort and the amount of soil cover. The effect of confining stress is represented by depth.

The effective stress parameters provided for the refuse material was based on the suggested design line from Jones et al. (1997) shown below.

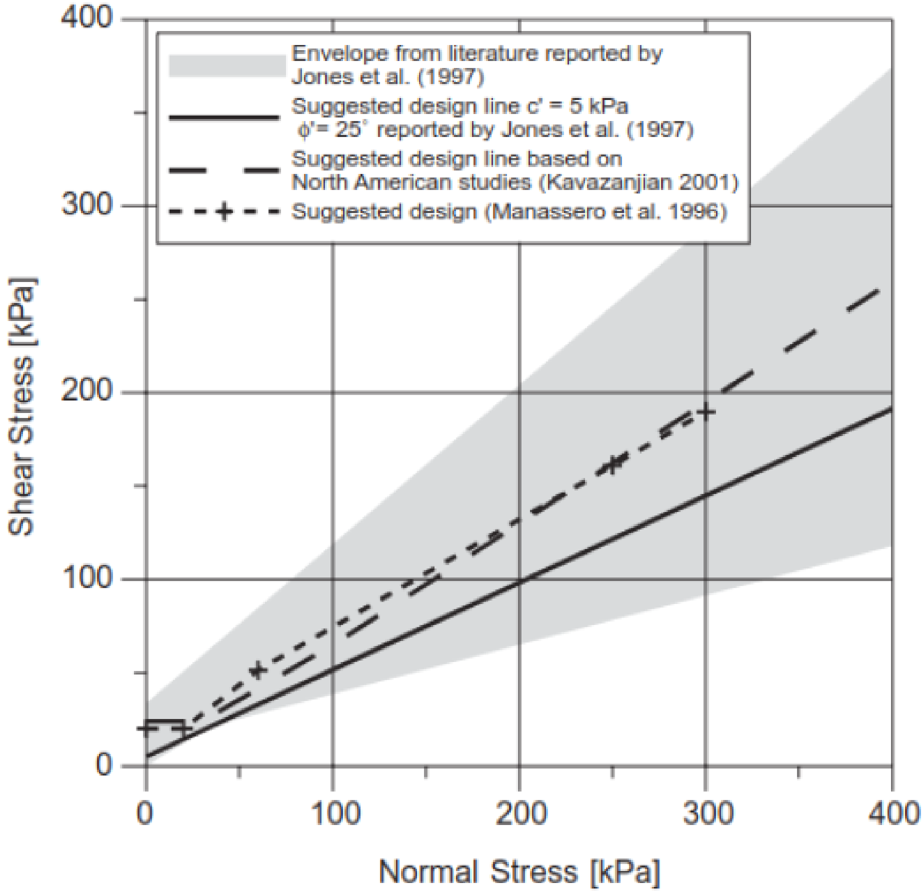


Fig. 6. Suggested MSW shear strength envelopes for design (after Jones et al., 1997).

44c ***Table 7.1, properties of landfill components. Only drained parameters have been given. Were these used in the short-term load cases (e.g. seismic and elevated groundwater)?***

Yes only drained parameters were used in modelling, including short-term load cases. This is because the landfill has a drainage layer at the base along with drainage pipes to remove any excess pore water pressure. Also the refuse material overall will behave as a drained mass even if there are some minor pockets of undrained material present.

The liner interface is the critical element for stability of the landfill, comprising on the interface between the textured/textured HDPE liner and protection geotextile, these elements behave like Velcro and therefore are unlikely to behave in an undrained manner.

44d ***Section 8.4, have sufficient quantities of suitable clay been identified to provide enough material for both liner and cap?***

Based on shallow site investigation data from within the proposed landfill footprint and associated landfill valley cuts and fills, we estimate that there should be sufficient clay soil of suitable quality for both the liner and cap. The type of material tested and considered suitable for liner and cap construction ranged from Sandy SILT to Silty CLAY. Assuming a 1.0 m thickness of soil from the cut area (55 ha) within the landfill footprint is acceptable for liner construction, approximately 550,000 m^3 of liner/cap material would be sourced.

Additional source material has been identified in the "clay borrow area", which covers an area of 4.3 ha. Site investigations within the clay borrow area consisted of three hand augers, which encountered 1.3 to 2.1 m of cohesive residual soils overlying Northland Allochthon material. Northland Allochthon derived soils haves been used successfully at Redvale Landfill for liner. This material from the proposed ARL site has not yet been tested in the laboratory for suitability as liner and cap material, but it appears to be suitable based on the soil descriptions.

Materials required to construct the landfill cap have a lower specification (higher permeability allowance) than the basal clay liner material, and it is likely that some materials that are not considered to be suitable for liner construction may still be suitable for cap construction.

Additional potential liner and cap construction material may be sourced from the access road construction, which is expected to produce a 600,000 m^3 surplus of material.

44d Section 8.4, what shrinkage characteristics are considered acceptable for these cap/liner materials, and how much of the material tested fell outside these parameters?

Shrinkage testing was not undertaken for the potential liner/cap materials. Shrinkage of the liner material is considered to be a low risk where the material will be compacted to an optimum moisture content/density and then covered after inspection.

Compacted fill material generally performs better than in-situ natural soil material with regard to shrinkage susceptibility. Shrinkage of the low permeability clay liner will also be mitigated where following construction the liner will be covered with HDPE and not likely to be subject to moisture fluctuation. The final cap material will be covered in topsoil but may be subject to some shrinkage. However, this is considered less critical as it can be replaced / modified if required post completion. Additionally, the cap layer is expected to differentially settle over time as the refuse breaks down. Shrinkage of the final cap due to desiccation is unlikely to lead to performance issues since the cap layer will be protected to some extent by the growth layer soils, and regular walkover inspections and monitoring will prompt repairs if needed. Specific testing of the cap material and comparison with a specification in the Landfill Management Plan will be undertaken progressively during the landfill's operational life at each episode of cap construction.

44d further clarification sought - It is proposed to use residually weathered soils derived from Northland Allocthon materials for the liner. Although it is noted that these have been used at Redvale, these materials generally have a very low shear strength. What geotechnical parameters have been assumed for the design, and are there any limits on where these materials can be placed to prevent the creation of a weak layer that could form a translational movement.

Our experience working with re moulded Northland Allochthon soils shows that when these materials are compacted to an appropriate specification they can achieve high undrained shear strengths (≥140kPa). The re moulding and compaction process breaks up the sheared soil fabric and therefore the potential weak layer effect. We note that, in terms of slope design (slope stability analyses), the liner interface strength parameters are likely to be lower than the re moulded liner soil strength parameters. The liner interface parameters have been chosen for stability analysis where relevant instead of the higher liner material strengths, so for that reason no liner material strengths need to be considered. The liner interface parameters are provided in Technical Report B Table 7.1. Extra care will be required during construction to protect the placed liner soil from traffic and weather disturbance.

44d further clarification sought - It is proposed to use sandy silt for the liner/cap construction. In a later sentence it is noted that some materials that are not suitable for liner construction (due to higher permeability) may be used for the cap instead. I presume that this refers to the sandy silt material, which will therefore be set aside for

use in the cap as it could be quite permeable. Please:

- ***Confirm that this interpretation is correct.***

Laboratory testing indicates that all cohesive soils including sandy SILT should be suitable for both cap and liner construction as stated below. Cohesionless soils not suitable for liner construction, such as sand or silty sand, but potentially suitable for final cap construction, will be stockpiled to construct the cap if there is insufficient suitable cohesive soil material available to form the cap.

- ***Confirm the permeability for this material, and it's suitability for use in the cap.***

The materials we undertook triaxial permeability testing on had sand contents ranging from 8% to 60% (i.e. >40% fines and therefore cohesive soils). All the tested samples achieved coefficient of permeability values suitable for both liner and cap construction, when compacted to 95% of maximum dry density and 3% wet of optimum water content as shown below. Note that the target coefficient of permeability for the liner is either 1×10^{-9} or 1×10^{-8} m/s depending on whether a GCL is used, and for the barrier layer of the cap is 1×10^{-7} m/s.

Test ID	Sample depth (m bgl)	Brief laboratory description of sample	Coefficient of permeability (m/s)
TP03	0.2 – 1.8	SILT, minor fine to coarse sand, trace fine gravel; reddish brown	5.8×10^{-10}
TP06	0.7 – 1.5	Silty fine to coarse SAND, some gravel; light brown	9.0×10^{-10}
TP08	2.6 – 4.1	Clayey SILT, some fine to coarse sand, minor gravel; reddish brown mottled light grey	7.6×10^{-10}
TP30	0.5 – 1.5	Silty CLAY, some sand; yellowish brown	3.5×10^{-10}

- ***Provide evidence that the material is present in sufficiently large zones to enable it to be sorted on site from the silty clay, so that it doesn't end up forming part of the liner.***

Site investigations undertaken within the proximity of the landfill footprint (various hand auger boreholes and test pits) and the Western Block (HA32 to HA39), combined with laboratory testing results summarised in the responses above, indicate that a large range of materials are likely to be suitable (with some mixing) for liner construction that achieve the target permeability acceptance criteria. The clay borrow area of several hectares and soil stockpile 1 have sufficient bredth to provide zones for selection, sorting and handling of materials for liner.

7 Earthworks

Questions regarding Regional Earthworks were received in the letter from Sentinel Planning on 18 September 2019. Further clarification of some of the responses was sought via email on 9 January 2020. The further clarification is provided below the original question and response.

45 ***Please detail the total area of proposed earthworks.***

We have attached an updated calculation of the sediment loads and earthworks areas based on the updated works methodology (Appendix H). This includes the proposed works area described by area and by year. This is summarised in the response to Question 51 below.

> ***Further clarification sought - This table provides the proposed area to be worked each season – but not the overall area of earthworks to be undertaken as part of the proposal. Is the total area of earthworks the sum of each year (being 46.ha?). Please note that year 4 states a total area of 3ha, however it should add up to 13.45ha.***

The sediment calculations presented in Appendix H of the S92 response summarised the proposed earthworks per earthworks season (years 1 to 4). The total area for year 4 is 13.45 hectares. The overall area of earthworks for the site establishment works can be determined by adding the sum of each year. This gives a total area of earthworks of 46.9 hectares for the site establishment works, with a maximum of 13.45ha in any one year (Year 4).

46 ***Please provide a breakdown of the proposed earthworks area for each of the earthworks activities (as described in the erosion and sediment control report). Please also include the areas for proposed streamworks activities, both within and adjacent to the streambed***

We have attached an updated calculation of the sediment loads and earthworks areas based on the updated works methodology in the response to Question 51 below. This includes the proposed works area per areas and per year.

The majority of streamworks activities involve the construction of the access road culverts. The culverts and culvert lengths are shown on drawing ENG-30. In total there are 9 culverts with a total length of approximately 330 m. Assuming the works will occur within 10m the stream margins, with widths varying between 1m and 5m, the total streamworks will be approximately 1,000 m^2 . The other main area of streamworks will be the construction of Pond 2. This will comprise an area of streamworks of approximately 1,000 m^2.

The remaining works within existing stream beds will be undertaken following the damming and reclamation of the streams. The works will be undertaken as part of the overall earthworks activities. Sediment will be managed as part of the earthworks management procedures including the permanent sediment ponds for the stockpiles, clay borrow, topsoil stockpile and landfill construction works.

> ***Further clarification sought - The answer provides information regarding sediment loads and earthworks area by catchment areas but not the earthworks area for each earthworks activity as described in section 4.3 of the sediment and erosion control assessment report. The areas noted in the ESC report do not clearly correspond to the table provided in the s92 response.***

Section 4.3 of the Sediment and Erosion Control Assessment Report included controls required for the following activities:

- Stockpiles 1, 2 and clay borrow;
- Landfill access road and bridge;
- Landfill ponds; and

- Bin exchange area.

The calculations in the initial Sediment and Erosion Control Assessment Report were based on the activities outlined above.

New sediment load calculations have been produced as part of the s92 response (Appendix H) based on catchments.

The relevant activities (as described in the initial Sediment and Erosion Control Assessment Report) within each catchment, and the total earthworks associated with these activities are summarised in Table 2 below, to clarify the relationship between the calculations in the s92 response and the activities described in the Sediment and Erosion Control Assessment Report. Note – no works are proposed in Wayby Wetland. The catchment names used in the Appendix H calculations describe the wider sub-catchments within which project activities will be undertaken, rather than describing the direct area of works.

Table 7.1: Specific works within each catchment

Catchment (as referred to in the s92 response calculations)	Project works proposed in catchment (as referred to in the ESC report)	Total earthworks footprint during site establishment
Upper Western Block – Wayby Wetland (South) Catchment	Landfill access road and topsoil stockpile	5 ha (2.5 ha/yr in Years 1 and 2)
Lower Western Block – Wayby Wetland (South) Catchment	No works proposed	0
Upper Western Block – Wayby Wetland (north) Catchment	Stockpile 1 and Clay borrow	20 ha (5 ha/yr over 4 years)
Lower Western Block – Wayby Wetland (north) Catchment	No works proposed	0
(Access Road) Southern Block Catchment	Landfill access road and bin exchange area	11.4 ha(4 ha in Years 1 & 2, 1.7 ha/yr in Years 3 &4)
Upper Waitaraire Stream Catchment	Stockpile 2	7.5 ha (3.75 ha/yr in Years 3 & 4)
Landfill (Valley 1, Eastern Block) Catchment	Engineered wetland and sediment pond 1	3 ha (in Year 4)

47 ***Please explain why chemical treatment of decanting earth bunds (DEBs) is not proposed. Chemical treatment of sediment retention ponds (SRPs) and DEBs is considered industry best practice and is adopted across regional earthworks sites in the Auckland Region. Auckland Council's Guideline Document 2016/005 Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region (GD05) also recommends that both SRPs and DEBs be chemically treated. Chemical treatment will significantly increase the sediment removal efficiency of the devices.***

We confirm that the use of chemical treatment will be considered for all SRPs and DEBs during the enabling construction works and during seasonal construction works, and in relation to landfill operations wherever a need is evident to maintain compliance with downstream water quality.

Addressed. Note: The term considered does not mean that Chemical treatment is proposed. Chemical treatment of DEBs & SRPs will be required to meet the calculated sediment loads provided. Chemical treatment is also a standard consent condition for all regional earthworks consents that utilise SRPs and DEBs.

We note that chemical treatment is a standard requirement to improve the performance of sediment control devices where the implementation of standard GD05 controls is proposed. In this circumstance, the proposal involves the use of an adaptive approach to sediment control through the use of on-going monitoring to provide a feedback loop to confirm and evaluate the effectiveness of erosion and sediment control measures. While it is likely that on-going use of chemical treatment will be necessary during site establishment works, in the event that other controls are demonstrated to provide appropriate management, then the continued discharge of chemicals to the environment where not necessary is not supported. We therefore would support a requirement to use chemical treatment where necessary and to have the ability to use flocculants in places, but would not support default requirement for chemical treatment where monitoring does not indicate that it is needed on an on-going basis.

48 ***The universal soil loss equation (USLE) calculations assume a 95% sediment removal efficiency for each activity. Please explain how this efficiency will be achieved including regard to the points below:***

- ***a.*** ***Chemical treatment of DEBs is not proposed. A chemically treated DEB will achieve around 70% sediment removal efficiency not 95%. For many of the proposed activities, a DEB is proposed as the main sediment control – please explain or amend accordingly.***
- ***b.*** ***A maximum slope length for the proposed earthworks areas is 50m – is this realistic?***
- ***c.*** ***The proposed time frame used is 0.5 years – Please confirm whether winter earthworks are proposed or are works only proposed in summer?***

The default sediment removal efficiency used in the USLE calculations is 75 % which was based on expected typical performance of sediment control measures. We have updated the calculations (outlined in response to question 51 below) using both the default value of 75 % as well as the higher 90 % and 95 % values which we consider reflect the likely sediment removal rates based on the controls to be implemented at the site. Refer Appendix H. The updated calculations include annual sediment loads during each year of earthworks.

While we agree that use of DEBs by themselves is unlikely to achieve to efficiencies greater than 75 %, the use of multiple measures increases the overall performance. This commonly includes the use of sediment socks within dirty water diversion drains, DEBs with chemical treatment and the use of silt fences downstream of the DEB outlet in addition to the use of erosion control measures including progressive stabilisation (particularly in advance of expected rainfall) and minimising open areas. Collectively, the measures increase the overall sediment removal efficiencies with removal efficiencies of over 95 % achievable.

Further clarification sought - 48b. Not addressed

Question 48(b) queried the use of a maximum slope length of 50 m. We provided revised sediment calculations in Appendix H of the s92 response, which supersede the sediment load calculations contained in the original assessment report. The calculations presented in Appendix H have been based on two scenarios representing work on steeper slopes with shorter slope lengths (50 m and 1 in 3 slopes), and longer but less steep slopes (150 m and 1 in 4 slopes). These scenarios represent works such as the access road (where the works will have shorter slope lengths but steeper slopes) and the stockpiles and bin exchange area where the works will have longer slope lengths but slightly less steep slopes. Both scenarios have similar sediment generation potential of 49 t/ha based on a standard 75 % removal efficiency. We note the calculated value of 49 t/ha is similar to the values used on the Puhoi to Warkworth project to represent sediment loads associated with works within steeper catchments and consider the calculated sediment loads are appropriate.

Further clarification sought - 48c. Not addressed

Question 48(b) queried whether winter earthworks are proposed. It is not expected that works will be undertaken over winter and this has not been considered as part of the assessment. We do note that depending on specific works and timing, works may be necessary but would be subject to the approval of Council as part of a winter works application.

49 *DEBs are proposed to be sized at 1% of the contributing catchment area. Please explain why a 2% storage capacity is not proposed. The latest version of GD05 (amended 2018) states a minimum of 2% for DEBs.*

This should have read 2 % to be consistent with GD05 and the final plan will be updated to reflect this.

50 *How will earthworks be managed where they border a significant ecological area? Earthworks controls can impact upon significant ecological area vegetation through severance and compaction of tree roots*

As discussed within the report, a site specific erosion and sediment control plan will be required for each works area. The specific measures will be designed based on the proposed works methodology. While the specific measures are subject to the site specific plan we would anticipate they would include as a minimum:

- Where possible works shall be at least 20 metres from the edge of the stream bed
- The use of clean water diversions to ensure no clean water enters the earthworks areas
- The use of dirty water diversion drains to minimise slope and path length (this may include the need for interim drains across the slopes)
- The use of filter socks within the dirty water diversion drains
- The use of SRPs and DEBs depending on the space available and catchment area with provision for chemical dosing (triggered by rainfall)
- The use of both interim silt fences within the works and downstream of the SRP or DEB outlet to provide a final sediment removal step.

Further clarification sought - not addressed – the answer does not address the question

Question 50 relates to how earthworks will be managed where they border a significant ecological area (SEA). For clarity no works are proposed in any of the SEAs identified in the Auckland Unitary Plan. We also note that the majority of project works are not in proximity to the identified SEAs, with the exception of the bin exchange area, where works may border a strip of SEA (but will be outside the extent of the SEA shown in the AUP).

The s92 response outlined that a site specific erosion and sediment control plan will be prepared for the works which are in proximity to the SEA near the bin exchange area. The response outlined what measures are likely to be included. It is unclear what the specific concerns are with the answer provided, but to expand on our original response we note that following controls will be implemented when works are being undertaken in proximity to the SEA:

- Avoiding any works where possible within the dripline of any vegetation within the SEA (we note that while works are not proposed to be undertaken within the SEA, that the dripline may extend beyond the SEA boundary);
- Ensuring the demarcation of any significant vegetation prior to works commencing including any significant vegetation within the SEA (this is included in the ecological management plan);
- Minimising works near identified SEA's.

51 *The erosion and sediment control report states that the Hoteo River catchment has a current sediment yield of 74.3 – 300t/km2/year. It also notes that the proposed construction will*

generate 183 tonnes. The submitted AEE and ecology report state that the effects of sedimentation are moderate but short term based on the sensitivity of the receiving environment. Please provide a detailed assessment of the potential effects to both the receiving freshwater environment and the ultimate receiving marine environment, based on the increase in the proposed sediment yield to the Hoteo River catchment as a result of the proposed earthworks.

Note 1: A similar approach to the assessment undertaken for the Puhoi to Warkworth motorway development in forming modelling and analysis could be undertaken to determine maximum open areas and effects on the

receiving environment.

Note 2: Aspects of the request for further information above are also covered in the requests on ecology.

We have updated the USLE sediment calculations based on the updated work plan Appendix H. This includes calculations of the sediment load during the works on each sub-catchment in the area. We have also assessed the key driver for sediment control for each sub-catchment based on the catchment characteristics. We note that all areas of the site discharge into the Hoteo River which drains to the Kaipara Harbour. Sedimentation with the Kaipara Harbour is a key issue with significant work being undertaken to understand the sources with the Harbour catchment. The Hoteo River provides the main mechanism for sediment transport from the catchment to the Kaipara Harbour with the main potential effects associated with the discharge of sediment into the Hoteo River associated with the increase in sediment in the Kaipara Harbour. There is potential for sediment effects within the streams within the site, where either there are species particularly sensitive to short term increases in sediment or the nature of the streams may result in sediment accumulation.

As discussed in the Ecological investigation, the streams within the site vary between hard bottom steep headwater streams as well as a number of flat mid-catchment sections where the wetlands have formed. The wetlands on-site are valley fills, which are linked to erodible geologies/soils and often form in the mid catchment. They are often lost through the modification of drainage systems, but often play an important role in regulating flood flows and facilitating surface water and groundwater interactions.

Headwater streams are typically relatively steep, and can be hard or soft bottomed. The headwater streams on-site are predominantly hard bottomed, with sections where sediment has accumulated. Studies on sediment movement within headwater streams indicates that the majority of sediment moves downstream to lowland areas and harbours. Where sediment does accumulate, it is mobilised downstream during subsequent rainfall events with sediment loads remaining relatively constant. Therefore, the main concern with sediment is the ultimate receiving environment (in this case being the Kaipara Harbour) and where there are species sensitive to acute (short term) changes in sediment loads.

In contrast to headwater streams, valley fills generally have discontinuous channels, are associated with wetland flora and can form several ways:

1. They can form where there is a rapid change in grade, from steep to flat areas, where the channel loses sufficient power and is unable to transport large sediment loads. The sediment then drops out of suspension and fills the channel and valley floor (hence valley fill).
2. They can form where there is a natural constriction in the valley, or channel at a downstream point, which causes backpooling and sediment to drop out through the valley floor.
3. They can form as a result of a change in the bed level of the receiving environment, such as the nearest river. If the bed of the receiving environment becomes elevated, this may

promote aggradation of the small tributary streams, decreasing channel capacity and increasing sediment deposition in the channel and across the valley floor.

In all cases, these systems are acutely linked to a continuous supply of replenishment sediment, as a reduction in sediment may promote incision, channelisation, and the subsequent loss of the 'valley fill' morphology. Once incision occurs, it becomes difficult to reinstate a valley fill morphology, especially if there is a lack of sediment supply.

We have reviewed the stream type for each sub-catchment to identify the key receiving environment which may be impacted by changes in sediment loads. This is summarised below.

Stream	Stream type	Key receiving environment for sediment
Western Block – Wayby Wetland (north)	Upland stream and valley fill	Wetland, Kaipara Harbour
Western Block – Wayby Wetland (south)	Valley fill	Wetland, Kaipara Harbour
Landfill (Valley 1, Eastern block)	Upland stream	Kaipara Harbour
Waitaraire Stream	Upland stream	Kaipara Harbour
Access road (Southern block)	Upland stream	Kaipara Harbour

Considering the additional sediment load information provided and the catchment context, we provide an updated assessment of ecological effects below.

Of relevance to this question is specifically the magnitude of effect (which we have determined to be 'low' in the assessment of ecological effects (AEcE) report) rather than the overall level of effect (determined to be 'moderate' and 'low' in the AEcE) which accounts for ecological values as well. The ecological values of the receiving environments have not changed since the AEcE was written.

We have used the EcIAG (Table 8 and 9) when determining magnitude of effect. We have looked at the existing environment as well as the criteria listed in Table 8.

We consider that the potential increase in sediment as shown in the tables attached will result in a minor shift away from baseline conditions. That is, while there may be a discernible change, the underlying character of the environment will be similar to predevelopment. This magnitude applies to all of the receiving environments listed above. When considering the magnitude we also need to consider the timescale of the impact. The proposed construction activities will last four years which is consistent with the EcIAG 'Temporary – Short Term'.

At the minimum sediment removal efficiency (75 %), the Wayby Wetland (South), Upper Waiteraire Valley and Valley 1 streams may have up to a 6 % increase in sediment loads over the construction period. Wayby Wetland (North) and the Southern Stream may experience up to 16% increased sediment load. The Wayby Wetland (North) is partially protected from sediment due to an existing online pond upstream of the wetland which is expected to restrict sediment movement. The existing pond is likely to have contributed to the channelisation of part of the wetland and subsequently the reduced 'valley fill' morphology.

As described below, we expect that the treatment efficiency of sediment controls across the site will be far greater than 75 % and more in keeping with treatment efficiencies recorded at other large-scale earthworks projects in Auckland.

If a removal efficiency of 90% is applied, which is achievable under the proposed devices-in-series scenario, then the maximum sediment increase is ~4 % at Wayby Wetland (North) and Southern Block, with an overall increase of 2 %.

Following the completion of the construction, we expect that the increased sediment loads (demonstrated in the tables attached) will be effectively removed from the headwater systems such that the post- construction state will be similar to pre-construction.

Following completion of the works and with the implementation of a multi-device treatment process (to have no more than 4% increase in sediment loads at 90 % efficiency) we consider it appropriate to assign a magnitude of 'Low' to account for the 'during construction' scenario. As such we maintain that during construction the overall level of effect remains as reported in Table 4.16 of the AEE being 'Low' for the Western Block and 'Moderate' for all other sub-catchments.

We further note that as the overall increase in sediment loads is less than 2% at the sub-catchment level, any increase in sediment loads within the Kaipara Harbour will be insignificant.

> ***Further clarification required. Please provide justification surrounding the summary statement that "We further note that as the overall increase in sediment loads is less than2% at the sub - catchment level, any increase in sediment loads within the Kaipara Harbour will be insignificant." How has this conclusion been reached?***

To further support the conclusion that any change in sediment load in the Kaipara Harbour will be negligible, we have compared the existing sediment load from the Hōteo Catchment with the potential load associated with the construction of the Auckland Regional Landfill.

A number of studies have been undertaken on the Hōteo Catchment which estimate the overall annual sediment loads. The estimated annual sediment loads vary between the different studies and estimation methods, with the published total sediment loads varying between sediment rates of 74 to 300 t/km^2/yr. The most recent modelling was undertaken using Sed Net and reported in the Kaipara Harbour Sediment Mitigation Study: Summary Report (2018), prepared by Streamlined Ltd. This reported a total sediment load from the Hōteo River to the Kaipara Harbour of 29,489 tonnes of sediment which equates to a sedimentation rate of 110 t/km^2/yr which is at the lower end of the ranges reported in previous studies.

Based on the most recent sedimentation rates of 29,489 t/yr of sediment within the whole Hōteo River Catchment, the calculated change in sediment loads due to the construction of the proposed landfill (based on a 90 % removal efficiency rate) is 121 t/yr which equates to an increase from 29,489 tonnes to 29,610 tonnes per annum during the construction period, or a change of 0.4 %. The increase corresponds to a sedimentation rate change from 110 to 111 t/km^2/yr with reference just to the Hōteo catchment (different rates are observed elsewhere in the other Kaipara catchment rivers). In context of the uncertainties in the modelling approach and the variation in published sediment loads within the Hōteo River Catchment, the increase is considered to be insignificant.

52 ***Please detail the proposed staging of works, and in particular, the proposed activities and area of earthworks for each year and earthworks season.***

A staging plan has been prepared by WMNZ. Based on the staging plan we have evaluated the active areas per year and the associated sediment loads per season. The summary is outlined in the attached tables (Appendix H).

53 ***Are any maximum exposed area limits proposed? If so, what are they and how have they been determined?***

No limit is proposed at present although limiting open areas will be a key consideration during the operation of the works. In the event that the monitoring indicates that additional controls are required to reduce sediment loads, then immediate responses available to the landfill operator include the reduction or limiting of exposed areas, the use of progressive stabilisation, and additional erosion prevention and sediment control measures. As outlined in the updated calculations below, the use of best practice erosion and sediment control measures is expected to ensure that the total increase in sediment loads during the construction periods is less than 1 %.

54 ***Table 4.4 of the erosion and sediment report does not include detail regarding the construction of the two sediment ponds, polishing wetland, office / workshop and energy platforms or ongoing landfill activities including stockpiling and clay borrow activities. Please update the table to include all earthworks activities.***

We have updated the sediment calculations to include the initial construction works for the landfill (Appendix H). This includes the construction of the wetland and Pond 2. Upon completion of these ponds, the control and effects of sediment have been assessed as part of the operational management of the landfill. The discharge from the ponds and wetland will be regularly monitored with the average discharge of total suspended solids expected to be below 20 mg/m^3 on a long term basis.

Further clarification required. Not addressed. An updated sediment and erosion control assessment report has not been provided which demonstrates that table 4.4 has been updated. It is stated that the calculations provided as part of the s92 response for sediment loads include these areas. Will the sediment and erosion control assessment report be updated to reflect this?

The original erosion and sediment control assessment will not be updated. The calculations and sediment loads attached to the s92 report (Appendix H) supersede the calculations and loads in the original assessment (Technical Report R) submitted with the consent application. We note that the updated calculations do not change the assessment or conclusions of the original assessment.

55 ***Please provide more detail on the adaptive approach proposed i.e. what are the triggers for when an adaptation will be implemented, especially regarding changes in water quality and morphological changes of the downstream receiving environment and what specifically will the adaptations include.***

The specific triggers will be developed during the preparation of the monitoring plan prior to works commencing. In general it is proposed to use a similar approach to the monitoring plan prepared for the Mt Messenger project where sediment effects on both the immediate stream environments and the ultimate receiving environment require management. A copy of the Mt Messenger adaptive management plan can be provided for information purposes if it is helpful for Council to see an example.

Further clarification required. Not addressed. A draft adaptive management plan and fresh water monitoring programme would answer this question.

Question 55 requested additional information on the adaptive approach proposed including information on the triggers and what the adaptions will include. We agree that the Adaptive Management Plan will need to be prepared prior to works commencing. However, we are currently undertaking additional baseline monitoring within the existing environment for turbidity. This will provide sufficient data to accurately develop appropriate trigger levels which will be used to develop the associated plan. Consequently we do not propose to draft the Adaptive Management Plan at this stage. While the triggers have yet to be developed, the proposed approach will involve development of trigger levels based on deviations from normal baseline conditions. If trigger levels were exceeded despite design and management systems being in place to avoid such an eventuality, an investigation into the effectiveness of erosion and sediment control devices would be undertaken, and additional measures to manage sedimentation and erosion would be required. Additional measure will depend on the specific circumstances but possible remedies could include:

- Undertaking additional stabilisation of open areas to reduce the sediment generation potential;

- Minimising opening new areas;
- Introducing additional cut-off controls (such as stabilised cut-off drains mid-slope) and mid slope treatment; and
- Reviewing the use of chemical flocculants and performance.

56 ***Please provide a draft freshwater monitoring programme for the proposed earthworks which details what will be monitored, at what intervals, where monitoring will be undertaken and establishes trigger levels requiring adaptations to be undertaken.***

A draft freshwater monitoring programme will be prepared prior to any works commencing and has not been prepared at present. The approach to development of the plan is outlined in the response to question 55 above.

Further clarification required. Not addressed. A draft adaptive management plan and fresh water monitoring programme would answer this question.

Question 56 requested a draft freshwater monitoring programme. As outlined above, we are currently undertaking additional baseline monitoring within the existing environment for turbidity to provide sufficient date to accurately develop appropriate trigger levels, which will then inform the associated plan. Consequently we do not propose to draft the Adaptive Management Plan at this stage. However, at a high level, Section 5.3 of the assessment outlines the proposed monitoring including:

- Fixed continuous turbidity monitoring installed upstream and downstream of the road access and bridge construction works;
- Fixed continuous turbidity monitoring installed upstream and downstream of the construction works associated with the landfill ponds;
- Manual TSS grab samples during rain events downstream of the stockpiles while significant works are being undertaken.

57 ***Turbidity monitoring is proposed which will indicate short term effects. Please detail how potential deposited fine sediment will be monitored, such as with sediment plates.***

As outlined above, the main risk for potential long term effects associated with sediment is accumulation within the Kaipara Harbour. Any effects within the headwater streams will be temporary while sediment within the valley infills is important in maintaining the integrity of the downstream wetlands. While that is the case, we propose to include the use of sediment plates in the stream downstream of the landfill and the Waiteraire stream downstream of Stockpile 2 where it is understood that Hochstetter Frog habitat is present. These will be monitored in the event that turbidity monitoring exceeds the triggers developed. This will enable monitoring of any short term increase and subsequent reductions during following storm events.

58 ***Will any automated sampling be undertaken? Manual sampling of sediment discharges is not always a good indicator of effects as sediment washes away from the immediate area soon after discharge***

Continuous turbidity monitoring will be undertaken during the establishment earthworks including downstream of all main works areas. TSS sampling is likely to comprise grab samples, but if during the development of the site specific erosion and sediment control plans the use of automated samplers can be considered.

59 ***Please provide a construction methodology for all activities within the bed of a stream or wetland.***

Please refer to GD05 section G4, works within a watercourse for guidance. Due to the sensitivity of the receiving environment and scale of the activities, this information is deemed necessary in order to assess how stream bed disturbance and generation of sediment will be minimised during construction.

The specific construction methodology will be developed as part of the detailed construction methodology, with a site specific erosion and sediment control plan to be developed. While the detailed methodology is not known at present, it will be undertaken in accordance with the guidance in Chapter G4.0 of the GD05 including:

- Works will be undertaken during dry weather where possible;
- The works will be timed to be undertaken during periods of low flow in the stream;
- The flows upstream of the site will dammed with water diverted or pumped around the works areas while the culvert is place;
- The culvert where possible will be installed with both inlet and outlet protection first to reinstate flows through the works areas;
- Silt fences will be placed downstream of the works;
- Exposed surfaces will be stabilised as the works proceed, and in advance of any heavy rain;
- Any fish present upstream of the works will be manually transferred downstream while the dam and diversion is in place.
- Following works, stream bed restored to the extent practicable to the natural profile.

Any refuelling and machinery will be kept out of the stream bed and floodplains.

8 Economics

Economic responses were completed by Mike Copland from Brown Copeland & Co Ltd and have been attached as part of this s92 response in **Appendix I.**

9 Traffic

Traffic responses were prepared by Stantec and are included in **Appendix J**. Additional s92 requests relating to traffic were received from Auckland Council on 30 January 2020. The same questions were also asked on 24 December 2019 in relation to the Private Plan Change Request. Responses to these questions were prepared by Stantec and are contained in **Appendix K**.

10 Waste acceptance

86 ***The proposed waste acceptance criteria for the proposed landfill are based upon the Type 1 landfill criteria outlined in the draft (2018) Technical Guidelines for the Disposal to Land produced by WasteMINZ. These criteria are in turn based on US EPA TCLP criteria (40 CFR §261.24), whose criteria list was last updated 13 March 2002 (67 FR 11254) and are not based on New Zealand Drinking Water Standards (NZ DWS). Accordingly, the list of contaminants outlined in the Waste acceptance criteria do not cover the wide range of contaminants of concern that could potentially enter a modern landfill. As the proposed TCLP criteria are based on US EPA drinking water standards they may not be sufficient to ensure compliance with NZ DWS nor sufficient to protect ecological receptors. Therefore it is requested that the waste acceptance criteria are amended to address the following:***

1 ***cover a wide range of contaminants covered by the NZ drinking water guidelines (including boron, fluoride and modern agrichemicals);***

2 ***include criteria for a number of persistent, bioaccumulative and toxic (PBT) organic compounds outlined within Stockholm Agreement;***

3 ***include waste acceptance criterion for zinc due to zinc ecotoxicity to aquatic organism and the mobility of zinc in groundwater/landfill leachate;***

4 ***include TBT and related compounds due to it's persistent, bioaccumulation potential and toxicity to aquatic organisms;***

5 ***comply with other New Zealand legislation including Hazardous Substances and New Organisms Act (and regulations i.e. Hazardous Substances (Storage and Disposal of Persistent Organic Pollutants) Notice 2004) and limits suggested in the Stockholm Convention/Basel Accord;***

6 ***include waste acceptance criteria for PFOA and Dicofol (as they are candidate compounds for inclusion into the Stockholm convention);***

7 ***include pH limits for material being accepted into the landfill. Note: Highly acidic or alkaline materials may result in mobilisation of some contaminants and potentially resulting in unacceptable discharges;***

8 ***provide clarification regarding whether it is proposing to accept asbestos waste within a Type 4 landfill and if so, what would be the waste acceptance criteria. Note: Currently under the managed fill rules within the AUP(OP) managed fills (Type 3 and 4 landfills) cannot accept asbestos;***

9 ***pre-acceptance testing be required for all HAIL sites including horticultural and agricultural land. Note: The landfill management plan will need to be updated to reflect this requirement. This will allow provide enough information to determine if the material can be accepted as either type 1 or Type 4 waste; and***

10 ***waste acceptance criteria be derived using NZ drinking water standards (NZ DWS) rather than US EPA drinking water standards. Note 1: An adjustment factor may be applied to derive de facto TCLP criteria. If so, justification for using this adjustment factor will need to be provided together with a review of literature to support it.***

Note 2: When deriving waste acceptance criteria for bioaccumulative substances, the ANZG WQG (2018)/ANZECC (2000) guidelines recommend using 99% ecosystem protection default guideline values / trigger levels for bioaccumulative substances, not 95% ecosystem protection default guideline values / trigger levels as used in the assessment.

The list of contaminants for which WAC are required will change with time. The Management Plan will include a process for assessing new contaminants and for developing acceptance criteria. The

WAC are not intended to be used to screen typical municipal solid waste (e.g. kerbside waste). They are intended to inform waste acceptance decisions for wastes identified as being potentially hazardous (i.e., to confirm the wastes are not hazardous). WAC have not been derived for all possible hazardous substances, or for the full range of contaminants identified in drinking water standards, as that would create an unnecessarily long list. For some specific waste types, it will be necessary to assess on a case by case basis, by considering the volume of waste, the characteristics of the contaminants, and the potential effect of accepting the waste on the mass of contaminant in the landfill and on leachate quality. These assessments will necessarily be on a case-by-case basis. It is unlikely that a special waste would exclusively contain contaminants that are not on the list.

WMNZ has developed additional WAC for some contaminants. A revised WAC table (Table 86-1) has been prepared and attached to this response (Appendix L). Chemicals with new WAC are shown underlined. It includes additional columns that compare the proposed WAC for ARL with WAC for other recently consented landfills (Kate Valley, 2016; Redvale, 2017). A second table (Table 86-2) has been prepared which compares the NZ DWS and US DWS, to address Question 86 point 10.In response to specific points in Question 86:

1 TCLP WAC for boron (20 mg/L), fluoride (200 mg/L) have been added. These are the consent limits applied for Kate Valley, which were taken from MfE's Class A guidelines. TCLP WAC for the historically common agrichemicals aldrin and dieldrin (sum of, not each: 0.00008 mg/L) have been added. If WMNZ receives an application for disposal of wastes containing modern agrichemicals, assessment of these will be on a case by case basis. We note that modern agrichemicals tend to break down more quickly in the environment than the historical agrichemicals for which WAC are provided.

2 WAC for the following PBT have been added: aldrin + dieldrin (sum of, not each: 0.00008 mg/L), taken from the MfE Class A guidelines and consent for Kate Valley. Many of the POPs listed in Annex 1 of the Stockholm convention already had WAC proposed (chlordane, endrin, heptachlor, hexachlorobenzene, lindane, pentachlorophenol, toxaphene). WMNZ has reviewed WAC for other recently consented landfills in New Zealand (including Kate Valley and Redvale), and has proposed WAC for 2 additional POPs (aldrin, dieldrin) because these were commonly used in New Zealand.

3 TCLP WAC for zinc has been added (500 mg/L), with a total concentration of 30,000mg/kg, which is consistent with the guide value used for Redvale Landfill. WMNZ developed the guide for Redvale Landfill was based on a review of TCLP and total concentration data for zinc-containing wastes received at Redvale landfill, which showed wastes with less than 500mg/L TCLP have total concentration less than 30,000 mg/kg. The notable zinc containing waste received at Redvale landfill is auto shredder waste. WMNZ's records show that Redvale Landfill has received around 6% (by weight) auto-shredder waste. A similar proportion would be expected at ARL. Leachate at Redvale landfill has typically contained around 2 mg/L zinc. Auto shredder waste received at Redvale has not resulted in unacceptably high concentrations of zinc in the leachate. This is consistent with zinc's tendency to bind to particulates. The guideline for Redvale Landfill is therefore considered appropriate for ARL.

4 TCLP WAC for tributyl tin oxide has been added (3 mg/L), taken from the Class 1 guidelines and consent for Kate Valley.

5 Compliance with HSNO. The WAC are consistent with the Hazardous Substances (Disposal) Regulations 2001 (and Notice 2017). Under (7)(3) of the Notice, a class 2.1.1, 3.1, or 4.1.1 substance may be discharged into the environment as waste or deposited into a landfill if—

(a) the substance will not at any time come into contact with class 1 or class 5 substances; and
(b) there will be no ignition source in the vicinity of the disposal site at any time that is capable of igniting the substance; and

(c) if the substance were to ignite, no person, or place where a person may legally be, would be exposed to an unsafe level of heat radiation.

The WAC prohibit explosive and oxidizing substances, which satisfies (a). Management controls provide for compliance with (b) and (c).

11 Under 9(1)(a) and 9(2)(a)(i), and 10(1)(a) and 10(2)(a)(ii) of the Notice, Class 6, 8 or 9 substances may be disposed to landfill, provided the landfill treats the substance by changing the characteristics or composition of the substance so that the substance is no longer a hazardous substance.

Alternatively, under 9(1)(b)(ii) or 10(1)(b)(ii), Class 6, 8, or 9 substances may be discharged to the environment provided the discharge does not, after reasonable mixing, result in the concentration of the substance in an environmental medium exceeding either the tolerable exposure limits (for class 6 and 8 substances) or the environmental exposure limits (for class 9 substances). The WAC criteria in the WasteMINZ guidelines are derived using an assumed dilution and attenuation factor based on a compacted clay liner.

Compliance with limits in Stockholm Convention and Basel Convention: The Stockholm Convention for Persistent Organic Pollutants (POPs) requires at Article 6(1)(d):

In order to ensure that stockpiles consisting of or containing chemicals listed either in Annex A or Annex B and wastes, including products and articles upon becoming wastes, consisting of, containing or contaminated with a chemical listed in Annex A, B or C, are managed in a manner protective of human health and the environment, each Party shall:

(1) Take appropriate measures so that such wastes, including products and articles upon becoming wastes, are: Handled, collected, transported and stored in an environmentally sound manner;

Disposed of in such a way that the persistent organic pollutant content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of persistent organic pollutants **or otherwise disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option or the persistent organic pollutant content is low**, taking into account international rules, standards, and guidelines, including those that may be developed pursuant to paragraph 2, and relevant global and regional regimes governing the management of hazardous wastes.

Placement in a secure, Type 1 landfill is the environmentally preferable option for disposal of waste contaminated with low levels of POPs in New Zealand. The Basel Convention applies to trans-boundary shipment of waste, and includes a requirement for parties to provide secure storage of waste. No trans-boundary shipment of waste is proposed for ARL. There are no limits for WAC suggested in the Stockholm Convention or the Basel Convention.

6 6 If WMNZ receives an application for disposal of PFOS and dicofol containing wastes, these would be assessed on a case-by-case basis. To assist this assessment, WMNZ has developed preliminary screening TCLP WAC, as described below.

PFAS are present in municipal landfills through their presence in consumer products. It is not intended that municipal waste that contains PFAS though inclusion of consumer waste (for example, textiles, carpets) will be tested for PFAS before acceptance. However, in future, landfills may be requested to accept soils contaminated with PFAS. As set out in the HRA, the acceptance of PFAS containing soils would be on the basis that it did not materially increase the mass of PFAS in the landfill, given that municipal waste will be the main source of PFAS being placed in the landfill. The HRA includes an assessment of leachate data from landfills that accept similar waste types to what is proposed for ARL, including one tested sample of Redvale Landfill leachate. The leachate data used in the HRA are the 95% upper confidence limits on leachate data from landfills accepting more than 50% municipal solid waste: PFOA 1.3 µg/L, PFAS (as sum of PFOS, PFHxS, PFOA) 5.2 µg/L. These concentrations are higher than what was measured in the Redvale leachate (refer HRA Appendix G Table 3). The leachate data used in the HRA have also been used to develop WAC for PFAS and PFOA, which could be applied to wastes specifically identified as containing PFAS (for example, contaminated soil).

WMNZ records for Redvale Landfill show that special wastes expected to be rich in PFAS (biosolids from municipal wastewater treatment plants, PFAS-contaminated soil) comprised 1.5% of waste received from 1993-2013 and 2.3% of waste received from 2014-2019. For the purpose of developing a screening TCLP criteria, we have assumed that up to 4% of the waste entering ARL will contain PFAS. If all the PFAS in leachate was coming from this waste, then WAC of 25-times the leachate concentration would mean that accepting the waste wouldn't increase the PFAS load in leachate. WMNZ proposes preliminary screening TLCP criteria for PFAS and PFOA at 4-times the leachate concentration adopted in the HRA: PFOA 0.005 mg/L; PFAS 0.02 mg/L. WMNZ proposes to include a five-yearly review of these preliminary screening TCLP for PFOA and PFAS, which will consider results of annual leachate testing and the estimated total mass of PFAS contaminated waste disposed at the landfill.

Dicofol is an organochlorine pesticide derived from DDT, but is less toxic and more rapidly degradable than DDT. It has been added to Annex A of the Stockholm Convention. No TCLP-based WAC has been proposed for DDT because of its low solubility in landfill leachate. Dicofol is more soluble in water than DDT (solubility ~0.8mg/L) and has a Log KOW of 4.3. There is no NZ DWS for dicofol. WMNZ proposes the TCLP WAC for dicofol be 0.05 mg/L, which is 100-times the NZ WQG (0.0005mg/L, level of protection of species not stated).

The danger of prematurely adding strict criteria on new contaminants is twofold. First, that Class 1 landfills may become unable to accept contaminated soils that have been historically and safely accepted (e.g. from HAIL sites) and that are expected to continue to be common. Secondly, the contaminated soils ordinarily accepted at Class 1 landfills could be pushed towards fly-tipping, poorly controlled managed fills, or being left undeclared on sites when removal would be a lower-risk outcome for the future users of the sites. WMNZ proposes a precautionary approach to assessing new contaminants via a process outlined in the landfill management plan.

7 7 Corrosive wastes are prohibited. Corrosive wastes are defined as those with pH less than or equal to 2 or greater than or equal to 12.5 (40 CFR §261.22). These pH limits will be explicitly added to the LMP.

8 8 Having reviewed the availability of suitable cover materials from within the landholding, WMNZ does not consider that it will be necessary to stockpile materials sourced from off-site. Therefore receipt of 'Class 4 Waste' or waste containing asbestos to permanent stockpiles is not an activity for which consent is being sought.

9 9 WMNZ has considered this request, and strongly maintains its desire to retain an exemption for up to 100m3 of soil from sites where the only HAIL activity is historical horticulture, provided the site was only ever part of broad-acre pesticide application. The intention of this measure is to avoid disproportionate testing costs for single-house developments, for chemicals that are known to bind strongly to soil. WMNZ contends that testing costs for small quantities of soil from small developments can be enough to discourage safe disposal of these soils, leading people to dispose of soil in an uncontrolled manner at inappropriate locations. Providing for disposal at a secure, Class 1 landfill, is a preferable environmental outcome.

10 10 As stated in the WasteMINZ Guidelines :

> *It is acknowledged that the US EPA criteria are based on US drinking water standards which are higher than Drinking Water Standards for New Zealand (DWSNZ) and therefore have lower concentrations than New Zealand. Adopting the US EPA waste acceptance criteria is effectively assuming a higher dilutionand attenuation factor (DAF) for constituents where the DWSNZ is more onerous. The design criteria for a*

Class 1 landfill will generally offer a higher level of hydraulic containment, where geosynthetic clayliner or flexible membrane liner are included in the liner design over the compacted clay liner originally prescribed by US EPA Subtitle D regulations. Adopting the US EPA TCLP criteria as they stand, which is effectively adopting a higher DAF, is therefore considered reasonable. Leachate data for landfill sites where the TCLP criteria have been utilised for waste acceptance have shown they are effective, but not overly precautionary, at controlling the concentrations of constituents in leachate.

We have compared the NZ DWS and US DWS (refer Table 86-2). For many contaminants, the NZ DWS are less stringent than the US DWS. For those contaminants where the NZ DWS is more stringent

than the US DWS, the values are within a factor of 10 except for xylenes (NZ DWS is 0.6 mg/L; US DWS is 10 mg/L). The TCLP limit for xylene in the 2016 Kate Valley consent is 100 mg/L. There is no limit in the 2017 Redvale Landfill consent, but the Redvale Landfill guide number is 5 mg/L. WMNZ proposes a revised TCLP limit for xylene of 6 mg/L, to reflect that the NZ DWS is more than 10x more stringent than the US DWS in this instance. No other TCLP limits are proposed to be revised.

87 ***For all compounds outlined within the waste acceptance criteria and within the assessment of environment effects (for nutrients and physiochemical parameters), please provide an update of the assessment to include the following:***

- ***account of culminative discharges from all sources (including background water quality, landfill leachate, stormwater and industrial stormwater discharges);***
- ***assessment of the potential environment effect of the combined discharge and demonstrate compliance with the national objectives framework outlined within the National Policy Statement for Freshwater Management;***
- ***assessment of chemical toxicants against the appropriate criteria outlined within ANZG (2018) freshwater and marine water quality guidelines, ANZECC (2000) freshwater and marine water quality guidelines against the appropriate criteria (99% for bioaccumulative toxins and 95% DGV for non-bioaccumulate toxins);***
- ***assessment of the concentrations of PFAS compounds against water quality criteria outlined within the HEPA (2019) guidelines; and***
- ***assessment of the size of any mixing zone and justification for the size of the mixing zone. Mixing zone size to be calculated in accordance with TR2010/046 A Review of Definitions of Mixing Zone and reasonable mixing in receiving waters, Auckland Council.***

The cumulative assessment is provided in the HRA.

88 ***Insufficient information has been provided within the site management plan to address AUP(OP) objective E12.2 that landfills are operated so that adverse effects on the environment are avoided, remedied or mitigated and policy E13.3 (3) that landfills are…operated in accordance with relevant industry best practice. With this in mind, please provide a draft landfill management plan for review which includes details on:***

- ***management of asbestos waste;***
- ***management of acid sulphate soils;***
- ***operation of the site;***
- ***monitoring, testing and sampling documentation;***

- ***management and disposal of non-comply materials;***
- ***environmental controls and monitoring;***
- ***record of non-complying material disposal;***
- ***meet the requirements of under the Hazardous Substances and New Organisms Act and Regulations;***
- ***response to natural hazards and unexpected discharges (including those identified in the Risk Management Assessment Report (Aecom, 2019); and***
- ***meet the requirements outlined 2018 draft Technical Guidelines for Disposal to Land.***

The Landfill Management Plan is likely to be similar to that for Redvale landfill. A copy can be provided on request. The draft section on waste control for ARL is provided in Appendix T. WMNZ notes that it closely controls the intake of wastes with high sulphur content (e.g., gypsum) to manage landfill gas quality as it affects odour potential and corrosion to the energy plant. The sulphur content of organic rich soil has not caused concern regarding high sulphur at Redvale Landfill and is not expected to at ARL. Any applications for disposal of special wastes that are classified as acid sulphate soils would be managed on a case by case basis, with consideration of volume and management and confirmation that they are not hazardous (e.g. pH) in terms of the waste acceptance criteria.

89 ***In respect of leachate monitoring, please:***

1. ***provide a wider range of parameters for quarterly monitoring, including boron, nitrate, nitrite, BOD and COD;***
2. ***provide a wider range of contaminants within annual monitoring, including the full NZ DWS suite for inorganic and organic compounds, POPs and SVOC compounds; and***
3. ***demonstrate that leachate monitoring (and all other compliance monitoring) will be undertaken in accordance with requirements outlined in the National Environmental Monitoring Standards (NEMS). The draft landfill management plan requested in question 88 should be developed to reflect this.***

The revised list of proposed quarterly and annual testing is provided in the revised Table 5.1 below. Additions are shown as underscored text. WMNZ notes that groundwater monitoring is focussed on indicators of leachate. If these indicators are detected, this would immediately prompt a wider list of parameters to be tested in groundwater and in leachate.

1. Range of parameters for quarterly leachate monitoring has been extended to include boron. Nitrate,nitrite, BOD, and COD have been added to the annual suite, not the quarterly suite. The ratios of BOD:COD and nitrate:nitrite may be useful to eliminate (or identify) leachate as a possible source of elevated nitrogen or oxygen demand, if changes are detected in groundwater or surface water. Annual frequency is considered sufficient for this. Refer revised Table 5.1 from the WAC report, below. New parameters added in underline.
2. Annual leachate monitoring has been extended to include selected, relevant parameters from the NZ DWS suite for inorganic and organic compounds. Many of the parameters on the NZ DWS list are not proposed to be tested in leachate, because they are present in drinking water as a result of disinfection(bromate, chlorate, chlorite, monochloramine, bromoform) or biological activity in surface water (cyanotoxins). WMNZ proposes to add PFAS to the annual suite. An SVOC suite has been added, however, WMNZ notes that virtually no SVOCs have been detected in leachate at Redvale landfill and monitoring for SVOCs has been discontinued. Commonly occurring POPs (organochlorine pesticides) were already in the annual suite, and will be part of the SVOC suite proposed for ARL. WMNZ proposes that consent conditions for monitoring should specify that after 3 years of testing, the annual suite will be reviewed and

monitoring of any parameters that have been consistently below detection limits or stable should shift to 3-yearly frequency (or cease altogether).

3 3 Leachate monitoring will be carried out in accordance with the NEMS for water sampling, in the absence of a specific NEMS for leachate sampling.

Table 10.1: Leachate monitoring

Quarterly (including annual)	Annual only
Metals for which there are leachability limits ('Total' concentrations to be measured in the case of leachate): • Arsenic • Boron • Cadmium • Copper • Chromium • Lead • Nickel • Mercury • Selenium • Zinc Other leachate quality parameters: • pH • Ammonia • Conductivity • Potassium • Chloride • Total petroleum hydrocarbons (TPH)	Nitrate and nitrite BOD and COD PFAS, including PFOA Volatile organic compounds, including: • Benzene, toluene, ethylbenzene, xylenes Chlorinated solvents SVOC suite, including: • Organochlorine pesticides, including DDT-compounds • Polycyclic aromatic hydrocarbon Other compounds in NZ DWS suite: • Antimony • Barium • Cyanide • Iron • Manganese • Molybdenum • Nickel • Selenium • Silver • Sodium • Potassium • Sulphate • 1,4-dioxane

90 ***The RCBA model does not appear to cover a sufficient range of contaminant species to assess the range of likely effects. To address this, please provide a response on the following:***

- ***the hydrogeological modelling should be undertaken using a wider range of contaminants including, but not limited to, modern pesticides and agrichemicals, inorganic elements (such as boron and zinc), nutrients, a wider range of persistent organic pollutants as well as modern industrial chemicals. Modelling should also account for background concentrations of inorganic chemicals and nutrients;***
- ***the results of the hydrogeological modelling should be compared to relevant water quality guidelines values (i.e. ANZG (2018) appropriate default guideline values (95 and 99% ecosystem protection values), HEPA guideline values for PFAS compounds and the NZ NPS FW (2011) national objectives framework as well as appropriate water quality classes outlined in Schedule 3 of the Resource Management Act (RMA).***

This information should then be used to undertake a more detailed (Tier 2) ecological risk assessment and incorporate background concentrations (as outlined in the BMR (T & T, 2019b)) as well as other sources on the site; and

- ***a range of leachate concentrations of the contaminants of concern from landfills in Australia and New Zealand should be provided. The contaminants of concern should include persistent organic compounds, inorganic elements, nutrients, physiochemical parameters, VOCs, SVOCs, agrichemicals outlined in the NZDWS and potential emerging contaminants of concern.***

Refer discussion on use of RBCA in the hydrogeological assessment and HRA.

10.1 Further clarification

Further clarification questions were received in relation to the above responses on 20 December 2019. Responses to these clarification questions are provided below.

86.1 Provide additional Waste Acceptance Criteria for typical modern contaminants of concern.

We note that PDP's discussion leading into this question acknowledges that waste acceptance criteria include not just TCLP limits but other parts of the waste acceptance evaluation process, including "policies and rules about the types of waste that can be accepted".

The proposed waste acceptance evaluation process and waste acceptance criteria apply to all potentially hazardous wastes. The waste acceptance criteria include prohibition of some types of waste, TCLP limits for some types of waste (relatively common wastes and contaminants), and case-by-case assessment for some types of waste (unusual or one-off waste types).

TCLP limits have been developed for contaminants that are commonly encountered in special wastes. A large proportion of special waste applications are for disposal of contaminated soil in which the contaminants of concern are historical agrichemicals that were widely used. Because these applications are expected to be received on a regular basis, TCLP limits have been developed for these agrichemicals.

Special waste applications for disposal of contaminated soil with other contaminants are also expected for example from industrial processes. TCLP limits have been provided for a range of contaminants, that range being considered sufficient to capture the contaminants themselves and contaminants that accompany and alert to even rarer contaminants.

Many other chemicals will be present in small quantities in municipal waste. TCLP limits are not proposed for all of these chemicals, because they are typically present in small quantities, and not sufficient to adversely affect overall leachate quality. Municipal waste is not proposed to be screened by TCLP. The TCLP test is not practical on municipal solids that cannot be pulped down for the test method. For example, plastics, e-waste, and trace toiletries/cleaning products will be accepted as part of municipal waste. A Class 1 landfill is the most secure option in NZ for non-recyclable municipal waste including non recyclable plastic and e-waste.

Applications that are received for disposal of non-routine industrial or commercial waste will be assessed on a case-by-case.

86.2 The applicant has also stated that "For some specific waste types, it will be necessary to assess on a case by case basis, by considering the volume of waste, the characteristics of the contaminants, and the potential effect of accepting the waste on the mass of contaminant in the landfill and on leachate quality. These assessments will necessarily be on a case—by-case basis."

Please provide further information on how this assessment will be undertaken (especially in the case where there are no New Zealand drinking water or environmental standards for a particular compound)

As noted in the application and management plan, the waste acceptance procedure that applies to applications for disposal of waste contaminated with chemicals of concern for which there are no TCLP limits includes consideration of the nature of the chemical (harmfulness), the amount of waste to be disposed, physical properties of the waste, and potential effects on landfill and leachate quality. WMNZ will look to international and local examples of waste acceptance criteria, and compare the concentrations of contaminants in the waste with criteria for other chemicals that behave similarly in the environment. The waste will be accepted based on an assessment of the potential for it to affect leachate quality.

Other management procedures may include (on a case-by-case basis):

- Placement within a logged location.
- Immediate burial.
- Restrictions around deliveries of material (e.g., multiple deliveries spread over a longer period, rather than a single large load).

86.3 The applicant has only provided criteria for the original persistent compounds but has not included a number of newer POPs or candidate compounds (such as short chained chlorinated compounds, brominated flame retardants).

Provide further information with respect to Article (4) 2(b) and 2(c) to ensure that low level POPs waste disposed into the landfill do not have an adverse effect on the environment or human health.

Article 4 2(b) and 2(c) of the Basel Convention state:

2. Each Party shall take the appropriate measures to: …

(b) Ensure the availability of adequate disposal facilities, for the environmentally sound management of hazardous wastes and other wastes, that shall be located, to the extent possible, within it, whatever the place of their disposal;

(c) Ensure that persons involved in the management of hazardous wastes or other wastes within it take such steps as are necessary to prevent pollution due to hazardous wastes and other wastes arising from such management and, if such pollution occurs, to minimize the consequences thereof for human health and the environment;

Disposal to specially engineered landfill is identified in the Technical Guidelines to the Basel Convention as a method that constitutes environmentally sound disposal (refer response to Question 86.5(b), below). The proposed design of the landfill and proposed leachate control meets the Basel Technical Guideline description of specially engineered landfill.

86.4 Provide further information justifying how the proposed WAC for zinc will be protective of aquatic life.

The proposed WAC for zinc in auto shredder residue (ASR) is the same as the guideline value for Redvale WAC (500 mg/L). The nature of the waste accepted at ARL is expected to be similar to that accepted at Redvale, and the leachate quality is expected to be similar.

RBCA modelling has been carried out for zinc using the zinc concentration in leachate from Redvale landfill (50 mg/L). The predicted concentrations at all modelled points of exposure for effects on surface water are below water quality guidelines for protection of 95% of freshwater species (0.008

mg/L). The predicted steady state exposure concentration at the nearest point of exposure (stream confluence) is 0.00012mg/L, i.e. well within the guideline.

86.5 Provide further information how waste accepted within the landfill will be controlled to comply with the requirements of Hazardous Substances (storage and disposal of persistent organic pollutants) Notice 2004, Stockholm Convention and Basel Convention. The applicant should demonstrate that:

86.5(a) that waste outlined in the Basel Convention Annex (particularly Annex (I) and Annex (Vll)) will be managed or rejected to ensure that they do not have potential adverse effects on the environment and/or human health.

We assume the reference is to Annexes I and VIII (Annex VII is not in force).

Annex I identifies sources from which wastes are derived, and specific constituents that may make a waste hazardous (e.g., metals). The TLCP limits and other waste acceptance rules and procedures apply to these wastes. Some are liquids, so are prohibited.

Annex VIII wastes are subject to TLCP limits and other waste acceptance rules and procedures. Many of the Annex VIII wastes are liquids, corrosive, explosive, or oxidising so are prohibited. Many of the Annex VIII wastes are unlikely to meet the TCLP criteria without pre-treatment. In these cases, pre-treatment would be required to remove the hazardous properties before the wastes could be accepted at ARL (with testing to demonstrate the wastes meet the TCLP criteria).

The construction of the landfill and the landfill management practices (lining system, stormwater control, daily cover, TCLP limits) will ensure that accepted wastes do not have adverse effects on the environment or human health.

86.5(b) develop waste acceptance criteria and policies / management for low level POP which comply with the Basel General and Technical Guidelines (including Technical Guidelines for mercury waste, Technical Guidelines for PCBs, Technical Guidelines for dioxins, Technical Guidelines for POPs pesticides, Technical Guidelines for SCCPs, Technical Guidelines for PFOS, Technical Guidelines for BDE and Technical Guidelines for HBCD).

The proposed WAC (acceptance procedures and TCLP limits) comply with paragraphs 326, 328, and 329 of **IV.G.3**(a) of the UNEP's General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (UNEP/CHW.14/7/Add.1/Rev.1; 20/06/19), which sets out the requirements for Specially Engineered Landfill as a method of Environmentally Sound Disposal. The proposal meets the requirements for Specially Engineered Landfill set out at **IV.G.3(a)**, which include the requirements that

- IV.G.3(a) para. 326: *"…Protection of soil, groundwater and surface water should be achieved through a combination of a geological barrier and a synthetic bottom liner system during the operational phase and through a combination of a geological barrier and a top liner during the closure and post-closure phases. Measures should be taken to prevent and reduce the production of gasses and, as appropriate, introduce landfill gas collection and control systems."*
- IV.G.3(a) Para 328: *"…a uniform waste acceptance procedure based on a classification procedure for acceptable waste, including standardized concentration limit values, should be introduced. Moreover, monitoring procedures during the operation and post-closure phases of a landfill should be established in order to identify and prevent any possible adverse environmental effects of the landfill and take the appropriate corrective measures."*

For ARL, there will be a thorough waste acceptance procedure in place, based on classification of acceptable waste. This is consistent with IV.G.3(a) paragraph 328.

The WAC also comply with the chemical-specific Technical Guidelines. In particular:

- The Technical Guidelines for mercury waste (UNEP/CHW.12/5/Add.8/Rev.1) identify that Specially Engineered Landfill should be permitted for the purpose of environmentally sound management of mercury wastes (III.G, para 166).
- The Technical Guidelines for wastes containing or contaminated with the following compounds (listed below) all refer to section IV.G.3 of the General Guidelines (i.e., Specially Engineered Landfill, see above) as methods that constitute Environmentally Sound Disposal:
  - Polychlorinated biphenyls (PCBs) (UNEP/CHW.13/6/Add.4/Rev.1)
  - Dioxins (UNEP/CHW.13/6/Add.5/Rev.1)
  - POP pesticides (UNEP/CHW.13/6/Add.6/Rev.1)
  - Short-chain chlorinated paraffins (SCCP; draft 10/12/17)
  - Bromodiphenyl ethers (BDEs) (UNEP/CHW.12/5/Add.6.Rev.1)
  - Hexabromocyclodecane (HBCD) (May 2015)

  The Technical Guidelines for PFOS waste require that:

- For wastes above the low POP content threshold (50 mg/kg PFOS), the waste must be disposed in accordance with methods sent out in IV.G.3 of the General Technical Guidelines (which include Specially Engineered Landfill).
- For wastes below the low POP content thresholds, disposal should follow the methods at IV.G.4 of the General Technical Guidelines, which requires *"they should be disposed of in an environmentally sound manner in accordance with pertinent national legislation and international rules, standards and guidelines, including specific technical guidelines developed under the Basel Convention"*. Disposal to Specially Engineered Landfill is an environmentally sound disposal method for these wastes.

86.5(c) Notwithstanding the limits proposed within the above technical guidelines, provide further information on how the proposed waste acceptance criteria and waste acceptance practices for hazardous waste will not lead to potential adverse effects on the environment and/or human health.

The waste acceptance criteria, including rules around prohibited wastes, are the primary control, in that they avoid hazardous waste types being present. The landfill design, with controls for leachate and landfill gas, and operational waste disposal practices (for example, daily cover) provide further protection against adverse effects on the environment and human health. Collectively, these controls provide for protection of human health and the environment.

The waste acceptance rules for prohibited wastes avoid hazardous wastes from being present. The purpose of the proposed TCLP criteria is to manage leachate quality arising from potentially hazardous waste, by screening out and not allowing disposal of any special waste that would have an ill-effect on leachate. Chemical transport modelling (RBCA) has been done using concentrations in leachate measured at Redvale Landfill. WMNZ expects that the waste profiles for Redvale Landfill and ARL will be very similar. The modelling shows groundwater concentrations at points of exposure (surface water, groundwater wells) are below water quality guidelines for protection of aquatic ecosystems and human health.

86.5(d) The applicant should demonstrate that the proposed waste acceptance criteria for PFOA (and other PFAS compounds) will not have potential adverse effects on the environment and/or human health.

RBCA modelling has been done using concentrations in leachate measured in Redvale Landfill. All concentrations at the point of exposure are below water quality guidelines. The concentrations in leachate from Redvale Landfill are considered representative of what will be present in leachate generated at ARL, because Redvale Landfill has received the same types of waste that WMNZ expects to receive at ARL. The main sources of PFOA and other PFAS compounds in waste at Redvale Landfill are municipal waste, biosolids, and contaminated soil, which are expected to be in similar quantities at ARL and with similar leachate character at ARL. The proposed waste acceptance criteria will be used to assess acceptance of contaminated soil and biosolids – WMNZ does not intend to test municipal waste for PFAS substances. The proposed limits are intended to ensure that the concentrations in ARL leachate remain consistent with what is expected for a landfill receiving municipal waste and biosolids, i.e., consistent with leachate quality from Redvale Landfill. This means that the results of the modelling (all concentrations below guidelines at the point of exposure) are relevant.

86.7 Provide an of assessment of landfill leachate generation and transport over a pH range consistent with the proposed waste acceptance criteria and the range of pH observed internationally from Type 1 landfills.

This assessment has not been provided, because it would not be illustrative of the potential effects of the landfill.

The WAC prohibit corrosive waste, which is waste with pH less than 2 or greater than 11.5. Leachate has a high buffering capacity. Individual loads of waste with low or high pH within this range (i.e., between 2 and 11.5) will not notably shift the pH of landfill leachate as whole. Furthermore, if any leachate escaped the landfill it would be subject to further pH buffering in the soil underlying the landfill. If contaminants in leachate do enter groundwater, they will be transported at the pH of groundwater.

Applications for disposal of large quantities of high or low pH waste would be considered on a case-by-case basis, taking into account the buffering capacity of the landfill leachate. WMNZ may require the generator to pre-treat the waste, or apply a trial period.

86.8 Provide further information on what type of historical horticultural sites that soil testing would be exempt from, how NES requirements would be met and what controls the applicant would put in place to ensure that soil sourced from these historical horticultural sites do not contain other contaminants (i.e. asbestos and lead).

The proposed exemption applies to areas subject to broad-acre application of pesticides. This specifically excludes spray sheds, greenhouses, bulk fertiliser storage areas. Broad-acre horticultural land is no more likely to have asbestos and lead contamination than other agricultural land. If information about the source alluded to the possible presence of anything else, then the exemption would not apply and the relevant testing suite would be required.

86.9 The applicant has provided Table 86-2 and stated that for many contaminants NZ DWS standard is less stringent than US DWS standards. Table 86-2 shows that for 17 contaminants NZ DWS are more stringent than US DWS (in some case by more than an order of magnitude) and that for 8 contaminants the US DWS was more stringent than NZ DWS. No reference was given on the date of either NZ DWS or US DWS.

Further information is required Including:

86.9(a) Date of NZ DWS used in Table 86-2 and confirm it is compliant with most recent update of the NZ DWS.

Drinking-water Standards for New Zealand 2005 (Revised 2018)

86.9(b) Provide the date of the US DWS and confirm that the values provided were the values used to derive the WAC reference in the WasteMINZ guidelines.

The concentration limits used to define the hazardous characteristic of toxicity in the United States Resource Conservation and Recovery Act (RCRA) were codified in 1990 (refer 40 CFR §261.24; 55 FR

11862). The toxicity characteristic leaching procedure (TCLP) is the operationally defined test that sets the definition of waste that is hazardous due to the characteristic of toxicity under RCRA.

The TCLP has been used in New Zealand to define an acceptable toxicity threshold to apply to wastes at landfills that do not accept hazardous waste. The criteria are intended to manage leachate quality, being the principal medium for contaminants if any to leave the landfill. There are now data available on the quality of leachate generated at New Zealand landfills that have applied these US-derived TCLP limits as waste acceptance criteria. The data show that the thresholds are appropriate.

As explained in the s92 response tranche 2 and WasteMINZ guidelines, although the proposed TCLP limits are based on values derived from US drinking water standards which are in some cases less stringent than NZ drinking water standards, these differences are considered to be outweighed by the significantly greater engineering controls provided in the proposal compared with the controls assumed in calculating the US TCLP limits.

86.9(c) Provide a copy of the spreadsheet used to calculate the updated TCLP criteria

No additional calculations have been carried out. All values are shown in Tables 86-1 and 86-2.

86.9(d) Identify the contaminants for which the TCLP criteria has been set using 4 x the expected leachate concentration and justify how these criteria will meet objectives 13.2 in AUP-OP

This approach has been used for PFAS substances and PFOA. These substances are in municipal waste and sewage sludge / biosolids. There is no practical way to remove these substances from municipal waste and sewage sludge / biosolids before disposal to landfill, so they will be present in landfill leachate. Concentrations of these substances in leachate are expected to be similar to those in leachate from other municipal solid waste landfills. The intention of applying a limit of no more than 4-times the expected leachate concentration to waste streams that comprise less than 5% of the total waste (e.g., biosolids, contaminated soil) is to avoid generating concentrations in leachate that are notably greater what is expected for municipal waste landfill leachate. Coupled with leachate collection and control, and operational processes for placement and daily cover of waste, this meets objectives 13.2.

86.9(e) Include Hampton Downs Waste Acceptance criteria in Table 86-2.

WMNZ does not intend to include these criteria.

11 Air Quality

60 Please assess the proposed air discharges against the requirement of AUP(OP) Policy E14.3(8) regarding the Best Practicable Option and precautionary approach. In particular, please detail how the proposed landfill design and management measures (including waste handling and landfill gas control) compare to modern landfill practices internationally and adopt a precautionary approach to minimise adverse air discharge effects. Please note that Plan Change 14 has made a minor amendment to AUP(OP) Policy E14.3(8) with immediate legal effect.

Policy E14.3(8) is concerned with avoiding, remedying or mitigating adverse effects on air quality from discharges of contaminants to air by using the best practicable option and by adopting a precautionary approach for significant adverse effects. For this application the best practicable option under E14.3(8)(a) has been adopted to manage discharges to air and the precautionary approach is not considered necessary as there is considered to be a negligible risk of significant adverse effects.

Details regarding the adoption of the best practicable option for emission control, are set out in Section 10.6.5 of the AEE. This includes adopting and using industry leading management practices, as described in Section 5.8 of the AEE. This includes use of cover materials, waste compaction, odour sprays, and waste acceptance criteria, which are all considered to be the best practicable option for managing emissions from the landfill operation.

Policy E14.3(8)(b) requires a precautionary approach to be adopted where there is uncertainty and a risk of significant adverse effects or irreversible harm. Technical Report D, Volume 2 demonstrates the conservative nature of the assessments undertaken and concludes that the envelope of potential effects is known and does not pose significant adverse effects or irreversible harm to the environment.

The proposal is consistent with this policy.

61 Please further assess and detail potential alternatives to discharges of contaminants into air from landfilling, particularly considering waste reduction and re-use opportunities for various waste streams, including e-wastes, demolition and construction wastes, and organic wastes.

A Class 1 landfill is a disposal site that accepts residual municipal solid waste which has not been diverted or recycled. Therefore, the opportunities for diversion from landfill have occurred prior to materials arriving at the site. These opportunities are managed and governed by legislation such as the Waste Minimisation Act and through initiatives such as the Auckland Waste Minimisation Plan. These are set out in section 2 of the AEE.

While opportunities to divert specific waste streams, such as organic materials and e-waste should continue to be explored and taken wherever possible, the existence of a landfill does not restrict or prevent these measures from being introduced. Restrictions on the production of waste by third parties, and requirements around recycling of materials by third parties, are beyond the jurisdiction of the Resource Management Act 1991 and this application for consent.

62 It is proposed to discharge contaminants into air from the combustion of landfill gas (LFG) within a maximum of 12 operational generators, each burning approximately 600m^3/hr of LFG (7200m^3/hr total). However, the maximum rate of LFG collection from the landfill is predicted to be 7970 to 10,089m^3/hr, leaving a quantity of LFG that shall be flared. As part of the assessment of alternatives and the Best Practicable Option, please justify the proposal for a maximum of 12 operational generators with additional flares. If it is considered that further generators could be employed to better utilise the LFG at the

later stages of the landfill's life, please assess the effects of the discharges from the alternative LFG combustion profile and compare this to that presented in the submitted report titled Auckland Regional Landfill: Air Quality Assessment, prepared by Tonkin and Taylor Limited, dated 30 May 2019 ('the AQR').

It has been assumed, for the purposes of the air quality assessment, that the LFG generators at the ARL will use the same technology employed at Redvale Landfill. However, it is likely that generation technology will change over time. For example, in the future, it may be preferable to install a smaller number of generators each with a larger capacity. Therefore, reference to the numbers of generators installed is potentially misleading and would be better expressed as maximum total generation capacity (12 MW) or maximum quantity of LFG burnt in generators (7,200 m^3/hr). However, to maintain consistency and for ease of understanding, this response will refer to numbers of generators each of nominal 1MW output.

The purpose of the LFG emission rate calculations was to provide realistic, but conservatively high, estimates of LFG generation (and collection) rates in order to assess the effect of the potentially highest rate of emissions to air. Therefore, the estimates focused on the possible peak (maximum) LFG generation rate, which will occur in the year of landfill closure. It is important to understand that there is considerable uncertainty in these estimates, and the actual peak generation rate will be significantly lower if waste placement rates or organic contents decline in response to waste reduction and diversion initiatives or if the nature of waste disposed changes significantly for any reason (note: the estimates assume a constant waste placement rate of 500,000 tonnes per year for a period of 40 years).

The number of generators installed will also relate to the duration over which they can operate. LFG generation/collection rates begin to reduce quickly after the year of landfill closure. While the lower bound estimates suggest that there may be sufficient gas to operate 13 generators in the year of landfill closure, the 13th generator would only be able to be used for one year. Therefore, the capital expenditure would not be warranted. The practical maximum number of generators that could be operated for a typical engine lifespan under the lower bound LFG collection estimate scenario is 12.

For the upper bound scenario, there may be sufficient gas to operate more than 12 generators after about 20 years, increasing to a maximum of 15 generators. However, as previously noted, these estimates are highly dependent on waste placement rates.

It is also important to note that gas yield from the landfill will vary, even from day to day, due to atmospheric and climate effects and collection infrastructure works, and by the 'priority principle' (whereby the optimum amount of gas is extracted according to the best environmental performance in terms of fugitive emissions and not the ability to generate electricity). That variation has to be taken up in a variable rate destruction unit such as a flare since generator engines do not have that turn down ability. This feature means that generators alone should never be used for the entire gas flow.

WMNZ is comfortable that the best estimate at this point in time is that there are likely to be 12 generators installed (at the earliest, about 20 years after waste placement commences). The assessment provides for residual gas under the upper bound scenario being burnt in a flare.

Emissions to air from generators are similar to enclosed flares, although there are slightly higher NO_2 emissions from internal combustion engines compared to external combustion in a flare. The emissions profile of internal combustion engines has improved significantly over the last few decades with respect to NOx emissions (amongst other things) and it is likely that there will continue to be improvements. Any ability to achieve more than 12 MW generation capacity will not be known for close to 20 years and, given the uncertainty both in LFG emissions and technology improvements, we consider this would be better addressed through a variation to the consent conditions, if required in the future.

63 Please provide a draft Construction Environmental Management Plan that details the proposed dust management and monitoring measures to minimise potential dust effects during the earthworks and construction of the landfill and associated roads. Please refer to the Good Practice Guide for Assessing and Managing Dust (Ministry for the Environment, 2016) in preparing this document.

As outlined in the Air Quality Assessment (Technical Report D), good practice dust control measures will be used during the construction works. This would typically include:

- The use of water for dust suppression;
- Reducing vehicles speeds on-site;
- Wheel wash facilities to prevent tracking off-site of mud which turns to dust; and
- Minimising stockpiling of soil material near sensitive receptors.

A draft Construction Erosion and Sediment Management Plan was provided as part of the consent application (Appendix B of Technical Report R), which included proposed measures for dust management. The specific construction methodologies have not been finalised yet, and therefore preparation of more detailed dust management procedures is not appropriate at present. The proposed conditions included in the AEE Appendix G require a more detailed Construction Management Plan to be prepared and provided to Council prior to works commencing.

64 Please provide an exemplar landfill management plan to demonstrate dust management and monitoring measures that are likely to be utilised to minimise dust effects from the operational landfill, including the proposed stockpiling and earth moving.

Note: This may be combined with the landfill management plan requested within question 88 below

A draft Landfill Management Plan has been prepared by WMNZ (Appendix T).

65 Please assess the potential ecosystem effects of dust deposition from the landfill tip-face and access roads, particularly noting the potential toxicity of dust from the waste streams to plant life, including heavy metals and other hazardous compounds.

Dust deposition effects on plant life are discussed in Section 7 of the Air Quality Assessment (Technical Report D). These effects are principally related to the physical impacts of dust and not to entrained contaminants. The landfill access road will be paved and will not be a significant source of dust except during its construction. Dust from construction activities associated with the landfill including the access road during construction will be from naturally occurring materials and will therefore not have elevated concentrations of contaminants above background levels for the site.

Dust can be generated at the working face, for example from tipping dusty loads, some of which may contain elevated levels of contaminants. Dust control measures include covering the waste promptly with general waste at the working face, operation of a limited-size working face, rejection of excessively dusty uncontained waste during the waste pre-acceptance process, and contingency use of water sprays. These controls are demonstrated to be effective at other landfills. Redvale has never had any complaint or external comment on any dust nuisance from the working face.

Vegetation productivity can be affected if there are very high levels of heavy metals in soils, depending on their bioavailability. This could only occur if there were significant levels of dust deposition with high metals concentrations over an extended period. Given the proposed dust controls and the distance from the working face to areas of sensitive vegetation, there are not expected to be any adverse toxic effects of dust on plant life.

66 Please detail proposed controls for the receipt and handling of asbestos containing wastes to minimise potential hazardous dust effects.

WMNZ has provided the following response: The procedures at ARL will be consistent with the Waste. Acceptance Criteria for Class A Landfills[14] and will include:

- Disposal practices for asbestos waste and asbestos-containing material (ACM) will be designed to prevent asbestos particles becoming airborne.
- Asbestos waste will be accepted at ARL only in non-friable condition, delivered in accordance with NZS 5433: 2012 Transport of dangerous goods on land. Friable asbestos will not be accepted.
- Asbestos waste awaiting disposal will be kept in containers that are (a) closed (b) impermeable to asbestos dust and (c) conspicuously marked as per the NZ Health and Safety at Work (Asbestos)
- Regulations 2016.
- In general, asbestos waste will be double wrapped in bags placed in a skip bin, or in large bags which can be lifted and lowered by 'HIAB'.
- Asbestos waste will be either taken straight to its place of disposal if it can be tipped without mobilising the asbestos (favoured because it avoids double handling) or taken to a dedicated lay-down area before removal with care to its place of disposal.
- Dampened ACM soil may be tipped from the truck direct into its place of disposal provided that the ACM is covered for transport and the working face is properly ready.
- The locations of asbestos waste will be recorded, so that precautions can be taken to avoid the possibility that they are dug up should it be necessary to excavate into the landfill at a future time.
- Customers must comply with the landfill's requirements with respect to pre-approval, giving advanced notice and arriving within agreed times frames.
- Any asbestos arriving without the proper documentation or treatment will be turned away, and the customer/haulier will be reminded of their responsibilities and warned that they will be refused further disposal contracts with WMNZ if it happens again.
- During tipping and burial, the area at or near the working face where the asbestos waste is being tipped will be evacuated of non-essential personnel.
- The drivers will be given clear instruction on where to tip from the gatehouse attendant and/or spotter. · Proper PPE will be used by anyone outside of closed vehicle cabs at or near the working face for asbestos waste disposal. Driver's PPE will be checked at the gatehouse.

67 The report titled Auckland Regional Landfill: Waste Acceptance Criteria, prepared by Tonkin and Taylor Limited, dated 30 May 2019 (the 'WAC') describes the receipt of 'Class 4 Waste' ('Controlled Fill', soils below or near-background contamination levels) to permanent stockpiles. However, it is unclear if these stockpiles will also be available to receive Class 4 Waste from external customers. Please assess the potential for dust discharges from the permanent stockpiles and resulting off-site dust effects, particularly noting the likely frequency of depositing and excavating material at these stockpiles.

Having reviewed that availability of suitable cover materials from within the landholding, WMNZ does not consider that it will be necessary to stockpile soil materials sourced from off-site. Also, it is unlikely that Class 4 waste would be transported to ARL when cheaper and closer disposal sites exist. Therefore receipt of 'Class 4 Waste' to permanent soil stockpiles is not an activity for which consent is being sought. The soil stockpiles will not be 'landfills'.

[14] URS, 5 September 2003: Final report, Waste Acceptance Criteria for Class A Landfills, prepared for MfE, ref 49324 021 R004-H

68 Please provide an exemplar landfill management plan to demonstrate odour management and monitoring measures that are likely to be utilised to minimise odour effects from the landfill. Note: This may be combined with the landfill management plan requested in question 88 below

WMNZ has prepared relevant sections of a draft Landfill Management Plan which outline proposed measures to manage and monitor odour effects. The draft Landfill Management Plan is attached to the s92 responses (Appendix T).

69 Please assess and comment on the potential odour effects from the laying of 'fluff layers' at the base of cells and provide examples of odour mitigation measures for this activity that could be employed to minimise odour risks from the landfill.

The "fluff" layer is a layer of non-soil refuse that is pushed out as the first layer to go over the base of a new cell. This activity occurs very infrequently but would be the occasion when the greatest surface area of fresh refuse is exposed to the open air, since daily cover is not placed on the sides of the waste right down to the contact with the leachate drainage blanket due to concern about soil blocking the drainage system. However, the depth of the fluff layer is relatively shallow and, as it is related to the development of a new cell where waste has not yet become anaerobic, there is no increased risk of fugitive LFG emissions associated with older waste. In WMNZ's experience, localised 'fresh refuse' odours are noticeable around the immediate area, but this has not been an activity typically associated with off-site odour complaints. The complaints record for Redvale Landfill (2005 to 2019) includes one complaint that mentions that it coincided with pushing out of the fluff layer in a new cell. This complaint occurred in July 2013, which was during a period when there were a number of complaints that were identified as being related to fugitive LFG emissions from an area where the integrity of the cover had been impaired by desiccation cracking. The investigation did not identify the placing of the fluff layer as the cause of the odour complaint.

The main odour mitigation method used during placement of the fluff layer is the use of odour suppressant sprays if necessary, through a variety of possible methods including a portable T-bar spray or a fogging cannon, same-day waste coverage over any area of cover removal off older waste, and exclusion of higher odour potential special wastes.

70 Section 5.8.3 of the AEE states that: "natural earth material or a suitable alternate material" will be used as daily cover. Please comment on the potential for alternate waste materials used as daily cover to generate greater levels of odour than those assessed by the AQR

The reference to "suitable alternate material" was not intended to be interpreted as waste materials but could include lightly contaminated soils. Although it is considered unlikely that Alternative Daily Cover (aka ADC) will be adopted at the ARL, some landfills overseas use inert covers (e.g. plastic sheeting or similar), instead of daily cover and WMNZ seeks to keep open the option to use alternative materials where this is operationally beneficial. The intention of daily cover material is to provide a physical barrier and suppress odour. To achieve the same performance, alternative cover materials to natural earth will be required to not be odorous themselves and to not leak odour through or around them.

71 The odour assessment makes broad statements regarding the likely frequency, intensity and spatial extent of landfill odours based on limited comparison to Redvale Landfill's complaints record. Such a comparative odour assessment is useful to assist with assessing the potential odour effects from the proposed landfill and identifying management measures to minimise these effects. Please expand on the comparative odour assessment in accordance with the guidance of the Good Practice Guide for Assessing and Managing Odour (Ministry for the Environment, 2016), detailing odour experiences (complaints and field assessments) at similar landfills to that proposed, drawing on examples from at least across Australasia, to assess the odour effects from

the proposed landfill (including the likely frequency, intensity, duration, odour character and spatial extent of odours).

WMNZ's landfills at Redvale and Kate Valley are considered to be the most comparable New Zealand landfills to the proposed ARL in terms of scale and operational practices. WMNZ and T+T are currently undertaking a review of available odour complaints records from these landfills to evaluate what additional information can be provided. This information will be provided to the Council once it is complete. We do not have access to complaints records from landfills in Australia and, in any case, our observation at landfills in Australia is that they have significantly different operational approaches.

There is limited publicly available data on relevant 'odour experiences' to undertake an assessment of the nature requested. WMNZ has provided T+T further detailed complaints records for the Redvale Landfill, however these records do not usually contain the level of detail and analysis required to ascertain the intensity or duration of odours.

A limited analysis of the spatial extent of odours can be undertaken based on the location of the dwelling on the complainant's property. However, it is important to note that odour complaints do not necessarily relate to odours experienced at the dwelling, i.e. they may relate to odours at other locations on a property. Also, complaints are mostly singular and rarely come in groups from a particular direction so there is little possibility of assessing spatial extent of odours based on complaints. Care must also be taken in drawing inferences from odour complaints as an indicator of odour effects as there are a variety of factors that influence whether people choose to make complaints.

Complaints records have been sought for other landfills in New Zealand in which WMNZ has an interest (Whitford Landfill and Kate Valley Landfill). However, even where data has been provided it has not been in a format, or categorised in a way that, allows detailed analysis, particularly of intensity or duration of odours, to be undertaken. We have not sought publicly available complaints records for other landfills as recent experience by T+T is that most regional council's do not disclose the location of complainants, or other details that would enable a meaningful analysis with regards to frequency, duration, intensity or spatial extent of odours.

In relation to the complaints records for Redvale Landfill, a simple comparison of odour complaints within certain distances of the Redvale Landfill is potentially misleading, as WMNZ has established a notional odour boundary across a number of properties close to the Landfill that will influence complaint behaviour. The location of complaints from WMNZ's odour complaints records for the Redvale Landfill are summarised in Figures 2 and 3 (). The Figures show that complaints have been received from a number of different locations since 2005. However, the majority of complaints have been received from locations within 1 km from the landfill.

There is a minimum separation distance of 1 km between the landfill footprint and neighbouring dwellings at the ARL, so our analysis has focussed on complaints received from locations more than 1 km from the Landfill. We have identified that there are 5 complainants that account for the vast majority of complaints at greater distances (over 1km) from the landfill footprint (see Table 1).

The location of these recurrent complaints is shown in Figure 1 (attached). There are no obvious meteorological or topographical factors that would explain why complaints are received from these particular locations and not from other properties. However these complaints represent a small percentage of properties in the wider area around the Landfill.

When comparing the environmental settings of the Redvale Landfill and the ARL, it is relevant to note that there are 142 dwellings within a distance of 1km and 2 km from the landfill footprint at Redvale Landfill, while there are 22 dwellings within this range from the proposed ARL footprint. The lower housing density around the ARL means that there is a reduced likelihood of particularly sensitive individuals being present.

Table 11.1: Locations of complainants greater than 1 km from landfill footprint

Location of complainant	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008
118 Kahikatea Flat Rd		8	4	6	2	4	3	8	4	4	
55 Postman Rd			1			6		1	2	4	9
55a Postman Rd				1					3	14	9
99 Tender Rd		6	1	7	9	14			1		2
55a Postman Rd				1					3	14	9
184 Richards Rd	11	7	5	9	7						
Postmans Rd vicinity*	2	11				1	1	2			
Subtotal	13	32	11	23	18	25	4	11	10	22	20
Other locations	1	10	1	3	4	1	1	0	0	2	4
Total complaints greater than 1 km from the landfill	14	42	12	26	22	26	5	11	10	24	24

* These are typically complaints passed on from Auckland Council

72 Please review the field odour monitoring records for Redvale Landfill (or any other similar landfills where records are available) to assess the odour risks arising from the leachate and LFG collection system, capped areas, and active working tip-face at the proposed landfill. Following this review, please specify proposed management measures (as detailed in the exemplar Landfill Management Plan) that address these risks.

WMNZ employs an air quality technician to undertake field odour monitoring at least daily (apart from Sunday when no waste is received) at the Redvale Landfill. In addition, an external party is engaged to undertake less frequent "independent" odour field monitoring at the Landfill (currently quarterly).The data recorded during the odour field monitoring includes:

- Whether odour was detected
- Odour intensity
- Odour character/hedonic tone (including descriptors like "gassy", "rubbish")
- Odour duration
- Meteorological conditions (wind direction and speed, temperature and whether it was dry or wet)
- Whether odour systems were operating (e.g. T-bar sprays, mobile sprays)
- Whether there was any suspicious odorous waste receipt in the last 2 hours

If odour is observed during the field odour monitoring, it is reported to the operations team immediately so they have the opportunity to find and correct any issues. A register is maintained of all the odour field inspections.

In relation to the analysis requested by the Council, the odour field inspections do not attempt to define a specific cause of any odours identified. Therefore, it is not possible to assess the odour risks associated with specific activities or aspects of the landfill operation (e.g. tipping, gas collection, leachate treatment) based on the field odour monitoring records.

The potential causes of odours at a landfill are well understood and the odour management practices reflected in the Landfill Management Plan are based on WMNZ's experience over many years. A summary of the known odour risk areas and proposed controls is set out in the following table.

Odour risk	Controls
Odour from working face	Minimised size of active face. Mobile odour neutraliser sprays. Tipping odorous waste as close as practical to its final place Rapid burial. Early planning and installation of gas collection system. Workface covered progressively during day (minimise open area). Daily cover Early application of intermediate cover and final cap. Waste acceptance and rapid escalation of attention to waste deliveries that cause odour events.
Passive venting of uncaptured landfill gas through cover	Adequate thickness of soil cover layer, e.g. augmented daily and intermediate cover. Extra soil cover if needed to avoid desiccation cracking or erosion. Elimination of trees especially ones with deep roots. Landfill gas collection system: • Gas extraction and collection pipe network in the waste. • Early planning and installation of gas collection system (install “as-you-go”. • Priority given to gas extraction for landfill gas and odour control. • Continuous vacuum. Placement of relatively inert, soil-like wastes as mono-fills around the edges of the landfill waste mass to improve the seal against the wall lining system. Odour controls for any excavation through cover into waste e.g. for gas wells.
Odour from special waste (including biosolids)	Require odour assessment as part of the Waste Pre-Acceptance procedure. Hold some less-odorous waste alongside the working face to quickly bury wastes found to be odorous. Requirement for hauliers to notify landfill in advance of delivery of known odorous waste. Requirement for hauliers to cover their loads. Gatehouse control and communications with working face. Restricted acceptance hours for odorous waste. Techniques for ‘clean’ tipping out of trucks e.g. disposable tray liners. Use of wheel wash facilities for outbound trucks from the working face
Odour from leachate	Minimal exposure to air, by way of small sumps and lidded storage tanks. Consider separation distance when determining location of storage tanks located away from receptors. Gas-tight cover over leachate re-injection ports. Rapid response protocol for leachate breakout.
Odour from re-excavation of cover soil	Minimise amount of odorous soil excavations at any one time. Minimise the time of exposure of old waste when tying into an old cell. Avoid early morning when weather conditions are commonly less favourable for dispersion of odour.

Odour risk	Controls
	Attention to design detail at temporary edges of the waste e.g. soil bunds.
Odours from trucks	Cart waste in sealed containers. Require known and suspected odorous waste types to be covered for road transport. Reject third party customers without covered loads.
Odour from mixing of incompatible wastes	Separately bury high pH wastes
Odour from combustion exhaust	Select and operate for optimal combustion efficiency. Routine maintenance. Elevated discharge points (stacks) to aid dispersion.
Passive venting through flare during power outage	Flame out auto-dial Auto slam-shut valve upon flame out Auto flame reignition

73 Please comparatively assess odour assessment methods to effectively monitor odour effects throughout the operational phase of the landfill. Particularly, please assess the utility of ambient air quality monitoring for H2S or another contaminant as a proxy for odour, portable olfactometers, thermal / gas imaging cameras for the detection of fugitive LFG discharges, and methods and locations for field odour scouting.

A discussion is presented below on possible methods for monitoring odour effects.

Ambient air quality monitoring for H_2S

Landfill gas comprises a mixture of odorous gases. While H_2S is a significant contributor to odour in LFG, other compounds like mercaptans, which are present at much lower concentrations, can also be important in terms of overall odour from LFG. A review published by the US EPA[2] found a poor correlation between ambient H_2S measurements and observation of odour by residents in a community near a landfill accepting gypsum drywall. In T+T's experience, the sensitivity of the human nose is more reliable than any of the currently available monitoring techniques for compounds, or mixtures of compounds, that may indicate the likely presence of odour.

Portable olfactometers

Portable olfactometry units have been designed to quantify the concentration of ambient odour, in terms of odour units. Neither T+T nor WMNZ has any direct experience with these units. However, based on T+T's experience with laboratory-based olfactometry testing, we anticipate that the accuracy and reproducibility of the odour measurements will reduce with reducing odour concentrations like one would expect in open outdoor spaces. For this reason, portable olfactometers are more likely to be a useful tool where there are relatively high levels of odour and where a comparative assessment is required, rather than an absolute measurement of odour concentration. As an example, portable olfactometers may be useful for evaluating the effectiveness of a new odour management technique by taking "before" and "after" odour measurements. Although it is noted that the same outcome may be achieved with the use of an olfactometer using odour observations on a scale of 1 to 6.

Given the expected limitations in accuracy and reproducibility at low odour concentrations, portable olfactometers are unlikely to be a useful tool for monitoring odours from normal operation of the landfill. Thermal or infrared imaging cameras

Infrared cameras have been used for a number of years in the oil and gas industry to detect leaks of natural gas. Infrared camera technology could be used to detect areas of elevated methane (LFG) emissions from landfill surfaces. For example, an infrared camera could be mounted under a drone, which may provide a quicker method of undertaking surface emission surveys compared to walkover surveys and would eliminate the health and safety risks of physically walking over the landfill close to machinery and obstacles. T+T has found studies comparing the sensitivity of infrared cameras with Photoionisation Detectors (PIDs). However, none of these studies have compared the sensitivity with Flame Ionisation Detectors (FIDs), which are the instruments used to undertake landfill surface walkover surveys. FID's have a much higher sensitivity to methane compared to PIDs and, combined with the ability to hold the probe very close to the landfill surface, walkover surveys are able to detect surface methane emissions to very low levels. It is our understanding that infrared technology cannot currently achieve the same levels of detection. WMNZ will continue to monitor developments in this technology, given its potential efficiency benefits.

Open path monitoring

Open path spectrophotometry is another measurement technique for remote sensing of methane emissions. This technique can be used to detect a methane plume passing across the pathway between a spectrometer and a reflector and could therefore potentially be used to detect fugitive LFG emissions passing across the site boundary. We are not aware if this method has specifically been evaluated for the purpose of monitoring odour. Given the need for a fixed location for the spectrometer and reflector, this approach has less flexibility than field odour observations.

Field odour scouting

Field odour scouting has been undertaken for several years at Redvale Landfill as a proactive method of monitoring odour to inform site management practices. The environmental setting for the Redvale Landfill differs to the ARL, particularly on account of significantly greater distance to receptors at ARL and forested area surrounding much of the landfill footprint. At the ARL, odour scouting is proposed where it is practical within the buffer zone landholdings at a nominal frequency of monthly to commence with, and venturing beyond the site boundary in specified contingency circumstances identified in the odour management plan.

74 Please review the results of ambient air quality monitoring for volatile organic compounds undertaken at Whitford Landfill or any other similar studies available, provide a summary of this data, and assess and discuss the potential applicability of these past monitoring studies to the discharges from the proposed landfill.

Ambient monitoring was undertaken in July to September 2015 at the Whitford Landfill. The monitoring comprised 5 passive sampling badges (3M Organic Vapour Monitors) that were exposed for approximately 90 days and analysed for a targeted VOC suite. There were 2 sample locations within the landfill site and 3 locations around the boundary.

The monitoring identified low levels of BTEX (including benzene). No chlorinated organic compounds were detected (level of detection not stated). Alpha- and beta-pinene and limonene were all recorded at low levels, which was attributed to non-anthropogenic emissions (e.g. pinus radiata and macrocarpa). Benzene was measured at all sites, with the highest concentration at Whitford Maraetai Rd (0.3 $\mu g/m^3$ as a 3-month average compared the ambient air quality guideline value of 3.6 $\mu g/m^3$ as an annual average). The analysis of the results determined that the benzene concentrations reported were most likely due to the influence of motor vehicle emissions.

75 Please describe the likely rates of fugitive LFG and methane discharges from the landfill over its lifetime, accounting for the likely variation in the extent of areas under daily and intermediate cover, waste age and LFG collection efficiency. A chart depicting expected LFG generation and collection volumes would assist.

This question appears to be based on the common misconception that the difference between predicted LFG generation and collection volumes represents the quantum of fugitive LFG emissions. The prediction is not precise due to unknown variables like waste composition and moisture, and the difference between predicted generation and actual collected can swing between positive and negative. An assumption is made that 90% of the predicted gas generation will be collected. Part of the remainder will escape as fugitive emissions but, as explained in Section 3.2 of the Air Quality Assessment, part will be treated through the landfill cap, which acts as a bioremediation layer where methane and other compounds are removed by oxidation processes. The NESAQ requires that the concentration of methane measured at the surface of the landfill does not exceed 5,000 ppm. In practice, there are typically no detectable levels of methane above areas of well-managed final or intermediate cap and measured odour emissions are the same as measured over grassed paddock areas.

Appreciable fugitive LFG emissions would typically only occur if there were deficiencies in areas of cover. Techniques such as surface emission monitoring are used to ensure that any fugitive emissions are detected and the cause remedied as soon as practicable, for example by supplementing the cover material to provide additional thickness.

Fugitive LFG emissions can occur around the working face at the landfill. While WMNZ uses techniques to actively collect LFG from around the working face, the rate of extraction needs to be carefully balanced to avoid drawing air (oxygen) into the waste mass. The pressure differential between the waste mass and the atmosphere provides the driving force for fugitive emissions of LFG from around the working face. The risk of fugitive emissions is greatest under conditions of low and falling barometric pressure. It is not possible to quantify these fugitive LFG emissions, however, along with odour from the waste itself, they are part of the characteristic odour that is experienced when standing on or near the working face.

76 SO2 discharges from the combustion of LFG have been estimated using an average H2S content within the LFG measured at Redvale Landfill and a mass-balance calculation. Please compare the assumed SO2 discharges with data from other landfills (at least across Australasia), noting any differences in H2S content and conversion to SO2, and assess the likelihood of higher SO2 discharges from the proposed generators and flares, particularly accounting for the potential volumes of waste plasterboard received.

T+T is not aware of any publicly available stack testing data for SO_2 emissions from landfill gas flares or generators in Australasia, other than limited monitoring undertaken at Redvale Landfill. The reported emissions from the generators at Redvale Landfill are significantly lower than the emission rate estimated using a mass balance calculation. Therefore, a mass balance approach would appear to be conservative.

The H_2S concentration in LFG that was used to estimate the maximum rate of SO_2 emissions from the flares and generators at the ARL was 307 mg/m^3, based on the average measured concentration in LFG at Redvale Landfill between 2007 and 2015. For comparison, the US EPA's recommended default H_2S concentration is 45 mg/m^3 (32 ppm) with a 95% confidence interval of 19 to 72 mg/m^3 based on 36 test reports.

The H_2S concentration in LFG at Redvale Landfill has been variable over time (see Figure 4.1 in Appendix B of the Air Quality Assessment). A period of relatively high H_2S concentrations in the LFG in 2004 to 2006 has been attributed to the historical placement of high sulphur-containing gypsum plasterboard waste. A similar elevation of H2S was experienced at Kate Valley Landfill following receipt of large amounts or earthquake debris containing dry-wall plasterboard. The composition of LFG will vary in different parts of the waste mass depending on the waste composition, age and localised conditions of pH, moisture and temperature. As the volume of LFG being generated at the landfill increases, its overall composition is expected tobecome more consistent and “averaged” due to dilution/blending. This appears to be the case at Redvale Landfill, where the H_2S concentration in the blended gas has steadily declined since 2007.

As the assessment of effects of SO_2 emissions from the ARL is based on the maximum rate of LFG being collected (in the year of landfill closure), it is considered reasonable to adopt a representative longer term H_2S concentration to avoid significantly overstating SO_2 emissions. The likelihood of SO_2 emissions exceeding the rate evaluated in the Air Quality Assessment is considered low because it would require ahigh average H_2S concentration (which is more likely to occur in the earlier stages of landfilling) combined with a high LFG generation rate (which will occur towards the completion of landfilling).

77 Please assess the effects of hazardous air pollutant discharges on ecosystems, including the impacts of SO2 and sulphate particulate on flora, with reference to the Ambient Air Quality Guidelines (Ministry for the Environment, 2002) or other relevant assessment criteria for the protection of ecosystems.

The Ambient Air Quality Guidelines (AAQG) include Critical Levels for sulphur dioxide (SO_2) for different land uses as set out in the table below. The Critical Levels are expressed as annual and/or winter averages.

Land use	SO_2 Critical Level	Averaging period
Agricultural crops	30 µg/m^3	Annual and winter average
Forest and natural vegetation	20 µg/m^3	Annual and winter average
Lichen	10 µg/m^3	Annual

The dispersion modelling results for wintertime average (June-August) and annual average SO_2 concentrations for the 2015 and 2017 meteorological years are presented as contour plots in Figures 1 to 4 in **Appendix N**. This data has been extracted from the modelling presented in the Air Quality Assessment (Technical Report D). The outermost contour represents the 10 µg/m^3 (wintertime average) predictions.

Concentrations exceeding 10 µg/m^3 (the lowest of the recommended Critical Levels) are localised to within the immediate vicinity (of the order of 100 m) of the Energy Centre. The area where SO_2 concentrations would exceed 10 µg/m^3 as a wintertime average (beige shaded area on the plots) are all confined well within the plantation pine forested area. Based on this, there are not expected to be any adverse ecosystem effects associated with SO_2 emissions from the ARL.

There is a Critical Level in the AAQG for sulphate particulate, which is identified as being appropriate in locations where ground level cloud is present for more than 10% of the time. Ground level cloud is not expected to occur around the ARL site. Sulphate particulate is associated with SO_3 emissions. We are not aware of any data on SO_3 emissions from combustion of landfill gas, however we would expect this to be very small compared to SO_2 emissions. Given the scale of the discharge, distance from sensitive ecological areas and absence of significant low level cloud conditions, there are not expected to be any adverse ecosystem effects associated with sulphate particulate.

78 The modelled 24-hour average SO2 concentrations have been compared to the Auckland Ambient Air Quality Target of the AUP(OP) (120µg/m³) in accordance with the hierarchy of the Good Practice Guide for Assessing Discharges to Air from Industry (Ministry for the Environment, 2016) to assess human health effects. The Air Quality Guidelines Global Update 2005 (World Health Organisation, 2006) has an alternative guideline for SO2 at this averaging period (20µg/m³). Please comment on the applicability of this alternate guideline and the potential for adverse human health effects if it is exceeded at any location as a result of the proposed SO2 discharges.

The maximum predicted 24-hour average ground level concentration of SO_2 at a sensitive receptor, where a person could reasonably be exposed over a 24-hour period, is 16 µg/m^3. This is less than the WHO guideline value. For completeness, we note that the appropriateness of the WHO guideline has not been evaluated in New Zealand and it has no regulatory status at present.

79 Please provide spatial plots of the modelled maximum 24-hour and annual average PM2.5 concentrations for the 2005 and 2007 modelling years.

Please see attached concentration contour plots of the modelled maximum 24-hour and annual average PM_{10} (Appendix O). All of the PM_{10} emissions arsing from combustion of LFG are assumed to comprise $PM_{2.5}$ and therefore separate plots of $PM_{2.5}$ have not been provided (as they would be identical).

80 The dispersion modelling assessment assumed a single 9m high flare stack, although the AEE states that more than one flare may be installed. Please assess the potential for differing off-site hazardous air pollutant concentrations to arise in the event that multiple flare stacks discharge contaminants simultaneously.

The decision as to whether a single large flare (with a high turn down) is the better choice to manage LFG compared to several smaller flares will be based on the rate at which LFG is generated (which will depend on future waste composition, waste acceptance rates, collection efficiency, any alternative utilisation technologies employed) and relative costs. The emission rates of contaminants and physical parameters (release height, temperature and velocity) will be similar for either scenario. The only material difference relates to thermal buoyancy – with a single larger flare having a higher plume thermal buoyancy compared to two smaller plumes. This means the dispersion of emissions from a single large flare is slightly better than several smaller flares because there will be a higher "effective stack height", which is the combination of the actual physical height of the release, plus plume rise due to buoyancy or momentum velocity. The effects on predicted concentrations of pollutant emissions from the flare of a slightly lower thermal buoyancy (lower effective stack height) will be very small at the closest sensitive receptor (about 1 km away). The proportion of gas being flared compared to burnt in generators will decrease as the rate of landfill gas collection increases over time. When landfill gas collection is at its highest, the flare emissions will only be a relatively small contributor to the predicted off-site effects of combustion products compared to engine emissions. On this basis, we consider the use of a single large flare or several small flares will not have any effect on the conclusions of the assessment.

81 Please assess the potential for hazardous air pollutants to be better dispersed from the LFG generators with lower off-site effects if discharged from a combined stack or stacks of differing heights to that proposed as part of the assessment of alternative methods of discharge.

The response to this question is similar to the response to question 80, as a combined stack discharge would have a higher thermal buoyancy. This issue was considered in detail at Redvale Landfill, and the findings were that:

- The generator suppliers were concerned about the impact of applying a higher backpressure on the generators. This would require re-tuning, and could decrease the engine efficiency and potentially increase the relative pollutant emissions; and
- While the increased thermal buoyancy would be beneficial, the dispersion models do not recognise the increased buoyancy that will occur in reality from merging of the plume from a row of generators located close together. Therefore the modelling of the impacts of a row of individual generator emissions is likely to be conservative and the benefits that were shown by modelling the effects of 6 generators combined into a single exhaust shroud were probably over-stated.

It was concluded that combining the generator exhausts into a single stack, or shroud, was not practicable and this conclusion also applies to the ARL.

82 Please assess the potential air quality effects arising from the proposed evaporation of leachate, including the likely discharges of hazardous air pollutants (including heavy

metals but excluding mercury, which is assessed in an appendix to the Health Risk Report) arising from this activity.

As outlined in Section 4.6 of the Air Discharge Assessment, the impact of the leachate evaporator on discharges to air is minimal due its relatively low operating temperature (meaning that volatilisation of loer boiling pints HAPs from leachate into the evaporator exhaust gas are minimised) and because the exhaust vapours are combusted in the flare. Any volatile, or semi-volatile, organic compounds that are stripped from the leachate will be substantially destroyed by combustion in the flare. Inorganic compounds (metals) would not be destroyed in the flare, as they have a low volatility (with the exception of mercury). These compounds are not expected to be volatilised to any appreciable degree at 90°C, which is the operating temperature of the leachate evaporator.

Based on this assessment, the potential air quality effects of the leachate evaporator are assessed as negligible (note: there is no change in emissions from combustion of landfill gas). We note that a separate (but related) response will be provided to a specific question about the destruction efficiency of the flare for PFAS compounds (Question 98), as these could potentially be volatilised in the leachate evaporator.

83 It is noted that the proposal shall generate approximately 740 vehicle movements per day, predominantly trucks travelling to and from the site along State Highway 1 to the south. Please assess the likely hazardous air pollutant discharges and potential increases to ambient air quality levels at representative roadside residential receptors arising from these additional heavy vehicle movements.

The impacts on air quality from additional heavy vehicle movements have been assessed using the NZTA air quality screening tool (Appendix P). The screening tool can be used to estimate air quality impacts of 24-hour average PM10 and annual average nitrogen dioxide (NO2). Current traffic data has been based on 2017 traffic counts on State Highway 1, south of the proposed site entrance (from the Integrate Transport Assessment), and the percentage of heavy vehicles is based on published data for State Highway 1 north of Warkworth (http://www.trafficcounts.co.nz/). The average vehicle speed was assumed to be 80 km/hr. A base year of 2026 has been adopted, assuming 3% per annum increase from the 2017 traffic counts. Background air quality concentrations were adopted for urban Warkworth, noting that this will be conservatively high for receptors located in rural areas:

- PM10: 37.5 µg/m3 (24-hr average)
- NO2: 13 µg/m3 (annual average)

The air quality impacts were calculated for a receptor located 20 m from the road and compared against air quality assessment criteria from the National Environmental Standards for Air Quality (for PM10) and the World Health Organization (for NO2). The results (summarised in the following table) suggest that air quality impacts of the increase in heavy vehicle movements will have negligible effect on air quality with respect to the assessment criteria.

Table 11.2: Summary of NZTA Screening tool fleet inputs and air quality outputs

	Without Project	**With Project**	**Air quality assessment criteria**
AADT	17536	18276	
Percentage heavy vehicles (%)	9	12	
PM10 (µg/m3, 24-hr average)	38.2	38.3	50
NO2 (µg/m3, annual average)	14.9	15	40

85 Lithium-ion batteries are one example of a waste-stream with particularly hazardous characteristics for landfills (acute fire potential). Please assess and detail the risks posed by auto-igniting materials (such as lithium-ion batteries and emergency flares) and potential mitigation measures, including fire-fighting protocols, waste acceptance criteria and waste receipt monitoring. Note: The draft response received on this in an email from Rachael Signal-Ross from Tonkin and Taylor Limited, dated 27 August 2019, would benefit from being more robust, in particular by drawing on international experience for evidence.

WMNZ has provided the following response:

Firstly, it is acknowledged that lithium-ion (and lithium-iron) batteries present an ignition source since they are rarely fully discharged, and they can be expected to turn up in landfill waste when there is no regulated or economic path for their disposal or recycling elsewhere. These batteries are not classified as hazardous waste from the point of view of chemistry, but they are of concern from the point of view of igniting a fire in material that surrounds them.

In the case of isolated small batteries of any kind arriving incidentally in general waste, it is not practical to individually identify and remove them. If they cause a fire in recent waste then the working face will be well equipped to douse it as per the emergency management plan. If electrical discharge occurs a longer time after burial, there will be low oxygen and deep fire in the waste will be unlikely.

In the case of flares, they are hazardous waste and the landfill will reject them. If however they arrive unseen and incidental to the general waste and if they go off in the recent waste then the accompanying plume of smoke will get attention pretty quickly by activation of the emergency management plan for fire at the working face.

In the case of bulk amounts of batteries, WMNZ's practice is to ask the customer to encapsulate the batteries inside drums backfilled with dry weak concrete mix followed by addition of water which removes the ability of the batteries to ignite waste after burial at the landfill.

Waste receipt monitoring will mostly take place at the working face, since most waste loads will be covered or containerised so the gatehouse attendant can't see it, apart from smoke. The landfill management plan (section on 'contingency' in the waste acceptance plan, and section on 'fire' in the emergency management plan) will contain a procedure for dealing with discovery of hazardous waste at the working face. WMNZ will also issue warnings to customers who offend repeatedly (Redvale has occasionally banned customers who flout safety expectations) although this disciplinary process will not be prescribed in the management plan. Fire-fighting protocols in the emergency management plan will include these steps for example:

1 If the fire appears too large to handle, call the fire service straight away.
2 Assume fumes are toxic. Stay out of the path of wind-blown smoke.
3 Put on protective gear if appropriate.
4 Identify the load or area on fire if possible. Warn others by site radio and call for assistance.
5 Use fire extinguishers if appropriate. Fire extinguishers are in the spotter's hut and WM vehicles.
6 Also, if necessary, use the water cart to spray water on the seat of the fire.
7 Also, if necessary, spread daily cover soil over the burning area to smother the fire.
8 Use machines to push nearby loose, flammable rubbish etc. out of the way if this can be done safely.

9 If these methods are unsuccessful, call for assistance from the Fire Service, dial 1 for a line out, then dial 111.

10 Exhume the burnt refuse in small sections.

11 Spray water on any fire which re-appears using the water cart, or if appropriate fire extinguishers. Firefighting reserve water can be quickly obtained from on-site hydrants, ponds, and nearby river.

12 Call for back-up fire extinguishers to be made ready.

13 Reconstruct the refuse cell to proper thickness with daily cover.

14 If a deeper landfill fire is apparent, design and implement a strategy to eliminate air entry to the refuse around the area of the fire which may include:

- Foam cover (NZ Fire Service)
- Isolate nearest gas extraction wells (WM)
- Drill injection wells for water or inert gas
- Check and seal leachate cleanout risers (WM)
- Inject water or inert gas into the waste

15 Arrange for fire extinguishers to be refilled.

16 All fires must be reported to the Auckland Council as soon as possible.

12 Risk management assessment

Technical Report S of the resource consent application was a Risk Management Assessment, prepared by AECOM.

Paul Crimmins asked the following question regarding this report:

84. Please provide the details of the author of the Risk Management Assessment, including their qualifications and relevant experience for environmental risk assessments.

AECOM provided the below response:

> *"The Risk Management Assessment has been collated by Kerryn McLellan, a landfill engineer with more than 13 years' experience in environmental engineering. The actual risk issues have been compiled from the technical assessments undertaken and through workshops on the issues with design leads. Oversight of the risk assessment process has been provided by Ian Jenkins who has conducted numerous environmental risk assessments over the past 28 years (resumes for project staff can be provided if required)."*

In addition, one question relating to the Risk Management Assessment was included in the letter from Sentinel Planning on 18 September 2019. A response to this was prepared by Ian Jenkins from AECOM and is included in **Appendix Q**

Further clarification was sought in relation to these responses on 20 December 2019. Responses to these clarification questions are provided in **Appendix R.**

13 Health risk

92 ***The HHRAR provides a systematic approach for identifying and selecting potential contaminants of concern in section 5.0. However, it is considered that the list does not cover enough emerging contaminants of concern, such as pharmaceutical compounds, personal care products, anti-microbial agents and persistent bioaccumulative toxic substances (and candidate compounds) listed in the Stockholm Convention (including short chain chlorinated paraffins and poly chlorinated naphthalene and hexachlorobutadiene). In addition, substances of very high concern have been identified by the European Union (i.e. highly environmental mobile substances such as nonyl phenol, alkylphenols and alkylphenol ethyoxylates (APEOs) and listed PBT/vPvB substances) as well as 1,4-Dioxane. Accordingly, please provide an assessment of likelihood of Persistent Bioaccumulative and Toxic (PBT) EmCoC within the leachate that could have a potential impact on human health receptors. Please also confirm how these compounds will be managed at the landfill in terms of waste acceptance criteria and site management practices.***

<u>Additional contaminants of potential concern</u>

There are many substances that can be present in leachate or landfill gas. It is consistent with recommended practice to undertake an initial screening assessment to identify a sub-set of these substances that are referred to as Compounds of Potential Concern (COPC). This selection process, or screening assessment, considers the relative amount of the substance (e.g. its concentration in leachate or landfill gas) and its toxicity relative to other substances. Although there is no clear cut-off between substances that are/are not of potential concern, the purpose is to identify the substances that pose the greatest hazard and carry them forward to a detailed quantitative assessment. Therefore, in responding to this question, we have first considered whether the substances would have been selected as COPC for the HHRA if they had been included in the screening assessment. If they would not have been selected as COPC (i.e. they are not identified as priority contaminants through the screening assessment) then no further detailed evaluation is warranted as their inclusion would not alter the conclusions of the HHRA.

We have reviewed the substance lists in the Stockholm Convention, the European ECHA (‘persistent, bioaccumulative and toxic’ (PBT) substances and ‘very persistent, very bioaccumulative’ (vPvB) substances) and other specific compounds mentioned in this request against the compounds already included in the screening assessment. The substances on these lists that were not included in the original screening assessment but have been analysed in leachate at the Redvale Landfill, are as follows:

- Lindane
- Phthalates
- Bis(tributyltin) oxide (TBTO)
- PAHs

Lindane, phthalates and TBTO

Drinking water quality guideline values are available for Lindane and the relevant phthalates, so these substances have been screened using the approach set out in the HHRA (Section 5.4.3 and Appendix B Table 3) using the ratio of the concentration in leachate to the drinking water guideline. The COPC in leachate that were taken forward to detailed assessment were selected as follows:

- The 15 highest ranked compounds in leachate (i.e. with the highest ratio), including the seven compounds evaluated based on Waste Acceptance Criteria; and
- Substances that are likely to be present in both landfill gas and leachate within the top 20 highest ranked substances.

Lindane, Bis (2-ethylhexyl)phthalate (DEHP) and TBTO would be ranked within the top 20 compounds in leachate (but not the top 15). As they are not present in landfill gas in any appreciable quantity, these substances do not meet the criteria for selection as COPC. It is also noted that Lindane is a banned agrichemical that has never been detected in leachate at Redvale Landfill and is very unlikely to be measurably present in waste disposed to the ARL.

Table 13.1: Screening assessment for lindane phthalates and TBTO

Compound	Adopted leachate concentration (mg/L)	Drinking water guideline (mg/L)	Ratio of concentration/DW guideline	Number of analyses above detection limits	Concentration rationale	DW guideline reference
Lindane	0.025	0.002	12.5	0	Half LOD	NZ MAV
Benzyl butyl phthalate (BBP)	0.005	0.1	0.05	2	Maximum at Redvale	MDOH
Bis (2-ethylhexyl)phthalate (DEHP)	0.078	0.009	8.67	24	Maximum at Redvale	NZ MAV
Dibutyl phthalate (DBP)	0.011	0.02	0.55	10	Maximum at Redvale	MDOH
Bis(tributyltin) oxide (TBTO)	0.014	0.002	7	26	Maximum at Redvale	NZ MAV

PAHs

PAHs are a family of compounds, some of which are identified as carcinogens. PAHs cannot be screened using the method set out above because there are no drinking water guidelines due to their low solubility (i.e. they are unlikely to be present in drinking water). We have therefore carried out a semi-quantitative analysis to determine whether PAHs need to be considered in more detail.

The NES Soil sets out a recommended approach for assessing mixtures of PAHs by multiplying the concentrations of individual PAHs by a "Potency Equivalency Factor" relative to Benzo[a]pyrene (see Table 2). The concentration of PAHs expressed as "Toxic Equivalents" is set out in Table 3.

Table 13.2: PAH potency equivalency factors (Source: NES Soil)

Polycyclic aromatic hydrocarbon	Potency equivalency factors
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(j)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Benzo(a)pyrene	1.0
Chrysene	0.01
Dibenz(a,h)anthracene	1.0
Fluoranthene	0.01
Indeno(1,2,3-c,d)pyrene	0.1

Table 13.3: PAH concentration in leachate expressed as Toxic Equivalent

PAH	Redvale leachate monitoring data	Potency equivalence factor	Leachate concentration (mg/L)	Concentration x PEF (mg TEQ/L)
Benz(a)anthracene	Yes	0.1	0.016	0.0016
Benzo(b)fluoranthene	Yes	0.1	0.0078	0.00078
Benzo(j)fluoranthene	No	0.1	-	-
Benzo(k)fluoranthene	Yes	0.1	0.0082	0.00082
Benzo(a)pyrene	Yes	1	0.0083	0.0083
Chrysene	Yes	0.01	0.014	0.00014
Dibenz(a,h)anthracene	Yes	1	0.005	0.005
Fluoranthene	Yes	0.01	0.0083	0.000083
Indeno(1,2,3-c,d)pyrene	Yes	0.1	0.005	0.0005
Total				**0.0172**

The NES Soil recommends assessing PAHs as non-threshold compounds using a risk-specific oral dose (equivalent to a 1 in a million increased lifetime cancer risk) of 0.0048 µg/kg BW/day. For context, this level of exposure would be equivalent to an adult drinking approximately 20 mL of leachate each day with a PAH concentration of 0.0172 mg TEQ/L.

PAHs are characterised by their low solubility and tendency to bind strongly onto solid particles in the soil and partition into sediments if they are released into water. If there is leachate seepage through the landfill liner system, PAHs will bind to particles in the clay under the landfill and are unlikely to reach groundwater. This is confirmed by the RBCA modelling of similar contaminants, which indicates there is virtually zero exposure via leachate seepage into groundwater and subsequent migration.

The HHRA also considers the potential for small amounts of leachate to be discharged directly into the stormwater system. The stormwater treatment system is designed to minimise discharges of sediment and will therefore also be very effective at removing any PAHs, which will be attached onto particles.

Based on this qualitative analysis of the potential exposure pathways, we do not consider there is any appreciable risk of exposure to PAHs from the landfill. For this reason, PAHs have not been subject to quantitative HHRA calculations.

Waste acceptance criteria and management practices

Many of the emerging contaminants identified in this question are present in landfills because they are a very small component of general municipal solid waste. In some cases they would be classified as “household hazardous waste”, e.g. residues of cleaning or personal care products in disposed packaging. In other cases, they arise from materials that are typically considered non-hazardous or within manufactured articles e.g. plasticisers contained within plastic packaging or plastic components. As these materials are co-mingled in the general waste stream, there is no practical way to monitor their presence in the waste itself. However, they represent a very small proportion of the overall waste stream and are therefore highly diluted in the case of liquids, or well dispersed through the waste mass in the case of solids. The potential for adverse effects from these materials is managed through the engineering controls at the landfill, such as the lining system and leachate and landfill gas management systems.

All commercial and industrial wastes are subject to waste acceptance controls. This comprises evaluation against a pre-determined set of waste acceptance criteria for materials that are more commonly sought to be disposed at the landfill, or a case-by-case evaluation for less common waste materials (which may include a requirement for pre-treatment). Specific waste acceptance criteria have not been developed for many of the emerging contaminants because the number of emerging contaminants is cumbersomely large and because the emerging contaminants are rarely elevated above common concentrations found typically in general commercial wastes sent to landfill under a contract. The approach to waste acceptance is to set screening and testing criteria that would address virtually all wastes apart from rare contaminants (like emerging contaminants) occurring in smaller waste deliveries that have relatively low impact on the scale of the whole waste mass.

93 It is unclear from reading the hydrogeological assessment and the HHRA if discharges of leachate / contaminated stormwater from spills / leachate from the bin transfer area are included in the assessment. Please provide clarification of all the sources / pathways into the environment that the HHRA considers.

The bins stored in the bin exchange area will be kept closed until they are tipped at the working area. In the unlikely event of a spill during storage and transfer, this will be cleaned up in accordance with the spill response procedures to prevent discharge to any stormwater system and subsequent discharge to surface water. The impacts of low probability accidental releases of this nature have not been considered in the HHRA.

We note that in response to other questions, further consideration has been given more generally to stormwater as a potential exposure pathway. It is noted that stormwater from the bin exchange area will be treated via a rain garden to reduce incidental contaminants associated with activities such as operation and parking of trucks.

94 Based upon the description in the hydrogeological assessment discharge concentrations of PFAS to the environment appear to have been modelled using RBCA. However, the standard RBCA model does not have PFAS compounds in its database and the Koc approach used by RBCA to assess retardation is not appropriate for assessing ionic organic compounds (i.e. the PFAS compounds assessed). As noted in the hydrogeological assessment memorandum from Alan Pattle and Aslan Perwick of Pattle Delamore Partners Limited, dated 28 June 2019, this is not considered an appropriate tool to use to estimate receiving environment concentrations due to discharges from the landfill. Accordingly, please provide clarification on how PFAS discharges were modelled as well as the physiochemical properties (and the source of the information) used to assess the transport of PFAS compounds in environmental media.

The PFAS discharge concentrations to the environment have been modelled using RBCA. Data for modelling PFAS was retrieved from the Risk Assessment Information System website (RAIS https://rais.ornl.gov/) including KoC values (see below). While KoC partitioning is used to determine retardation in RBCA, the partitioning and associated retardation has no effect on the predicted concentrations at the receptors for the PFAS compounds. This is because the modelling did not account for any degradation of PFAS compounds and assumed an infinite source and steady state conditions. So on this basis, the partitioning option does not have an effect on the outcome of the modelling.

Contaminant	Perfluorohexanesulfonate (PFHxS)	Perfluorooctane sulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)
RAIS Koc (L/kg)	112.2	371.5	114.8
RAIS H	0	0	1.64E-04

95 Please confirm how background concentrations of the various parameters of concern and the effect of cumulative sources (i.e. stormwater, aerial deposition (where appropriate), runoff from the bin transfer area, etc.) have been taken into account when predicting final groundwater and surface water source effects.

Comment on background concentrations

The purpose of a health risk assessment is to characterise the change in health risk associated with a proposed development. In other words, the HHRA for the ARL estimates the worst case incremental (additional) health risk associated with exposure to contaminants that may be released from the landfill and assesses them against acceptable risk criteria developed for the same purpose. For this reason, the HHRA does not attempt to quantify individual exposures to contaminants from other sources and via other pathways, such as from consumption of purchased food and drink, smoking or workplace exposure.

Comment on cumulative effects from the landfill sources

The HHRA does however consider the cumulative effects of exposure to contaminants from different sources at the landfill (leachate and landfill gas), transport mechanisms (via groundwater, surface water, aerial transport) and exposure pathways (ingestion of drinking water, home-grown produce, soil, etc). This is described schematically in Figure 4.1 in the HHRA.

96 Please provide justification as to why a 50% dilution factor has been used for calculating the contributing volume from Valley 2.

Valley 2 has a similar catchment area to Valley 1. Therefore, during rainfall events when the discharges from the landfill will occur, the runoff at the point of discharge from the site i.e. wetland outlet will be mixed immediately at that point with the flow from Valley 2 at a 50 % dilution rate.

97 The hydrogeological assessment indicates that because the Watercare intake from the Hōteo River is upstream of the site that potable water risks have not been considered in the HHRA. Accordingly, please undertake a review of consented water takes within 5km downstream of the site and confirm with landowners downstream that there are no potable water takes.

The consented surface water takes reported in the Hydrogeology Assessment (based on Auckland Council records) appear to be mainly for the purpose of irrigation, other than the Watercare consented take. On this basis, the HHRA exposure scenarios have considered the potential for surface water takes from the Hōteo River to be used for irrigation but not as potable water supply. However, there is sufficient information in the HHRA to understand the effects if water from the Hōteo River was used for drinking water, as discussed below.

Appendix D Table 1 of the HHRA compares predicted concentrations of contaminants in the Hōteo River, as a result of leachate seepage into groundwater and subsequent migration, with drinking water guideline values. The predicted concentrations are all well below drinking water quality guidelines, with the most significant potential exposures being lead (0.80 % of the guideline) and arsenic (0.76 % of the guideline).

It is important to note that the concentrations reported in the HHRA as being in the Hōteo River are actually the concentrations in groundwater at the point of release into the River – i.e. they do not take into account the very significant dilution that would occur in surface water within the River. Taking this dilution into account, the incremental health risk to a receptor drinking water from the Hōteo River will be lower than the worst case representative residential receptor presented in the HHRA and does not warrant more detailed consideration.

For this reason, we do not consider it necessary to undertake the requested review of consented surface water takes.

98 **The HHRA assessment assumes that fluorotelomers will be destroyed within the flare and that there are no TRV (toxicological reference values) for PFAS fluorotelomers. Both of these assertions are not considered to be correct. The C-F bond needs temperatures of greater than 1,200 degrees Centigrade to be destroyed, therefore the flare may transform some PFAS compounds, but not destroy them. Also, there are published TRV for PFAS compounds. Accordingly, please provide comment on the validity of the assumption made about the destruction of fluorotelomers in the flare.**

99 **There is a wider variety of PFAS compounds that could potentially be discharged such that only assessing three compounds could underestimate the overall risk. A recent NTP report (https://ntp.niehs.nih.gov/results/areas/pfas/index.html) suggests short chain PFAS may affect some organ systems and therefore their effects could be additive. Some studies suggest that landfill leachate may contain elevated concentrations of short chain PFAS compounds. Accordingly, please provide justification for why only three compounds have been assessed to demonstrate potential risks associated with PFAS compounds and further, whether the presence of shorter chain PFAS compounds would potentially change the human health risks assessment.**

The response to these questions is provided in the form of an update to Appendix G of the HHRA (see attached Appendix S, referred to here as **Appendix G Revision 1**). A brief summary of the updated findings as set out in Appendix G Revision 1 is set out as follows:

- We accept the reviewer's comments that PFAS may be subject to partial (rather than complete) combustion in the flares and generators due to the stability of the C-F bond. A discussion of the most likely partial combustion products is set out in Appendix G Revision 1.
- A quantitative assessment can only be undertaken where there is data to support estimation of the concentration of the PFAS compound at the point of exposure and a relevant toxicity factor. The HHRA was based on the three PFAS compounds where this information was readily available. PFAS are emerging contaminants of interest and, as such, there is ongoing research and new information is becoming available over time. A more detailed discussion of available data on concentrations of PFAS compounds in leachate and landfill gas, and toxicity data, is set out in Appendix G Revision 1. As a result of this further analysis:
  - PFHpA has been conservatively assessed in the HHRA using the toxicity factor for PFOA
  - Representative data was identified to enable PFBS to be evaluated quantitatively. However, PFBS was not carried forward into the detail HHRA calculations based on a comparison with PFOA - the concentrations of PFOA and PFBS are similar, but the toxicity value for PFBS is two orders higher (less toxic) than PFOA. If the HHRA concluded that exposure to PFAS compounds was close to acceptable levels, then the contribution of PFBS would have been considered (note: the assessment shows exposure is well within acceptable levels so quantitative assessment of PFBS is not warranted).
  - No toxicity data or landfill gas concentration data was identified to enable a quantitative assessment of PFAS compounds released to air, including FTOHs (i.e. quantitative assessment can only be undertaken for leachate exposure pathways).

As explained in more detail in Sections 9.2.1 and 9.2.2 of the HHRA, if the Hazard Quotient and cumulative Hazard Index are less than unity (1.0), then no adverse health effects are expected as a result of exposure to a substance (or group of substances) via the pathway(s) under consideration. This value of 1.0 is shown in the tables as the 'Hazard Threshold'.

As shown in the updated tables below, the inclusion of PFHpA in the quantitative assessment does not alter the conclusions of the HHRA with respect to PFAS compounds and there remains a significant margin (5 orders of magnitude) between the calculated cumulative residential exposure and the Hazard Threshold (i.e. the tolerable level of exposure).

This significant margin provides reassurance that even though the assessment does not consider all PFAS compounds (because the data is not available to do so) it is very unlikely that the effects of cumulative exposure will be unacceptable (based on our current state of knowledge).

Residential receptor

Updated Table 9.4: Residential receptor using bore water for potable supply and to irrigate the vegetable garden

Contaminant	Hazard Quotient				COPC Hazard Index
	Chicken egg ingestion	Produce ingestion	Drinking water	Soil ingestion	
PFOA/PFHpA	9.94E-07	1.31E-07	2.81E-07	1.95E-09	1.41E-06
PFOS/PFHxS	1.95E-05	1.84E-07	3.32E-06	2.31E-08	2.30E-05
Hazard Index	2.05E-05	3.15E-07	3.60E-06	2.50E-08	2.44E-05
Hazard threshold	1.0				

Wild food collector

Updated Table 9.5: Wild food collector eating eels and incidental ingestion of surface water

Contaminant	Hazard Quotient		Compound-specific Hazard Index
	Ingestion eels	Ingestion water	
PFOA/PFHpA	1.40E-06	1.26E-07	1.53E-06
PFOS/PFHxS	4.90E-04	1.56E-06	4.91E-04
Hazard Index	4.91E-04	1.69E-06	4.93E-04
Hazard threshold	1.0		

Public consumer

Updated Table 9.7 Comparison of estimated concentrations in food with PFAS trigger points

Contaminant	PFOA/PFHpA		PFOS/PFHxS	
	Estimated concentration (µg/kg)	Trigger point[1] (µg/kg)	Estimated concentration (µg/kg)	Trigger point (µg/kg)
Finfish	0.00097	41	0.042	5.2
Mammalian animal meat (e.g. beef)	1.39E-06	28	8.40E-05	3.5
Milk	1.51E-05	2.8	1.71E-06	0.4[2]
Poultry eggs	0.00013	85	0.00032	11

[1] Source FSANZ, undated b

[2] or level of detection if higher

100 The proposed monitoring programme recommends monitoring only pH and elevated conductivity, boron, ammoniacal nitrogen (ammonia) and chlorides as indicators of

leachate breakout. These indicators may not be suitable for compounds such as PFAS, phenol ethyoxylates as well as nonionic compounds. From experience in reviewing reports from several different landfills within New Zealand, these parameters are subject to a number of external sources and confounding factors which makes interpreting the results difficult. Also, for compounds that have very low human health guidelines, these indicators may not be sufficiently sensitive enough to detect a potential leachate breakout. Therefore there is a potential for 'false negatives' when interpreting these results. The use of secondary indicators such as PFAS would provide definitive indication of a leachate breakout. Accordingly please provide commentary on why the indicator parameters proposed are enough to detect leachate breakouts and whether additional parameters are warranted.

Landfill leachate typically has elevated conductivity, boron, ammoniacal nitrogen and chlorides. While each individual parameter may be subject to confounding factors (e.g. they could be affected sources other than leachate), consideration of these different parameters together is a good indicator of the presence of leachate. The purpose of the monitoring is to quickly identify the potential presence of leachate and to avoid release of contaminants to the environment by containing the stormwater.

Leachate is unlikely to come into contact with stormwater as any rainfall runoff that comes into contact with waste is directed into the leachate collection system and treated as leachate. Therefore, cross-contamination could only occur from a scenario such as a leachate breakout through the soil cover or cap away from the working face, or seepage into the underdrain in the initial stages of the landfill. This would be picked up by the proposed stormwater monitoring and regular visual inspections of the landfill cap. Testing of PFAS in stormwater as an indicator of leachate contamination is not considered practicable or necessary given the high costs and longer laboratory turnaround time, bearing in mind that periodic analysis of trace constituents in the leachate will be specified to correlate leachate indicators identified above to contaminants like PFAS.

We note that the proposed monitoring programme is not intended as a basis for assessing potential effects. The HHRA has considered the very unlikely scenario of a continuous discharge of up to 8.2 L/day of leachate into the stormwater pond (corresponding with the anticipated upper trigger level for release of stormwater from the site). The proposed stormwater monitoring should ensure that any leachate entering the stormwater system would be detected well before this occurred, and the source of leachate would be identified and remedied so there was no ongoing discharge. Nonetheless, the HHRA has shown that even if this discharge did occur, there would not be unacceptable health effects.

101 No reference or justification has been provided for a number of parameters used in the HHRA e.g. size of the garden area and various transfer factors used in calculations. Please provide references to the source of all parameters used in calculations for the HHRA and justification as to why those parameters where selected.

The parameters were taken from the NES Soil or the HHRAP where available. Where the parameters are not taken from these sources, an alternative reference is given or they are stated as being assumptions. The media concentration scenarios not covered by the NES Soil or the HHRAP are:

- Accumulation of contaminants in soil in domestic vegetable gardens, as a result of contaminants being present in water used for irrigation. See Section 7.5.2 of the HHRA for justification of the following assumed parameters:
  - Watering rate: 10 L/min
  - Watering duration: 60 minutes/day
  - Watering period: 100 days per year

- Garden size: 45 m2
- Entrainment of contaminants in roof collected drinking water. See section 7.6 for justification of the following assumed parameter:
  - Percentage of rainfall collected: entire mass of deposited contaminants collected in 50% of the potential rainwater volume.

We were unable to locate any transfer factors used in the calculations where the source was not identified.

102 The health risk from organic and element mercury compounds has not been adequately assessed in the HHRA. Please assess the risk of organic and element mercury compounds.

As explained in the HHRA (Appendix H), there has been only one analysis of mercury in landfill gas at Redvale Landfill. This was carried out in 2002 and although the result was a non-detect, the method used had a very high detection limit (2775 µg/m3) relative to the concentration that would typically be expected in landfill gas (of the order of 1 µg/m3). In the absence of site-specific data, we have relied on published data on concentrations of mercury in landfill gas. The maximum concentration of mercury in landfill gas recorded at UK landfills is 1.33 µg/m3 with an average concentration of 0.58 µg/m3 and the US EPA AP 42 default emission factor for mercury is 2.435 µg/m3.

As mercury is one of the few compounds in landfill gas that is not destroyed by combustion, there will be an ongoing release of mercury from the flares and generators. As discussed in the HHRA, most of the mercury exiting the flares and generators will be elemental (inorganic) mercury, which does not readily deposit, but is vertically diffused (in the vapour phase) to the free atmosphere. Therefore inhalation exposure (rather than deposition and subsequent ingestion) will be the most significant exposure pathway for emissions to air.

In reviewing the assessment of mercury emissions, we identified an error in the calculations presented in Appendix H for mercury emissions associated with the leachate evaporator. Revised calculations are shown below.

Update Appendix A Table 4: Calculation of losses of mercury and water vapour from leachate into the flare (via the leachate evaporator)

Component	Vapour pressure	Molecular weight	Mass fraction	Moles per kg of leachate	Vapour mole fraction	Loss rate	Loss rate
	kPa	g/mol	g/kg	mol/kg	Unitless	g/s	kg/day
Water	70.182	18.015	0.9999935	0.055509	0.9999994	694.444	0.9999935
Mercury	0.02167	200.59	6.50E-06	3.24E-08	5.84E-07	1.39E-06	6.50E-06

* Assuming evaporator is sized to evaporate 60L/day water

If all of the mercury in the 60 m3/day leachate treated through the evaporator were volatilised, this would equate to 0.39 g/day of mercury being released into the flare along with the water vapour. However, calculations based on partial vapour pressure show that approximately 0.12g/day (1.39 x 10-6 g/s) of mercury would be released, which is 30% of the mercury in the leachate, is likely to be lost to the flare and the balance will remain in the leachate and be recirculated back into the landfill (or disposed off-site). We note that this estimate is based on a conservative assumption of 0.0065 g/m3 mercury in the leachate, which is the highest measured concentration (recorded in 1998). There have been 51 analyses of leachate samples from Redvale Landfill for mercury between 2005 to 2015. In these more recent analyses, mercury was only detected in one sample at a concentration of 0.00016 g/m3 (i.e. 2.5% of the concentration used in the calculations above), with the detection limit typically being 0.00008 g/m3.

We have undertaken dispersion modelling based conservatively on the year of peak landfill gas collection, assuming a concentration of 2.435 µg/m3 mercury in the landfill gas all passing through the flare to atmosphere. The sources considered in the modelling are the emissions from the flares and generators including the emissions from the leachate evaporator (via the flare), as well as fugitive emissions from the working face and areas under daily cover. The model predicts annual average concentrations of mercury of 4.50 x 10-6 µg/m3 (2015 meteorological year) and 5.59 x 10-6 µg/m3 (2017 meteorological year) at the closest residential receptor to the Energy Centre. These values are 5 orders of magnitude lower than the New Zealand ambient air quality guideline of 0.33 µg/m3 (annual average) for inorganic mercury.

The concentration of mercury is routinely monitored in the leachate at Redvale Landfill. Apart from two high concentrations recorded in 1998 (including the highest measured value of 0.0065 g/m3), the mercury concentration in the leachate has been well below (typically at least an order of magnitude) the New Zealand drinking water guideline (MAV) for total mercury of 0.002 mg/L. Given that the leachate is likely to meet drinking water guidelines for total mercury (based on monitoring at Redvale Landfill), we consider leachate is unlikely to be a significant exposure pathway to mercury.

Based on this assessment, we consider emissions of mercury from the ARL pose a very low human health risk.

103 The Good Practice Guide for Assessing Discharges to Air from Industry (Ministry for the Environment, 2016) recommends that the acceptable environmental risk arising from industrial air discharges to residential receptors is 1 in 1,000,000 (10-6, GPG: Industry section 4.5.2). However the HRAR has adopted an acceptable risk of 1 in 100,000 (10-5, HRAR section 9.2.1). Please comment on the suitability of the acceptable risk level adopted for the HRAR and assess how the guidance of the GPG: Industry may alter the conclusions of the HRAR with respect to Air Quality Effects.

The acceptable risk level of 1 in 100,000 (10-5) adopted for this study was based on the recommendations of the Toxicology Advisory Group on the NES Soil (2011) (see Section 91.2 of the HHRA).

The justification given for use of an acceptable risk level of 1 in 1,000,000 (10-6) in the Good Practice Guide (GPG) Industry is that this value "has been adopted by the Ministry for the Environment in a range of guidelines for the management of contaminated land", with a subsequent reference to the 1999 guidelines for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand (MfE, 1999). We understand that the intent of the GPG Industry was to be consistent with the approach used for the management of contaminated land, but it appears not to have been updated when the GPG Industry was reviewed in 2016.

We consider adoption of an acceptable risk level of 10-5 (10 per million) is appropriate. However, the cumulative incremental lifetime cancer risk calculated in the HHRA, using conservative assumptions, was 0.23 per million and therefore even if the GPG Industry value of 1 per million was used, the conclusions of the HHRA would not change.

104 Table B1 of the HRAR lists 1,3-Butadiene as a threshold compound with a screening assessment criterion of 9.9µg/m3. However, the NZ Ambient Air Quality Guidelines list this contaminant as a carcinogen with an ambient air quality guideline of 2.4µg/m3 (annual average) and the US EPA IRIS database shows an Inhalation Unit Risk of 3x10-5 (µg/m3)-1. Given this, please review the derivation of assessment criteria and categorisation of contaminants (threshold or genotoxic) for the HRAR's screening assessment and assess how any changes may impact the conclusions of the HRAR.

It is acknowledged that 1,3-butadiene could also be included as a priority contaminant in the HHRA as the WHO has concluded that there is a high degree of confidence that it is genotoxic carcinogenic.

The New Zealand ambient air quality guideline value is not based on a unit risk value, but was set to reduce ambient concentrations to as low a level as reasonably practicable. The WHO ambient air quality guidelines for Europe do not set a guideline value for 1,3-butadiene on the basis of their being inadequate data to determine a unit risk. However, as noted in the question, the US EPA IRIS database cites a unit risk of 3 × 10-5 (µg/m3)-1 and therefore this has been adopted as the toxicity criterion to evaluate the incremental cancer risk from exposure to 1,3-butadiene via inhalation.

The US EPA has not set a unit risk for oral exposure as 1,3-butadiene is a gas at room temperature and pressure, making oral exposure unlikely. Therefore, only exposure via inhalation has been considered.

The highest annual average concentration of 1,3-butadiene in air from the dispersed emissions from landfill gas and combustion products is predicted to be 1.66 x 10-5 µg/m3. Multiplying this by the unit risk gives a lifetime incremental cancer risk via inhalation exposure of 4.98 x 10-10. The cumulative lifetime incremental cancer risk via inhalation exposure to all non-threshold carcinogens (see Table 9.2 in the HHRA) was calculated to be 6.17 x 10-8 (0.0617 per million). Adding the risk of exposure to 1,3-butadiene does not change the calculated cumulative risk (rounded to three significant figures).

105 The predicted emission rates of contaminants to air primarily depend on the assumed rates of landfill gas (LFG) emissions. As detailed in Appendix E of the HRAR, it is assumed that the generators and flares shall combust 11,100m3/hr LFG with a 97% contaminant destruction capacity in accordance with US EPA AP-42 (2008). Further, fugitive discharges are assumed to arise only from the active tipping area (10,000m2) at a rate of 110m3/hr (double the calculated 55m3/hr). AP-42 suggests that the majority of LFG shall discharge through cracks in the landfill cover and a capture rate of 75% is reasonable as a default value. The air quality report and HRAR however assume a 95% capture efficiency. Surface emission monitoring undertaken at Redvale and Whitford regularly find areas of high methane above the intermediate and final cap, showing fugitive LFG discharges occur at these comparable facilities from more than the active working face. The assumed rate of LFG discharge greatly influences the HRAR's predictions of contaminant discharges and resulting potential health risks. Accordingly, please undertake a sensitivity analysis of the potential health effects arising from the contaminants within LFG accounting for the potential that LFG discharges may be greater than assumed by the HRAR.

We do not agree with several of the statements in this question.

First, the LFG collection efficiency has not been assumed to be 95%. The LFG collection efficiency in each stage of the landfill is assumed to vary as the cell is progressively filled and the ratio of landfill surface to waste volume increases (see table below, reproduced from Table 3.2 in the Air Discharge Assessment).

Year of waste placement in stage	LFG collection efficiency in stage
Year 1	0%
Year 2	50%
Year 3	60%
Year 4	75%
Year 5	80%
Post filling	90%
Post closure	95%

These values are considered to be appropriate and are consistent with the discussion in the US EPA AP42 document, as reproduced below:

> *"Reported collection efficiencies typically range from 50 to 95%, with a default efficiency of 75% recommended by EPA for inventory purposes. The lower collection efficiencies are experienced at landfills with a large number of open cells, no liners, shallow soil covers, poor collection system and cap maintenance programs and/or a large number of cells without gas collection. The higher collection efficiencies may be achieved at closed sites employing good liners, extensive geomembrane-clay composite caps in conjunction with well engineered gas collection systems, and aggressive operation and maintenance of the cap and collection system."*

Second, we do not agree with the assertion that surface emission monitoring at Redvale and Whitford suggest there are significant fugitive emissions through the intermediate and final cap at these landfills. These surveys are probably poorly named, as they do not actually measure methane mass or volumetric emissions. Rather, they measure the concentration of methane a few centimetres above the surface of the landfill cap using a sensitive Flame Ionisation Detector. "Elevated" concentrations of methane (typically of the order of tens to hundreds of ppm) are sometimes detected during surface cap and cover surveys. However, the localised presence of methane does not mean that there is any appreciable flow rate. Any areas identified in these surveys are inspected and any defects (for example small cracks that are most commonly of the order of a few centimetres) are repaired or additional thickness of cover material placed over the area. In our experience, and using odour as an indicator of LFG, the working face is a major source of LFG emissions to air at a well-run landfill under normal conditions.

The estimated volume of landfill gas that could be released, untreated, through the working face is 55.5 m3/hour (see Appendix F2 in the HHRA). In order to provide a conservative assessment, the HRA calculations have been based on an assumed emission of 110 m3/hour untreated LFG. Given this conservatism, we do not consider it is appropriate to evaluate the potential impacts of higher LFG emissions. If it were assumed that a portion of these emissions were released from the working face and the balance from other areas on the landfill (e.g. through defects in the cap) this would not make a material difference to the conclusions of the HHRA.

106 The HHRA considers that the key sources of contaminants from the proposed landfill facility are leachate (potential seepage of leachate through the landfill liner and underlying soils into groundwater and leachate breakout into the surface water) and landfill gas (airborne pollutants emitted from flares and generators, and fugitive emissions of landfill gas). Insufficient information has been provided on the reasons not to take into account stormwater runoff from the vicinity of the proposed landfill area as one of the sources of contaminants. This is based on the considerations set out below:

- **Section 4.5.1 of the HHRA considers dust emission from placement of waste will be negligible beyond the immediate working area when dust control measures are in place. However, there is no supporting evidence provided such as dust emission modelling or monitoring data. Without the additional information, dust emission beyond the open working face cannot be excluded;**

Dust from the working face at a landfill is typically negligible as most waste materials are wet. All commercial and industrial wastes are accepted subject to a manifest and specific waste acceptance procedures. Potentially dusty wastes are identified through this process and their receipt and placement is carefully managed for health and safety reasons. This can include a requirement for the waste generators to wet materials prior to delivery. Dusty wastes are received with prior notice and are mixed into the waste mass during tipping to minimise the generation of dust. At least one water cart will be active on a full time basis and available to further wet dusty materials, if required.

As discussed below, stormwater monitoring at Redvale and Whitford landfills contains typical stormwater contaminants, such as zinc and copper associated with motor vehicle movements and does not indicate elevated levels of other metals that might be associated with waste materials.

- **Section 4.5.1 of the HHRA states that lightly contaminated soils will be used as daily cover and considers that the potential for dust being blown beyond the landfill footprint in any appreciable quantity is negligible due to the low concentrations in the original soil, distance to receptors and tendency for forests to filter the air flow. Again, insufficient evidence has been submitted to support this statement. In addition, the report has not considered the possibility of the soil and bonded contaminants being washed away by surface water and being transferred to the stormwater ponds. The proposed acceptance criteria (recreational land use criteria) for lightly contaminated soils to be used as cover material is unlikely to be supported in consideration of the overall good water quality present in the catchment and the surrounding rural residential zoning.**
- **In respect of [sic], please provide and justify alternative acceptance criteria in this regard.**

Soils used for daily cover are proposed to meet recreational land use criteria. Daily cover is used to cover the waste at the end of each working day and will therefore only be stockpiled or used within the landfill footprint. Similar to the comments above in relation to dusty wastes, it is considered very unlikely that dust from daily cover would be conveyed beyond the landfill footprint and be entrained in stormwater. Also, soils used for daily cover will rarely not be moist and non-dusty and will not be subject to disturbance by truck traffic, which is the most common source of dust generation (apart from waste) on a landfill site.

Soil meeting recreational criteria is considered acceptable for use on playing fields where direct contact with soils is anticipated (including by children) and there would typically be no treatment for stormwater runoff-off. Although it is considered very unlikely that contaminated dust would be conveyed beyond the landfill footprint and be entrained in stormwater, it is noted that stormwater from the site will be:

- treated through a stormwater treatment system meeting best practice for an Industrial and Trade Activity (ITA) site;
- will be subject to ongoing monitoring; and
- will be required to meet site-specific trigger levels developed with reference to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

The use of lightly contaminated soils as cover material within the landfill footprint is considered appropriate and is common practice at many landfills in New Zealand. We consider that the use of recreational soil acceptance criteria is conservative but is generally appropriate.

- **Section 4.4.1 of the HHRA indicates that all surface water, except for surface water coming into contact with waste in the open working face and associated areas, including the tipping pad, is treated as leachate and will pass through the stormwater treatment system prior to release to the receiving environment. There is the potential for stormwater runoff being tainted by contaminated dust potentially deposited beyond the open working face and tipping pad, as well as the contaminated soil used as daily cover; and**
- **it was noted during a site visit to the Redvale Landfill facility that soil was removed from the landfill open working area for considerable distances. It is understood that recreational land use criteria are used as the acceptance criteria for daily soil cover in Redvale Landfill. It is reasonable to expect that the surface water runoff from the**

vicinity of the landfill area is likely to be contaminated. The extent of the contamination is unknown.

Section 9.3.1 of the Stormwater and Industrial and Trade Activity report (Technical Report P) describes the findings of a review of stormwater monitoring at Redvale and Whitford landfills. These landfills are broadly similar to the proposed ARL with respect to stormwater management practices and Redvale Landfill uses lightly contaminated soils as daily cover. The review included a detailed assessment of pH, COD, conductivity, ammonia and heavy metals including aluminium, zinc and copper, over a period of more than two decades. The only contaminant of concern which exceeded the relevant ANZECC guideline or trigger level was copper. In the case of Redvale landfill, copper results were elevated at both the upstream and downstream receiving environment monitoring sites indicating that the elevated concentrations were from alternative sources.

The stormwater monitoring at Redvale and Whitford landfills further supports that the potential for material being deposited at the working face (including daily cover) to be conveyed beyond the landfill footprint result in contamination of stormwater is low and is very unlikely to appreciably contribute to contaminant concentrations in stormwater.

- **In light of the above commentary, please justify with evidence why stormwater runoff should not be considered as one of the sources of contaminants. Otherwise, please include this source of contaminants in the risk assessment in consideration of the above comments. This should include the consideration of additional contaminant loads from stormwater runoff in addition to the potential leachate currently assessed (8.2 L/day as specified in section 7.2 of the report as well as section 7.4) and justification of any additional mitigation measures, future monitoring programmes and the criteria for stormwater discharge.**

Stormwater from the site is likely to contain typical urban stormwater contaminants, such as oils/greases and heavy metals like zinc and copper, mainly from the use of motor vehicles on site roadways. The site stormwater will be treated through a best practice treatment system for an ITA site. It is not usually considered necessary to evaluate the potential for health effects of stormwater discharges that have been treated to this standard.

The proposed stormwater monitoring programme is described in the Stormwater and Industrial and Trade Activity report (Technical Report P). Site-specific trigger levels will be developed in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (FMWQ Guidelines), taking into account existing background levels of contaminants (which are typically low). The trigger levels will be no greater than the 95% species protection Default Guideline Values (DGV) in the FMWQ Guidelines.

The DGV values are compared to the Maximum Acceptable Values (MAV) in drinking water in the following table. The only parameter where the DGV may not be protective of human health is arsenic. This has been identified previously at other landfills and taken into account in setting trigger levels. For example the stormwater trigger level (Trigger Level 1) at Redvale Landfill is set at the MAV value of 10 µg/L.

As explained above, zinc and copper are the metals most likely to be found at elevated concentrations in stormwater. The DGV for these metals are three orders of magnitude below the respective drinking water guidelines (and the site-specific stormwater trigger levels set for the ARL are likely to be lower than the DGV).

On the basis of this screening analysis, there would be no benefit in undertaking more detailed health risk assessment calculations for contaminants in stormwater.

Parameter	FMWQ Guidelines 95% DGV (µg/L)	NZ Drinking Water Guidelines MAV (µg/L)
Arsenic (III)	24	10
Arsenic (V)	13	
Cadmium	0.2	4
Chromium (III)	3.3	50
Chromium (VI)	1.0	
Copper	1.4	2,000
Lead	3.4	10
Nickel	11	80
Zinc	8	(3,000)*

*Zinc is an essential trace element. According to WHO, levels above 3,000 µg/L may not be acceptable to consumers for aesthetic reasons

107 Please clearly identify site specific activities relevant to human health effects, including identification of the extent and locations of food harvesting and recreational uses by both Māori and the wider community in the surrounding environment. This should be included on a map as well as a description of each of these activities. It appears that a cultural value assessment report may be available which may address some of the above matters. If so, please provide a copy of this report for review.

The requested information about Maori and community recreation has not come to light in extensive consultations or in a CVA provided initially to WMNZ. The HHRA has considered ingestion of river water, which would correspond to the potential recreational use of the river for bathing and boating. In relation to food harvesting, the HHRA has made worst case assumptions, for example that eels and watercress are continuously exposed to worst case concentrations of contaminants at the point of discharge into the unnamed stream. It is unlikely that recreational uses or food harvesting would be carried out at this location as it is within the WMNZ landholding. As exposures at other locations will be lower than the conservative scenario that has been assessed, we do not consider it is necessary to determine where these activities might occur in reality.

108 Section 4.6 of the HHRA provides a summary of the exposure pathway assessment. The pathway for exposure to residents has considered inhalation, as well as deposit onto roof and soil, and stock watering. Irrigation from bore water has also been considered as a pathway. However it is understood that there are current consents for surface water takes in the surrounding environment. Please provide additional information on surface water takes, and justification as to why surface water irrigation takes are not considered in the HHRA as an exposure pathway, noting the points raised in question 97.

As explained in response to question 97, the concentrations reported in the HHRA as being in the Hōteo River are actually the concentrations in groundwater at the point of release into the River – i.e. they do not take into account the very significant dilution that would occur in surface water within the River. Taking this dilution into account, the concentrations of contaminants in the Hōteo River (arising from the landfill) will be lower than the predicted concentrations in the groundwater bore.

The assessment has considered the health risks associated with the use of bore water for irrigation and potential for accumulation of contaminants in soils and uptake into homegrown produce. This assessment has concluded that there are no appreciable risks to human health. The equivalent human health risk calculations for water taken from the Hōteo River would give even lower values and are therefore not considered warranted.

109 Birds exist in large populations in some existing landfills. This is considered as a potential risk to health, as birds can take up pathogens from landfills and transfer them to waterways and reservoirs, potentially transmitting disease. Please confirm whether there are water supply sources or reservoirs within the vicinity of the proposed landfill. Please also justify whether microbiological contamination should be included as a contaminant of concern, and if so, provide an assessment of the potential health risk of microbiological contamination of streams associated with the proposed landfill operation and any proposed mitigation measures.

Birds, particularly seagulls, and other pests can be attracted to landfills where they see them as a potential food source. This was particularly a problem at older style landfills or “tips” where waste was left exposed. The primary controls to minimise pest numbers at a modern landfill are minimising the size of the working face, operating compaction machines continuously, and applying daily cover so that waste is not exposed and available as a food source. Other forms of targeted pest control, including control of birds within the landfill if required, will be undertaken at the ARL. This will minimise the potential for effects associated with birds, such as additional excrement loading and putrid waste morsels on roofs used for water collection, which then only tend to occur with larger birds like gulls which are targeted in ongoing control programmes. The potential for birds to impact on microbiological contaminant loads in nearby waterways is considered very low assuming that nuisance bird populations are kept small, and, unlike private roof collected water supplies, municipal supplies are subject to treatment and monitoring for microbiological contamination.

13.1 Updated HHRA summary tables

For completeness, we provide updated tables summarising the overall results of the HHRA reflecting the responses to the S92 questions. The key changes from the tables presented in the HHRA report are:

- Inclusion of 1,3-butadiene as a non-threshold compound that is present in landfill gas. Exposure only occurs via inhalation.
- Updated values for exposure to PFAS compounds, including PFHpA.

These changes do not alter the conclusions of the HHRA.

Updated Table 9.1: Summary of risk assessment findings for residential receptor

Receptor-pathway	Lifetime incremental cancer risk (genotoxic carcinogens)	Hazard index (threshold compounds)
Inhalation of airborne contaminants at residential receptor	6.22E-08 (0.0622 per million)	0.0101
Residential receptor with potable supply from roof collected water	7.63E-08 (0.0763 per million)	0.00259
Direct ingestion of soil	3.26E-11* (0.000036 per million)	1.47E-06
Ingestion of home grown produce from vegetable garden and eggs from chickens (PFAS only) at residential receptor subject to aerial deposition of contaminants and using farm bore irrigation	9.59E-08 (0.0959 per million)	0.00163
Cumulative risk/hazard	2.35E-07 (0.235 per million)	0.0143
Acceptable risk/hazard level	1.00E-05 (10 per million)	1.0

* Note: this value has been adjusted from the HHRA report as the incorrect body weight was used in the calculation

Updated Table 9.2: Genotoxic carcinogens – Residential receptor drinking roof collected water and using bore water to irrigate the vegetable garden

Contaminant	Incremental lifetime cancer risk				COPC cumulative risk
	Inhalation	Produce ingestion	Soil ingestion	Drinking water	
1,2-dibromoethane	3.42E-08	5.16E-08	3.02E-11	2.77E-08	1.14E-07
1,2-dichloroethane	1.32E-11	4.24E-14	2.97E-18	1.74E-13	1.34E-11
1,2-dichloropropane	2.07E-10	1.38E-12	4.23E-16	1.31E-09	1.52E-09
1,3-butadiene	4.98E-10	*	0.00E+00	*	4.98E-10
Acetaldehyde	4.21E-09	*	0.00E+00	*	4.21E-09
Acrylonitrile	7.12E-09	2.44E-08	8.20E-14	1.04E-08	4.19E-08
Arsenic	-	2.75E-11	2.08E-12	-	3.68E-11
Benzene	6.03E-09	3.02E-11	1.18E-14	2.82E-09	8.88E-09
Dichloromethane	7.86E-09	1.91E-08	1.61E-13	3.07E-09	3.01E-08
Trichloroethylene	4.42E-10	6.22E-12	3.51E-15	1.94E-10	6.43E-10
Vinyl chloride	1.61E-09	7.86E-10	2.64E-14	3.08E-08	3.32E-08
Total cumulative incremental lifetime cancer risk	6.22E-08 0.0622 per million	9.59E-08 0.0959 per million	3.26E-10 0.00000326 per million	7.63E-08 0.0763 per million	2.34E-07 0.234 per million
Acceptable risk level	1.00E-05 (10 per million)				

Table note:

Contaminants that have concentrations so low they are “indistinguishable from zero” based on RBCA modelling are not presented in this table.

As the values in this table are very small, they are expressed as exponentials for ease of reading. For example 3.24E-08 is the same as 3.24 x 10-8 or 0.0000000324

Table key:

- Indicates no exposure via this media (e.g. arsenic is present in leachate but not landfill gas and therefore there is no exposure via inhalation or roof collected drinking water)

* Acetaldehyde and 1,3-butadiene are carcinogenic via inhalation, however no slope factors have been published to allow an evaluation of exposure to them via ingestion. Both acetaldehyde and 1,3-butadiene have a high volatility and the main exposure pathway will be via inhalation

Updated Table 9.3: Threshold compounds – Residential receptor drinking roof collected water and using bore water to irrigate the vegetable garden (Table 9.3)

Contaminant	Hazard Quotient				COPC Hazard Index
	Inhalation	Produce ingestion	Soil ingestion	Drinking water	
Carbon tetrachloride	4.94E-04	2.22E-05	8.80E-09	4.69E-04	9.85E-04
Chlordane, total	-	1.95E-08	1.19E-09	-	2.07E-08
Chlorobenzene	7.55E-07	5.33E-07	3.91E-10	9.71E-05	9.84E-05
Chromium	-	1.17E-07	2.56E-08	-	1.42E-07
Dichloromethane	1.75E-05	1.43E-03	3.80E-08	2.28E-04	1.67E-03
Endrin	-	4.48E-07	1.33E-08	-	4.61E-07
Formaldehyde	3.17E-05	8.66E-05	7.89E-10	2.28E-05	1.41E-04
Hexachlorobutadiene	NA	3.72E-07	1.03E-06	1.14E-03	1.14E-03
Lead	-	7.05E-10	3.03E-10	-	1.01E-09
Methyl ethyl ketone	1.17E-06	3.35E-05	3.32E-09	1.13E-04	1.48E-04
Methyl isobutyl ketone	9.06E-07	NA	NA	NA	9.06E-07
PFOA/PFHpA	-	1.31E-07	1.95E-09	-	1.33E-07
PFOS/PFHxS	-	1.84E-07	2.31E-08	-	2.07E-07
Styrene	6.04E-03	1.77E-06	2.97E-07	1.16E-04	6.16E-03
1,1,2,2-tetrachloroethane	6.08E-06	5.96E-06	3.41E-09	2.63E-06	1.47E-05
Tetrachloroethylene	1.47E-05	2.34E-05	1.71E-09	5.70E-05	9.51E-05
Toluene	1.09E-04	4.03E-06	2.15E-09	2.22E-05	1.35E-04
Total reduced sulphur	3.26E-03	NA	NA	NA	3.26E-03
Trichloroethylene	X	8.47E-06	8.05E-09	1.41E-04	1.50E-04
Trichloromethane (chloroform)	9.30E-05	9.31E-06	4.93E-09	1.66E-04	2.69E-04
Xylene	1.73E-05	6.02E-06	2.53E-09	1.07E-05	3.40E-05
Hazard index	0.0101	0.0016	0.0000015	0.0026	0.0143
Hazard threshold	1.0				

Table note: Contaminants that are not present in this media, or have concentrations indistinguishable from zero, are not presented in this table.

As the values in this table are very small, they are expressed as exponentials for ease of reading. For example 4.94E-04 is the same as 4.94 x 10^{-4} or 0.000494.

Table key:

- Indicates no exposure via this media (e.g. lead is present in leachate but not landfill gas and therefore there is no exposure via inhalation or roof collected drinking water)

* No toxicity factor available:

There are no established toxicity values for exposure to total reduced sulphur compounds via ingestion, and they are expected to have a low oral toxicity.

The WHO has established an oral toxicity factors for hexachlorobutadiene, however no relevant published inhalation toxicity factors could be identified

The WHO has established inhalation toxicity factor for methyl isobutyl ketone, however no relevant published oral toxicity factors could be identified

X Trichloroethylene is assessed as a genotoxic carcinogen via inhalation

14 Draft Landfill Management Plan

A number of s92 questions requested a draft Landfill Management Plan. A draft Landfill Management Plan (LMP) for Auckland Regional Landfill has been prepared by Waste Management NZ Ltd to support the consent application. This includes key sections to support the consent application, including details on proposed site management to address potential effects such as odour. A full LMP will be produced once consent is granted, so that it can respond to conditions of consent and detailed design. A copy of the draft LMP is included in **Appendix T.**

15 Ecology

PLN1 It is noted that proposed enhancement of wetlands includes the placement of felled logs to improve biodiversity values (pg 92 of the EcIA). This would suggest that rule (E3.4.1) A5 (Depositing any substance for the purposes of habitat enhancement or scientific research – Restricted Discretionary) is an appropriate trigger for consent. It is further noted that proposed condition 195, which describes the requirements of the Stream Compensation Works Plan also references in-stream habitat enhancement.

Read in the context of Table E3.4.1, we consider that 'substance' is intended to relate to materials such as sand, gravels, rocks, weed mat, geotextile and other inert materials, and not tree logs. Such an interpretation is consistent with the rule relating to the deposition of substances for habitat enhancement or research, and in particular for the provision of fish passage through culverts (trees and other vegetation would not be appropriate materials with which to provide fish passage through a culvert). "Trees", whether in place or felled, is considered to be "vegetation" under the Unitary Plan (see for example, the definition of "Managed Fill" and the reference to "biodegradable materials (e.g. vegetation)". Nonetheless, for the avoidance of doubt we confirm that the applicant seeks consent under this rule for the deposition of trees for habitat enhancement.

PLN2 It is noted that the stormwater discharge from the bin exchange area is proposed to be discharged to the stream via a riprap outlet (pg 12 of the SW and ITA report). The design drawings also indicate an outlet from the polishing wetland discharging to the stream (drawing: ENG-43). The details of these outlet structures do not provide confidence that the permitted activity standards are met (E3.6.1.14) including erosion or scour management works not exceeding 5 m in length. It is also not clear if the outfall structures will be within or outside the bed of the stream. Therefore, it is possible that rule (E3.4.1) A44 (Any activities not complying with the general permitted activity standards in E3.6.1.1 or the specific activity standards in E3.6.1.14 to E3.6.1.23 - Discretionary) may be an appropriate trigger for consent.

WMNZ proposes to meet the permitted activity standards for discharge outlets and will address those requirements at detailed design stage rather than at this concept design stage. As such, consent is not sought under this rule, and if need be consent conditions can specifically require that these discharge outlets are either constructed in accordance with those permitted activity standards or a resource consent be sought. If following any grant of consent, detailed design identifies an area where the permitted activity standards cannot be met, consent would be sought separately in accordance with any such condition, however, the need to do so is not anticipated at this time.

1 Page 49 of the EcIA states that "all enhancement works proposed are additional to any other enhancement that may be otherwise required. There are no covenants or consent conditions that require any of these activities to be undertaken, with the exception of the Overseas Investment Office (OIO) conditions, which specify enhancement activities be undertaken as determined through the Resource Consenting process". However, table 4.22 of the EcIA states that the Hōteo River margins are required to be planted and protected in the OIO conditions, which would appear to contradict the statement above that all enhancement works proposed are additional to any other enhancement that may be otherwise required. Appendix 8 of the AUP:OP sets out a framework for offsets including the principle that offsets are demonstrably additional to what otherwise would occur. Therefore, please provide evidence that the aspects of the proposal that are presented as offsets are additional to any actions that are required to occur under any existing agreements.

A letter from Sentinel Planning on behalf of Auckland Council, dated 18 October 2019, has confirmed that any requirement to plant the Hoteo River margins are not solely requirement of the OIO approval, rather the requirement is to offer to undertake this work as part of any resource consent process, and accordingly no issues of additionality apply.

2 In reviewing the AEE including section 10 (Assessment of alternatives) and the Site Selection Process report (Appendix D) it appears that consideration of ecological constraints in selecting the site location was limited to the use of existing Auckland Unitary Plan overlays such as SEAs, NSMAs and WMAs. It is noted that the Technical Guidelines for Disposal to Land[15] state that initial investigations should include an assessment of the sensitivity of biota and fauna at the site and downstream. Additionally, noting that careful siting of a landfill is fundamental to protect the environment from potential adverse effects associated with the disposal of waste materials.

A. Please clarify whether specific on-site ecological surveys were undertaken prior to selecting this site (the property and valley 1), over any of the discounted sites.

B. Please provide details of all on-site surveys used to discount locations; particularly investigations that may have identified the presence of threatened or at risk native fauna, as well as, the high freshwater ecological values within valley 1 (as reflected by the high SEV scores).

As set out in Appendix D of the AEE, the proposed site for the Auckland Regional Landfill was identified as the result of an extensive site selection process, undertaken over the course of a decade. This process took into account a range of considerations, including underlying geology, site access, cultural values and ecological values, assessed to the extent possible without undue intrusion and alarm for multiple landowners as explained below. Sites with listed ecological values (identified by the AUP) within a potential landfill footprint were avoided, consistent with the criteria listed in the Technical Guidelines for Disposal to Land.

The Technical Guidelines recognise that a balanced approach to site selection is required, as no one site is likely to score highly on all criteria. As described in the AEE, the Wayby Valley site was identified as the preferred site for the landfill development following an extensive site selection process as it scored highly in the assessment due to a number of factors, including the ability to avoid sites of identified cultural significance, SEAs and other identified features in the AUP (or PAUP as it was then).

It was not feasible to enter onto and undertake physical investigations of multiple sites, due to the highly sensitive nature of identifying potential landfill sites, and restrictions i.e. landowner resistance to accessing privately owned properties. This application does not identify the other sites considered. This is due to commercial sensitivity and the potential impact on current landowners of the many other sites considered, as the vast majority of landowners would be unaware that their land was considered. If this information was made public it would cause significant uncertainty for them and unnecessarily breach the peaceful enjoyment of their land.

Once the Wayby Valley site had been identified as a preferred site, and permission for access obtained, on-site surveys were commenced, in line with the suite of investigations recommended by the guidelines. This included ecological investigations, which informed the project layout as described in Section 10.5 of the AEE. Ecologists have been involved in discussions around project design and layout since the site selection was confirmed. Changes were made to the design and layout in response to particular ecology concerns. In relation to the landfill footprint specifically, the stream values within Valley 1 are considered to be representative of stream values in the surrounding forestry catchments.

[15] WasteMINZ, Technical Guidelines for Disposal to Land, August 2018.

As described, this layout and conceptual engineering design details were refined in order to further avoid areas with particular ecological or other values.

3 Given the scale of the project and complexity surrounding the management, avoidance, salvage and relocation of native fauna, Council is of the opinion that leaving the management plans to a condition of consent is inadequate to assess the full implications of the project, therefore:

Please provide a suite of management plans, appropriate to the individual species, that details the specific management actions necessary to understand how the proposal will avoid, remedy and/or mitigate the actual and potential adverse effects on native biodiversity, including but not limited to

- **Adverse effects generated by noise, odour or dust (especially during nesting seasons)**
- **Disturbance from tree felling, in relation to both bats and birds.**
- **Translocation / relocation of native fauna to appropriately identified habitat**
- **Salvage and relocation of threatened / At-Risk flora.**

A draft Ecological Management Plan (EMP) has been prepared and is appended to this response as Appendix U. The EMP includes the following sections:

- Vegetation Clearance Management Plan (VCMP)
- Bat Management Plan (BMP)
- Avifauna (Bird) Management Plan (AMP)
- Lizard Management Plan (LiMP);
- Invertebrates (peripatus, snails) (IMP).
- Residual Effects Management Plan (REMP).

The preliminary management plans have been prepared to provide high level direction as to how species appropriate protocols will be implemented to address actual and potential effects resulting from the project.

Further detail coming out of the consultation, notification and hearing process will be incorporated into the plans as appropriate.

An additional plan is proposed - the Hochstetter's Frog Management Plan (HFMP). In addition, further detail will be added to the REMP. These documents are still in progress as we are consulting with the Department of Conservation and the Frog Recovery Group to ensure that concerns raised are addressed in the HFMP and REMP. We are proposing additional frog survey in early 2020 (pending permits from DOC) which will also feed into the HFMP.

4 Provide a suite of appropriate species required to fully restore each of the degraded habitats. The detail shall be consistent with the Indigenous and Terrestrial Ecosystems of Auckland (as published by Auckland Council), and be consistent with Appendix 16 of AUP:OP.

This information has been provided within the Draft REMP submitted in relation to Q3.

5 Table 6.1 of The EcIA describes approximately 0.6 ha of kahikatea pukatea forest will be affected by the project. Please clarify if this area is considered wetland as per the RMA definition.

We have classified the kahikatea pukatea forest as WF8 forest type in accordance with the technical publication by Singers et al (2017) entitled 'Indigenous Terrestrial and Wetland Ecosystems of Auckland. As per table 1 in question 6, the extent of WF8 vegetation being impacted is 0.46 ha.

The RMA defines a wetland as 'permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions'. As detailed in Singers *et al.* (2017) the WF8 forest type is dependent on a high water table and wet soils. Many of the plants typical of these forest types (WF8) are adapted to wet conditions, such as swamp maire and kahikatea, which are abundant in these forest types on site.

Correspondingly, field surveys indicate:

- That wet soils are present within WF8 forests in the WMNZ landholdings; and
- Plants adapted to wet environments are present (kahikatea among others).

Consequently, we agree that this habitat could meet the definition of wetland under the RMA, however the ecological values within this habitat type and the corresponding management of effects are terrestrial in nature (e.g. the vegetation is forest and includes terrestrial birds, lizards and invertebrates).

6 The AEE (pg 33) and tables 6.8 and 6.11 of the EcIA state that approximately 0.85 ha of native wetland is directly affected by the project footprint. However, table 6.1 of the EcIA notes 0.1 ha of manuka tangle fern scrub/fernland and 0.03 ha of raupo reedland is directly affected by the project foot print. Even with the 0.6 ha of kahikatea pukatea forest noted above this does not equate to 0.85 ha. Please clarify how the 0.85 ha of native wetland directly affected by the project footprint has been calculated.

We note that there were some inconsistencies in the tables in the report (Table 6.1 and Table 6.15) and provide a correct summary of all terrestrial and wetland ecosystem impacts in Table 1, 2 and 3 below. The minor differences between tables 2 and 3 are rounding errors, and Table 2 provides the areas consent is sought for.

Table 15.1: Summary of tables within the Ecology Report and highlighted areas of inconsistency for native or wetland ecosystem types. Other minor inconsistencies (0.01 dp) are rounding errors.

Ecosystem impacted	Table 6.1	Table 6.8	Table 6.9	Table 6.10	Table 6.11	Table 6.12	Table 6.15
Indigenous wetland	0.13	0.85	0.85	0.85	0.8491	0.85	0.13
Mature native forest	0.9	0.86	0.87	0.87	0.86	0.86	0.86
Regen native forest	4.6	4.62	4.62	4.62	4.62	4.62	4.62
Exotic wetland	0.47	0.478	0.48	0.48	0.47	0.48	1.07

Table 15.2: Updated table of effects based on our broad categorisation

Habitat/vegetation type	Area within WMNZ landholdings (ha)	Area impacted (ha)
Indigenous mature forest (non-SEA)	16.8	0.87
Indigenous regenerating forest	44.01	4.62
Exotic wattle forest	49.42	9.11
Exotic pine forest	679.4	86.88
Indigenous wetland (non-SEA)	2.28	0.85
Exotic wetland	6.1	0.48

Table 15.3: Updated tables of effects for native and wetland vegetation, according to Singers classifications.

	T+T category	Ha	AC Singers et al category	Ha	Differences
Forest types	Mature Native	0.86	WF12	0.16	
			WF8	0.46	
			WF9	0.04	
	Total			0.67	According to Singers et al classification, reduction of mature native by 0.19 Ha.
	Regenerating Native	4.61	VS2	4.80	
			VS5	0.03	
	Total			4.83	According to Singers et al classification, increase of 0.21 Ha native regeneration.
	Grand total	**5.47**		**5.49**	**Only rounding difference**
Wetland types	Indigenous wetland	0.85	WL12	0.58	
			WL19	0.12	
	Total			0.70	According to Singers et al classification, reduction of indigenous wetland by 0.15 Ha.
	Exotic wetland	0.47	EW	0.64	
	Total			0.64	According to Singers et al classification, increase of 0.17 Ha exotic wetland.
	Grand total	**1.32**		**1.34**	**Only rounding difference**

As can be seen from Table 3, the total area of native wetland being impacted is 0.7ha according to Singers classifications and is comprised of WF19 (raupo reedland) and WF12 (manuka fernland) vegetation types. We trust this clarifies the question.

7 **The EcIA states a coarse level biodiversity offset model will be developed in accordance with national guidance to quantify the enhancement measures proposed across all terrestrial and wetland ecological values that are potentially affected by the project. This information will be provided as supplementary reports (pg 100). Such a supplementary report is not evident as part of the application. Please provide this supplementary report.**

A biodiversity offset and compensation model will be provided as a supplementary report later in the consenting process, following further consultation with key stakeholders and once proposed offset and compensation sites have been confirmed and adequately assessed. The Biodiversity Offset

Accounting Model (BOAM) (Maseyk et al. 2016) will be applied to determine offsetting requirements for native vegetation. The Biodiversity Compensation Model (Baber, Maseyk et al (in prep)), a modified version of the BOAM, will be used to determine the compensation requirements for the loss of fauna values at impact sites.

8 It is noted that the general site roading described on page 32 of the Engineering Report crosses areas of wetland in the vicinity of the proposed clay borrow pit and stockpile 1. Please clarify:

a. how these wetland areas will be crossed.

b. if the area of these wetlands impacted by the crossings has been accounted for in the calculation of the area of wetland reclamation being proposed.

Note: the definition of a culvert in the AUP:OP does not include provision for crossing of wetlands. Therefore, pipe and embankment structures for access across wetlands are interpreted to not meet the definition of a culvert.

The project works in this area include permanent works (being culverts in this instance) and associated temporary construction works. It is proposed to prepare the bedding, place the culvert pipes and then fill the road above. The extent of project works proposed is drawn on the ecology plans as a bold red line, with cross-hatching. The area within the red hatching that overlaid an ecological feature or vegetation type (for example, wetland) was calculated using ArcGIS. As such, the total wetland area being impacted by the works is considered to be accurate for all works required.

While the proposed works do include culverts which will provide some retained ecological function (rather than complete loss of all functions as would occur with reclamation), we have conservatively assumed complete loss when determining magnitude of effects.

9 It is proposed to locate the Bin Exchange Area on a wetland system. Please provide clarity as to why this location was preferred over other locations, such as an open area of pasture?

The overall concepts for the landfill were considered at an early stage, with progressive refinement as the site was inspected, with decisions made as to which part of the site would be developed for the landfill footprint, where the access should be, and other key decisions considering a broad range of engineering and potential environmental effects criteria. The reasoning behind these decisions is described generally in the Engineering Report and Site Selection process described in the AEE. It was decided that the main access to the landfill should be through the Southern Block and that the landfill would be in Valley 1.

The primary purpose of the Bin Exchange Area is for road vehicles to drop off full bins and pick up empty bins and leave the site as quickly as possible. Site haulage vehicles then pick up the full bins and take them to the tip face before returning them empty to the bin exchange area. Some of the key considerations for locating a Bin Exchange Area are thus:

- It needs to be conveniently located near the site entrance/public road to make it easily accessible by road vehicles, and ideally accessed immediately from a State highway which avoids landfill traffic needing to travel along local roads.
- It needs to be between the site entrance and the landfill disposal area – thereby not increasing the overall haul distance and minimising fuel/energy consumption.

- It should be located in a manner that does not increase the vertical climb for vehicles – thereby not increasing fuel/energy consumption.
- It requires a large flat area for the storage and manoeuvring of bins.

The selected area near the site entrance was the only suitable area available that met all of these criteria. All other parts of the site between the entrance and the landfill are on relatively steep terrain and all other locations on the landholdings considered for the bin exchange purpose would disproportionately increase effects in relation to other environmental aspects such as noise, visibility, vegetation clearance, fuel efficiency, traffic flow and neighbourhood disruption.

The bin exchange area is predominantly in an area of cut (the hillside to the east of the area), wattle forest and pasture. A small part of the bin exchange area covers areas of wetland. The areas affected comprise 3,300 m2 of "exotic wetland" as identified in the Ecological Report (Technical Report G) and 1,570 m2 of indigenous wetland (none of which is SEA-listed wetlands). The indigenous wetland affected comprises approximately 14% of the indigenous wetland at the location of the Bin Exchange Area. The extent of wetland affected is shown on the drawing ENG-30W appended (Appendix W). The effects on this wetland have been reduced as far as is practicable through the design of the access road/bridge, and the design of the bin exchange area. The wetlands located at the Bin Exchange Area are of lower quality compared to others across the WMNZ landholdings. Notwithstanding, wetlands are a threatened ecosystem and we propose measures to address the effects associated with the Bin Exchange Area placement.

10 Table 4.22 of the EcIA refers to the degraded streams to the west of the clay borrow area (2c) as part of the compensation package (950 m). However, these are not highlighted for proposed planting on figure 13, nor referenced in the body of the report text. Please clarify these streams are part of the proposed compensation package and nature of the planting and enhancement including proposed width of riparian planting.

Note: The streams to the west of the clay borrow area clearly represent an opportunity to offset a portion of the significant residual adverse effect resulting from the proposed activity that can be realised. Figure 13 (of the EcIA) as depicted, not showing enhancement planting on these streams, appears to contradict the statement that "the offset and compensation package identified in Table 4.22 below summarises all currently available opportunities for enhancement within the WMNZ landholdings" (pg 48 of EcIA).

We confirm that the areas shown on the Figures 13, 14 and 15 of the AEcE provided are the proposed enhancement sites and anything not marked within these figures is not included.

All opportunities available for enhancement were identified in discussions with WMNZ. The ETS offset planting area and potential future requirements for clay liner have meant that some areas of the WMNZ landholdings were not available for consideration for ecological offsetting. The enhancement package proposed is what is considered to be possible at this stage of the project. Therefore, all available opportunities have been identified and incorporated into the offset and compensation package.

11 Page 99 of the EcIA refers to enhancement and/or protection of 14 km of stream within the WMNZ landholdings. Please confirm the protection in perpetuity of all proposed offset and compensation enhancement areas within the WMNZ landholdings, including areas 2a, 2b,3c, 2d, and 2e.

WMNZ confirms that they will commit to protection in perpetuity for all enhancement and protection areas within its landholdings, through a covenant or similar measure, subject only to the need for maintenance of and potentially access across some of those areas.

12 Table 4.22 of the EcIA refers to the retirement and protection of the 10 m margins of waterways within the Matariki Forestry areas (of permanent streams, greater than 3 m wide) (2g). Please clarify

a **if the 10 m margins are on each bank or in total**

b **if weed control and enhancement planting is also proposed for these retired margins**

c **if the area of 2g mapped in figure 13 of the EcIA is greater than 3 m in width and therefore coincides with the text in table 4.22.**

d **if there is likely to be further stream within the Matariki Forestry areas greater than 3 m in width that is not mapped, and if these potential additional riparian margins will also be retired and protected.**

Responses to each of the components of the question are itemised below:

a The retirement and protection of 10 m margins is proposed to be on both banks, measured from the edge of the bank.

b We understand that weed control and enhancement planting is not proposed. The existing native understory vegetation albeit disturbed by harvest will likely regenerate relatively quickly after harvest

c We have not surveyed all stream length within the Matariki area, however based on our observations in the upper reaches, we are confident that the stream length shown in 2g has a bankfull channel width of no less than 3 m. Figure 1 below was taken at the confluence of Valley 1 and Valley 2 streams and is wider than 3 m. Downstream near the MC 3 site the stream is a similar width. We expect that the stream widens as more contributing catchments enter the stream.

d Based on our observations downstream of Valley 1 it is possible that other sub-catchments within the Matariki Forestry areas might have streams wider than 3 m. At this stage, those areas are not identified for retirement and protection, only the length identified as 2g (and 2h) on Figure 13.

Figure 15.1: Photos taken within Eastern Valley main stem downstream of Valley 1 (left) and fieldworker moving into Valley 1 tributary at confluence with Valley 2 and main stem in foreground of the photo (right). Both photos taken during March 2018 and are representative of lower flows.

13 The retirement and protection of the 10 m margins of waterways within the Matariki Forestry areas (of permanent streams, greater than 3 m wide) (2g), noted above, is proposed as a quantified offset measure. Please comment on the key principle of additionality as outlined in appendix 8 of the AUP:OP in respect to this proposed retirement action, specifically with reference to the permitted activity conditions for replanting setbacks in the NES-Plantation Forestry (section 78).

The NES-Plantation Forestry provides for certain setbacks as permitted activities, however there remains a viable consenting pathway for any forestry companies who might choose, for example, to seek resource consent to replant within these setback areas. In other words, planting within close proximity to streams – and within the permitted activity standard setbacks – is not a prohibited activity.

The requirement to provide setbacks for new afforestation is set out in regulation 14(3) of the NES, and failure to meet any of these permitted activity standards is only a restricted discretionary activity, with discretion restricted to the effects on ecosystems, fresh water, and the coastal environment: (b) the effects on the values of the significant natural area: (c) the information and monitoring requirements.

Likewise, the restrictions on replanting include permitted activity standards in regulation 78(2), with any breach of regulation 78(2) being a restricted discretionary activity, with the matters of discretion restricted to similar matters as set out above.

Provided that the matters of discretion are appropriately addressed in any application, it is entirely possible that at some point in the future a forester could successfully obtain resource consent to afforest or undertake replanting in close proximity to the waterways within the Matariki Forest.

On that basis therefore there is no additionality aspect in play, because the offer by WMNZ to provide permanent retirement and protection to these areas is a measurable and material benefit that would not otherwise be required by any other district or regional plan, other planning instrument, or covenant.

14 Table 4.22 of the EcIA refers to protection of the western margin of the Waiwhiu Stream within WMNZ land (~3 km) (2h). Please clarify

a **the width of the proposed riparian margin protection**

b **if weed control and enhancement planting is also proposed**

Where the Waiwhiu Stream is wider than 3 m, the width of riparian protection will be 10 m from the top of bank. Where the Waiwhiu is less than 3 m, the width or protection will be no less than 5 m. These margins are consistent with the NESPF.

Weed control and enhancement planting is not proposed for these margins, except weed control will be undertaken in the event that walking and cycling tracks are formed through this margin.

15 Please clarify the proposed width of riparian enhancement (on each bank) proposed for area 2e (as shown on figure 13 of the EcIA). Also, please clarify the location and offset of area 2e from the top of the stream bank.

A minimum 10 m riparian enhancement and protection of the both banks along the Waiteraire Stream, except where the stream is within 10 m from the title boundary or bridge abutments. Where the stream is within 10 m from a proposed access for enabling works construction, enhancement works would occur after the enabling works construction is complete. The 10 m is measured from the top of the bank.

16 The EcIA states that the package offered to address residual adverse effects of stream loss provides for a close to 1:1 length offset and compensation and that WMNZ has

committed to undertake similar activities over an additional c. 30 km of stream over the life of the project (pg 49). Given the clarifications sought above in respect to the offset and compensation offered and the diversity of actions proposed (retirement / setback, enhancement planting and protection), it is not clear what these similar activities over the additional c. 30 km of stream entail. Please clarify the minimum standards of this proposed compensation action in order to enable an informed assessment of the level of benefit provided, including minimum riparian widths (on each bank), as well as, minimum plant sizes and planting densities for proposed enhancement planting.

An OSSCP has been prepared which outlines the approach proposed to ensure that the offsite compensation actions provide ecological benefit commensurate with the effects. Refer to the OSSCP attached at Appendix V for full detail. See below a summary of the proposed compensation approach.

On the basis that a total 15.4 km of stream is being impacted, a total of 46.2 km of stream must be enhanced to meet the proposed overall 1:3 ratio. Taking into account the 14 km of stream being enhanced within the WMNZ landholdings, a further 32.2 km of stream enhancement is required to be undertaken outside of WMNZ landholdings to meet the overall required 46.2 km.

The OSSCP provides the approach for delivering this 32.2 km of offsite compensation. The proposed compensatory measures will specifically target aquatic habitat enhancement with an aim to enhance degraded rural stream that would benefit from fencing, planting and protection. Sites will be preferentially selected within the Hōteo catchment.

As the compensation sites are as yet unknown, we cannot predict the existing or potential enhancement values or what landowners may allow within their land. As such we have prepared an Ecological Gains Matrix (EGM) which identifies several enhancement options with associated multipliers to account for the varying level of ecological benefit for each.

The EGM provides a selection of base enhancement options (BEO) with associated multipliers. The multiplier recognises the quantum of ecological benefit gained from that specific BEO in relation to the stream length lost. For example, riparian planting of 10 m margins (with appropriate species and protection measures etc) has a multiplier of 1. That is for 1 km of planting of this BEO type, 1 km of the required 32.2 km requirement is met. If the margins were less than 10 m, the multiplier reduces to 0.95, so that for every 1km of enhancement, only 0.95 km of the required 32.2 km is met.

Additional 'enhancement activities' are actions that promote greater ecological outcomes on top of each BEO. Each additional enhancement activity has an associated value that is added to each BEO multiplier as appropriate.

Refer to the OSSCP for further information regarding the proposed compensation measures.

17 Page 128 of AEE states: The up-valley stream crossing was moved approximately 45 m to the east with the effect of reducing the length of the culvert under the fill from about 120 m to 60 m, and reducing the encroachment into the NSMA to an area of no more than approximately 80 m². Table 8.2 of the AEE also notes the culvert will encroach into the NSMA by approximately 10 m [Linier]. However, the EcIA states that the culvert will be 105 m in length (pg 39), this is supported by the Engineering Report which states the culvert will be 104 m in length (pg 29). Please clarify the length of the culvert and encroachment of the NSMA in linier m and m2.

For the original concept design the stream crossing was located at the most logical point from an engineering perspective, to cross the stream where its width was narrowest, at the location of a convenient spur on the northern side of the valley. However, in looking at long sections along the stream at this location, this section of stream was very steep such that the fill embankment followed the slope of the stream for a considerable distance, making the fill embankment wider than it may have needed to be. The section showed that the stream was much flatter immediately upstream of the initial selected location, requiring a much smaller embankment width and, hence, a much shorter culvert. However, subsequent changes to the road horizontal and vertical alignment necessary for the overall design resulted in the length of the culvert being increased compared with this initial shortening of length.

The current design and details of the encroachment into the NSMA are further described in the response to the question below (ECOL 18). That describes an encroachment into the NSMA for the design presented with the application of 186 m2 of encroachment into the NSMA overlay, including an area of stream of 20-40m² and approximately 20 m length. The culvert length for this option is 104 m (approximated to 105 m). However, we note that this is based on the existing LiDAR survey, which may not be accurate in this area. Through detailed design we will obtain a more accurate survey of the area and optimise the location of the embankment and culvert. The current embankment slope is set at 1V:2.5H. During detailed design consideration could be given to further reducing the encroachment and the culvert length by using a toe retaining wall or steeper reinforced earth slopes. The option of a higher level culvert in a direct line is also described in answer to the question below.

18 **It is noted that the placement of the culvert encroaches into the NSMA, and the stream in the Southern Block is reported as having high freshwater and terrestrial ecological values in the vicinity of the proposed culvert (Including the scores for SEV1 and SEV2 which are 0.77 and 0.79 respectively despite being limited by poor IBI scores as a result of the existing barrier). Please provide an assessment of alternatives, such as a bridge, which could be utilised as a more appropriate method of crossing at this point to reduce, and avoid, the adverse effects on the freshwater environment.**

A number of options were considered for the construction of the access road to the landfill, and these are described in the Engineering Report. From the assessment of the options a route along the southern bank of the stream was selected as fitting best with the topography and having a smaller effect on any native vegetation. Constructing the road on the southern bank requires a crossing of the stream to gain access to the landfill site. A number of locations for the crossing were considered and the current location selected, as described in the Engineering report. Two options have been considered for the crossing: an embankment with a culvert, and a bridge. These are described in further detail below:

<u>Option 1: Embankment</u>

The crossing location was selected originally because of the presence of an existing spur on the northern side of the stream on which the access road could be constructed and which would reduce the length of the embankment. The initial design of the embankment in this area impinged heavily onto the NSMA. Due to the relatively steep slope of the stream channel at this location (>10 %), the width of the base of the embankment was quite large. In order to minimise the impact on the NSMA and to minimise the length of the culvert under the embankment, the embankment was moved upstream. This moved the embankment away from the spur, requiring a greater fill volume overall and increasing the area of vegetation affected but reducing the width of the embankment at stream level.

The stream at the location of the embankment is not in a straight line so the culvert will be installed either with a bend part way through or placed on a shorter route on the north side of the stream channel and include a formed cascade at the discharge side at similar gradient to the existing stream channel. This alternative would comprise a culvert about 70 m long with a cascading fall from approximately 97 mRL at the outlet to 91 mRL at the stream. The original culvert is shown on drawing ENG-CULVERT appended (Appendix W). The alternative culvert is shown on Drawing ENG-CULVERT2 appended.

The embankment option is shown on drawings ENG-30. An enlargement of this is shown on the sketch ENG-CULVERT2 included in Appendix W.

Key details of the embankment/culvert option are:

- Area covered by fill: 8,600 m^2
- Volume of fill: 46,700 m^3
- Encroachment into NSMA: 186 m^2 which may be able to be reduced by adopting a steeper fill slope or by providing alternative (steeper) toe support.
- Culvert length: 104 m or approx. 70 m (alternative)
- Culvert diameter: 1200 mm
- Culvert grade: 9.5% (or 1 to 2% for alternative)
- Length of road over embankment: 180 m
- Estimated rough order construction cost*:$2.5 M

* The construction cost excludes the cost of road construction which is common to all options.

There is an existing 300 mm diameter culvert and retaining wall forming a crossing over the stream at this location. This is shown in Figure 1 below and forms a barrier to fish passage. The stream in this location is expected to be intermittent in nature and is likely to flow during winter months.

Figure 15.2: Existing stream crossing at proposed embankment location

<u>Option 2A: Bridge – Two-span</u>

The alternative of a bridge at this location was also considered. Two options for a bridge were developed. These are shown on drawings ENG-61, ENG-63 and ENG-64 included in Appendix W and are described below.

The option for a bridge was based on the original road alignment to achieve the shortest possible span with the road located on the spur on the northern side of the stream. With this alignment a 2 span bridge is possible with some fill and retaining walls at each abutment, but these works are more extensive on the southern abutment. The bridge would have 2 x 30 m spans. A single pier is required which is just off the stream alignment. The approach roads for this option are within the original design parameters.

The bridge for this option will impact on the NSMA as follows:

- The northern approach road/abutment encroaches on the NSMA by approximately 220 m^2
- The southern approach road/abutment encroaches on the NSMA by approximately 50 m^2
- A pier needs to be constructed near the stream. This will require the construction of platform for the drill rig to stand on while drilling and an access road to get to this platform. As the valley is relatively steep this may require relatively extensive earthworks and associated loss of vegetation within the NSMA.

The advantage is that there would be no permanent structures within the stream, and this option can be constructed to meet all other design requirements.

A cost estimate has been prepared for this option on the basis that the bridge will have an importance level of 3+ in accordance with AS/NZS 1170 as it will provide the sole access to the facility. The estimated rough order cost is $6.2M, or $3.7M **more than** the embankment option (Option 1).

<u>Option 2B: Bridge – Single-span</u>

To overcome the potential effects associated with constructing a pier adjacent to the stream a single span bridge was considered. In order to reduce the length of the bridge sufficiently to achieve a single span the level of the bridge was lowered by approximately 5.5 m. The bridge would have a single 35 m span. As the level of the road where it crosses into the landfill valley is fixed this increases the grade on the road between the bridge and the landfill to 10 %. This is steeper than the design maximum road grade of 8 % specified by WMNZ. It is too steep for full refuse vehicles to travel efficiently up hill (as will be the case) and introduces a higher safety risk for empty vehicles travelling downhill.

The bridge for this option will impact on the NSMA as follows:

- The northern approach road/abutment encroaches on the NSMA by approximately 660 m^2
- The southern approach road/abutment encroaches on the NSMA by approximately 250 m^2
- There will be no works down at stream level.

The estimated rough order cost for the bridge for this option is $5.7 M, , or $3.2M **more than** the embankment option (Option 1) including costs associated with the extra excavation required for lowering the bridge level.

<u>Conclusion</u>

The steep section of road required for the single span bridge (Option 2A) is not acceptable to WMNZ for long term operation of the landfill, on the basis of safety and operational efficiency. This option is thus ruled out of further consideration. Both the embankment (Option 1) and two-span bridge option (Option 2B) have effects on the stream environment, with the bridge option impacting on a greater area within the NSMA. Because of this, and the significant cost savings associated with an embankment option, it is proposed to proceed with the embankment option at this time.

19 The preparation and implementation of a Native Freshwater Fish and Fauna Management Plan (NFFFMP) is offered by the applicant as a condition of consent

(proposed conditions 56 and 57). It is also noted that the EcIA considers this action to mitigate the magnitude of potential injury and mortality on native fish from 'high' to 'low' (table 4.15 of the EcIA) and the AEE considers the direct effects on freshwater fauna following the implementation of the NFFFMP to be minor. It is also noted that the implementation of the Native Freshwater Fish and Fauna Management Plan is to occur prior to any forestry works to avoid a reduced ability to access the streams. Given the scale of reclamation proposed and the existing difficulty in accessing the streams (as evident though site visits and the approach taken to classifying the streams by the applicant – where modelling was used due to limited access) please comment on both the feasibility and level of effort required to achieve a magnitude of impact of 'low' following the implementation of the Native Freshwater Fish and Fauna Management Plan.

Note: the proposed condition 56 (Native Freshwater Fish and Fauna Management Plan) refers to the New Zealand Freshwater Fish Sampling Protocols for methodologies for the capture and transportation of fish. It is noted that the protocols are developed for sampling reach scale diversity and relative abundance and do not consider transport or release of native fish

A draft NFFFMP has been prepared (and attached at Appendix X) which outlines at a high level our proposed approach. This involves a combination of fish salvage techniques which will be employed across the landholdings as suited to the particular area. We provide a summary of the potential magnitude of effects on fish for each of the proposed impact areas as shown in Table 4.20 of the AEcE and in respect of the wetland areas which will also be fished.

Overarching principles for all areas include:

- Based on fishing undertaken to date, distance from the Kaipara Harbour, the presence of existing barriers (natural and artificial) and the elevation (particularly in the headwaters), we consider that the fish populations in the headwater catchments are likely to be small.
- Target species in the headwater reaches are long fin eel, koura and banded kokopu. A non-targeted approach will be applied across the remainder of the stream lengths within the project footprint with the exception of threatened or at risk species where additional effort will occur.
- Focus on permanent streams as these are easiest to access and have higher quality fish habitat.
- Fish salvage will be undertaken in summer months when intermittent streams have dried and fish have moved downstream into areas of more permanent habitat.
- A whole of catchment approach will be undertaken where fishing will start at the upstream extent, moving downstream and installing progress barriers to restrict fish from moving upstream.
- Access tracks will be cut and fishing will take place prior to forestry felling to enable the easiest access.
- The most challenging component will be moving fish out of the Valley 1 catchment prior to forest harvest. Storage tanks will be used to reduce potential stress to fish and provide an opportunity for bulk movement of salvaged fish to relocation sites.

<u>Stockpile 1, Bin Exchange Area (BEA), Clay Borrow and Soil Stockpile, (Western and Southern Block)</u>

These areas include wetland areas and 1.41 km of stream length all of which can be easily fished. There are no restrictions to access and relatively standard methods can be applied to salvage and relocate fish. Within the Stockpile 1, BEA and Clay Borrow/Stockpile areas we maintain that, following fish salvage, the magnitude of Low ecological effects can be achieved.

Topsoil Stockpile (Western Block) and Combined Ancillary Stream Length (miscellaneous)

0.96 km of stream is anticipated to be impacted resulting from the topsoil stockpile and miscellaneous activities across the site. Some of this stream loss may be avoidable through detailed design or may be in dry intermittent headwater reaches (e.g. along the proposed road down to the north western end of the landfill or along the proposed road between the Clay Borrow and Soil Stockpile 1). Residual areas of impact will be fished and for the most part are either easily accessible or headwater intermittent reaches which will be dry and contain no fish. On this basis we maintain that, following fish salvage, the magnitude of Low ecological effects can be achieved.

Access Road (Southern Block)

Approximately 2.1 km of stream within the Southern Block will be fished. Nearly half of this length is intermittent channel and we expect it to provide little habitat suitable for fish in summer due to the steep nature of the site reducing the potential for remnant pools to remain. Access to these streams is not particularly restrictive as it does not have the forestry slash typically seen in the Eastern and Upper Waiteraire Blocks. The Southern Block streams comprise 14% of the total stream length being impacted on the WMNZ landholdings and we consider that fish salvage can be completed for all areas impacted in the Southern Block. Within the Southern Block we maintain that, following fish salvage, the magnitude of Low ecological effects can be achieved.

Soil Stockpile 2 (Upper Waiteraire Tributary Block) and Valley 1 Landfill (Eastern Block)

We consider that Valley 1 is the area most likely to be of concern in respect of Q19 however the access and habitat conditions are the same in Stockpile 2 so these areas are addressed together. 1.4 km of stream is present within the proposed Stockpile 2 location, comprising 0.8 km (58%) intermittent stream length. 9.5 km of intermittent and permanent stream is located within the Valley 1 landfill footprint, comprising 62% of the total stream length being impacted. Within Valley 1, 5.4 km (57%) of the stream length is intermittent.

This means that nearly 60% of the streams in Stockpile 2 and Valley 1 are expected to dry up during summer months. As for the Southern Block the intermittent streams are in steep areas and unlikely to maintain a substantial amount of suitable habitat in summer.

Approximately 4.6 km of stream length remains within the footprint of Soil Stockpile 2 and Valley 1 which is anticipated to provide permanent habitat. Fish salvage will be focussed on the mainstream channels and the permanent tributaries which can be easily accessed. Access tracks will be cut through the forestry to enable fishing to be undertaken on major tributaries. To enable a focussed effort on fishing, aerated holding tanks will be placed in proximity to fishing areas. This will allow field staff to spend more time salvaging fish and will reduce the risk of additional stress related fish mortality. It is estimated that no less than 75% of the 4.6 km stream length can be accessed and fished using the protocols outlined.

Within the Stockpile 2 and Valley 1 area, we are proposing fishing or fish exclusion to take place within 9.7 km of the 10.9 km stream likely to be present. We consider that after implementation of salvage and relocation measures that there would be a Low magnitude of effect, as there is likely to be a 'minor effect on the known population'.

Summary

In summary we expect to be able to fish all of the reaches within Stockpile 1, Bin Exchange Area (BEA), Clay Borrow/Stockpile, Access Road and Combined Ancillary Stream areas, which are estimated to comprise a total length of 4.5 km stream (29% of all stream proposed to be impacted).

A further 6.3 km (41% of all stream proposed to be impacted) of stream within Valley 1 and Stockpile 2, is anticipated to dry up during summer months and provide little to no habitat for fauna.

A remaining 4.6 km (30% of all stream to be impacted) of stream is anticipated to provide permanent fish habitat and efforts will be concentrated on fishing these areas.

Overall, we are confident we can easily salvage fish or exclude fish from dried streams across approximately 70 % of impacted streams.

Of the remaining 4.6 km, likely permanent habitat, where access is expected to be more difficult the fish salvage and relocation measures outlined within the NFFFMP will be applied. We estimate that at worst, fishing may not be possible within 1.15 km of stream within the impact area. We expect that there will be some injury or mortality to fish and consider this to be a Low magnitude of effect, in that there will be a minor effect on the known population. Following the successful implementation of the proposed salvage and relocation protocols we do not consider that the effects would be equivalent to a Moderate magnitude of effect which is described as 'loss of a moderate proportion of the known population'.

Notes:

Numbers have been rounded to the nearest decimal place and due to rounding the total numbers may not completely add up to those reported. For confirmation, the total stream length being impacted is consistent with the AEcE report and all areas outlined above will be fished.

20 It is noted that the EcIA states "SEVi-P were not calculated for streams within the Southern and Waiteraire Tributary Blocks as the SEVi-C values were so high that it is considered that potential values would be very similar if modelled as many of these values are similar to reference conditions (as shown in the SEV guide)". In the interest of understanding the appropriateness of this approach please comment on the ability to increase the Vrough variable score for SEV11 and SEV20 from the current values to a potential value following realistic best practice enhancement. Please also comment on how this potential score would impact the calculation of the extent of enhancement required to offset the effects of the access road and stockpile 2.

We have provided the calculations as requested below. We note however that the Waiteraire Tributary Block is in forestry and in the absence of the proposed ARL would remain in forestry and so the potential for it to be restored is very low.

The SEVi-P values have been calculated and a description of the changes proposed in Table 1 below. A very small increase is anticipated between the current and hypothetical future potential state. As such, the ECRs have been recalculated to provide context to the relevance of these changes for this project (Table 2).

The length of stream within the Southern and Waiteraire Tributary Blocks being impacted and addressed through offset remains 3,495 m and 1,306 m^2 (AEcE, Appendix G Table 1). The proposed offset stream length and area available remains 2,350 m and 4,492 m^2 (AEcE, Appendix G Table 2). Refer also to Appendix G Table 3 in the AEcE when considering the adjusted numbers in Table Y below.

Using the SEVi-P values results in a very small increase in the ECR and consequently increases the quantum of stream required to meet a no net loss state. If these new ECRs based on hypothetical potential value are used, an additional 255 m^2 streambed area and 153 m stream length would be required to be enhanced to achieve 'no net loss' (according to the formula).

This does not change the overall length of stream proposed to be enhanced onsite to meet the 1:1 length onsite previously offered. We consider that the very small increases in the ECRs do not change the approach proposed or the quantum of stream enhancement proposed within WMNZ landholdings given that all available opportunities for enhancement within the landholdings have already been offered as part of the application.

Table 1: Updated SEV values incorporating potential values.

	SEVi-C	SEVi-C (Excl IFI, FFI)	SEVi-P (Excl IFI, FFI)	Description of changes in SEVi-P
SEV 11	0.86.	0.84	0.86	• Vrough (0.88 to 1.00) changed from 'regenerating indigenous in late stage' (0.5), 'mature native damaged understory' (0.1) and 'low diversity regen stock excluded' (0.4) to 'regenerating indigenous in late stage' (1). • Vphyshab (0.95 to 0.97) increased riparian integrity from 16 to 18. • Vripcond (0.71 to 0.80) – auto-populated change from Vrough.
SEV 20	0.85	0.85	0.89	• Vrough (0.70 to 1.00) changed from 'mature exotic trees' (0.6), 'low diversity regen stock excluded' (0.35) and 'disturbed bare soil' (0.05) to 'regenerating indigenous in late stage' (1). • Vripfilt (0.95 to 1.00) changed from 'very high' (0.95) and 'no filtering' (0.05) to 'very high' (1). • Vphyshab (0.90 to 0.97) increased riparian integrity from 10 to 18. • Vripcond (0.63 to 0.80) – auto-populated change from Vrough.

Table 2: Updated ECR values when incorporating SEVi-P values.

Impact area	Impact SEV	Offset site SEV	Old ECR	Old offset area required	New ECR	New offset area required	Offset difference
Stockpile 2	SEV20	SEV19	3.101	1947 m^2	3.246	2038 m^2	Increased by 91 m^2 and 36 m.
Access road culvert	SEV2	SEV19	2.444	173 m^2	2.444	173 m^2	No change to ECR.
Access road reclamation	SEV11	SEV19	3.064	812 m^2	3.137	812 m^2	No change as using all offset available.
		SEV17**	3.056	720 m^2	3.129	720 m^2	No change as using all offset available.
		SEV19 (2a)	3.677	392 m^2	3.764	556 m^2	Increased by 164 m2 and 117 m.
Total area required to achieve 'no net loss'				4,044 m^2		4,299 m^2	

** see answer to Q24 for additional commentary regarding SEV17-P.

21 **It is not clear how the length of near flat banks (Vgalspwn) for SEV17 increases from 0 m to 50 m. Please clarify what actions result in this outcome (noting that the quality of galaxiid spawning is assessed separately under Vgalqual).**

22 **60% of the channel for SEV17_C is assessed as being straightened and/or deepened (Vchann). It is not clear how the proposed enhancement actions for area 2d result in**

none of the channel being straightened or deepened following enhancement (SEV17_P). Please clarify and update proposed offset actions and/or SEV and ECR scores as required.

23 Similarly, it is not clear how the proposed enhancement actions for area 2d result in an improvement in floodplain connectivity (Vbank), especially given there is no change in Vdepth. Please clarify and update proposed offset actions and/or SEV and ECR scores as required.

24 Vchann for SEV17_P does not equate to 100%. Please correct.

Q21 – 24 are addressed as a single answer as follows.

Assumptions associated with the proposed enhancement actions for each of the enhancement reaches were summarised in Appendix G, Table 2 of the AEcE. We acknowledge that the comments lacked detail regarding individual variables. In brief, it is proposed to gently regrade the banks to facilitate better floodplain engagement, provide for potential galaxiid spawning and provide a more natural in-stream channel. Specific assumptions for each variable are provided in Table X below.

Specifically in relation to Q24 – this was an error in the calculator and has been remedied by increasing the proportion of 'Natural channel, but flow patterns affected by reduction in roughness elements (e.g. logs, boulders)' increased from 0.6 to 0.8. This results in an overall increase in SEVm-P from 0.75 to 0.77. This is an increased potential ecological gain that could be captured in our ECR calculations (see Table X above for Q20). Specifically, it reduces the ECR from 3.129 to 3.00 and consequently reduces the overall amount of 'new' offset by 40 m2 from the 4,299 m2 to 4,259 m2. A above, this doesn't change the proposed approach to undertaking enhancement on the streams identified within the WMNZ landholdings.

Based on the further detail provided we consider no changes need to be made to SEV17m-P in regards 21-23. We consider the change relating to Q24 to be immaterial and have not updated SEV or ECR calculations in response to these questions.

	SEV17 P
Vchann	Channel shaping to improve naturalness of banks
Vlining	No change
Vpipe	No change
Vbank	Channel shaping to improve connectivity
Vrough	Regenerating late succession, wetland, early successional, flax. Wetland area historically
Vbarr	No change.
Vchanshape	Autopopulated
Vlining	No change.
Vshade	Combination of very high, high and moderate to account for channel width changes
Vdod	Removal of stock from catchment, riparian vegetation, change to channel shape, increase to sub optimal
Vveloc	No change.
Vdepth	No change.
Vripar	20 m margins planted
Vdecid	Removed deciduous component (0.1)
Vmacro	Reduced macrophytes due to higher shading. Still some macrophytes present
Vretain	Autopopulated

Vsurf	Increased woody debris, added small amount of bedrock and gravels(as is typical for catchment), added leaf litter, retained roots.
Vripfilt	Increase to very high as will be 20 m wide margin
Vgalspwn	Slight change due to bank modification
Vgalqual	Slight improvement in quality of habitat
Vgobspwn	
Vphyshab	Improved diversity, slight improvement on abundance, and heterogeneity, improvement in shade and integrity
Vwatqual	No change
Vimperv	<10%, high control
Vfish	Excluded
Vmci	Excluded
Vept	Excluded
Vinvert	Excluded
Vripcond	Auto populate
Vripconn	No change

25 Vrough, Vshade, and Vphyshab for SEV19_2a_C do not appear to reflect the existing vegetation on the true left bank. Please clarify.

For the most part the SEV19m-C variables have been used in the SEV19_2a_C as the general condition of the stream is the same. We note also that only some of SEV19_2a_C has some existing riparian margin so we consider that the values provided are an overestimate of the current state for some of the length. Irrespective a description of the variables where the current condition has been captured is provided below.

Variable	SEV19-C	SEV19_2a_C	Description of change
Vshade	0.0	0.24	Changed from 'no effective shade' (10) to 'no effective shading' (6) and 'moderate shading' (4)
Vripar	0.1	0.5	Increased to account for one whole bank having an intact margin.
Vripfilt	0.2	0.5	Increased to account for one whole bank having a wider buffer.
Vphyshab	0.36	0.44	Shade increased from 0 to 6
Vwatqual	0.04	0.09	Automatically updated following improvements to Vshade

Two errors were identified in this revision:

- Vrough had erroneously not been improved under the SEV19_2a_C scenario, and
- 'Riparian vegetation integrity' had not been modified in Vphyshab.

Upon reflection it became apparent that Vripar had been overestimated as the intact vegetation on the true left bank riparian margin comprises only half of the length (at best) (refer Figure X below).

As such additional changes are proposed to the SEV19_2a_C score.

Variable	SEV19-C	SEV19_2a_C	Description of change
Vripar	0.1	0.25	Reduced to 0.25 to reflect the true extent of the intact vegetation present.

Variable	SEV19-C	SEV19_2a_C	Description of change
Vrough	0.23	0.35	Added 0.2 mature indigenous and 0.05 late succession indigenous and reduced short grass by 0.25.
Vphyshab	0.36	0.49	Riparian vegetation integrity improved to recognise the vegetation present along part of the true left bank.

Following the addition of these changes the SEV19_2a_C remains 0.43 (See summary sheet below for all variables under the 'final' scenario). Therefore no further changes to the ECR's are proposed.

Variable (code)	SEV19-C	SEV19_2a_C
Vchann	0.37	0.37
Vlining	0.80	0.80
Vpipe	1.00	1.00
NFR =	0.51	0.51
Vbank	1.00	1.00
Vrough	0.23	0.35
FLE=	0.23	0.35
Vbarr	1.00	1.00
CSM=	1.00	1.00
Vchanshape	0.90	0.90
Vlining	0.80	0.80
CGW=	0.83	0.83
Hydraulic function mean score	0.64	0.67
Vshade	0.00	0.24
WTC =	0.00	0.24
Vdod	0.40	0.40

DOM =	0.40	0.40
Vripar	0.10	0.25
Vdecid	1.00	1.00
OMI =	0.10	0.25
Vmacro	0.10	0.10
Vretain	0.20	0.20
IPR =	0.10	0.10
Vsurf	0.79	0.79
Vripfilt	0.20	0.50
DOP =	0.49	0.64
Biogeochemical function mean score	0.22	0.33
Vgalspwn	0.85	0.85
Vgalqual	0.25	0.25
Vgobspwn	0.10	0.10
FSH =	0.16	0.16
Vphyshab	0.36	0.49
Vwatqual	0.04	0.09
Vimperv	0.70	0.70
HAF =	0.37	0.44
Habitat provision function mean score	0.26	0.30
Vfish	0.47	0.00
FFI =	0.47	0.00
Vmci	0.43	#DIV/0!
Vept	0.50	#VALUE!
Vinvert	0.23	1.00
IFI =	0.39	#DIV/0!
Vripcond	0.11	0.29
Vripconn	1.00	1.00
RVI =	0.11	0.29
Biodiversity function mean score	0.32	#DIV/0!
SEVscore (Excl FFI, IFI)	0.36	0.43

26 EcIA acknowledges the effects of excess in-stream sedimentation but notes that "*many native fish species are tolerant of high levels of suspended sediment in the water column*" (pg 36). In contract, the ESC report notes that "*seven species of native fish have been recorded within the wider catchment, including two 'at risk-declining' species (long fin eel and inanga) and banded kokopu, which are particularly sensitive to suspended sediment*" (pg 4). Please clarify this discrepancy in reported tolerances of freshwater fish to the effects of excess in-stream sedimentation.

We consider that there is no discrepancy in the reporting. Many native species are tolerant of elevated suspended sediment, measured either by turbid water or high concentrations of total suspended solids (TSS)[16]. However, of the species identified, banded kokopu are particularly

[16] For summary of research see Clapcott, J.E., Young, R.G., Harding, J.S., Matthaei, C.D., Quinn, J.M. and Death, R.G. (2011) Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.

sensitive to in-stream sedimentation. Banded kokopu exhibit avoidance responses, reduced feeding rates, reduced in-stream occurrence and limited upstream migration above turbidity of 25 NTU. We have highlighted the sensitivity of banded kokopu as these are recorded across the site and are recognised as being a 'benchmark' species.

27. Please clarify the location and extent of the catchment areas used to calculate the total sediment load from the existing catchments based on existing land use (693.55 tpa) (within table 3.2 of the ESC Report).

Refer to responses in Section 7.

28. Table 4.4. of the ESC Report which concludes a total enabling works sediment load of 183 t does not appear to include the construction of the landfill sediment control ponds and polishing wetland. Please clarify and update as required. Also, please provide further clarify as to how this total will be divided across the anticipated 3 – 4 year enabling works period.

Refer to responses in Section 7.

29. Please clarify the change (from existing baseline scenario to during construction scenario) in annual sediment loading (post mitigation) for the high ecological value watercourses across the site; in particular: the watercourse downstream of stockpile site 2; the watercourse downstream of the footprint of the landfill and associated sediment ponds; and, the watercourse alongside the access road.

a. Please detail the locations for where these scenarios have been provided

b. Please also clarify the change (from existing baseline scenario to during operation scenario) in annual sediment loading (post mitigation) calculated for the watercourse downstream of the footprint of the landfill and associated sediment ponds.

Refer to responses in Section 7.

30. The EcIA considers that the overall effects resulting from short term construction sediment generation following the implementation of mitigation measures will be 'Moderate' in most catchments, and 'Low' in Western Block WB catchment (pg 36). Please provide further justification for this assessment given the overall change in annual sediment loads to the receiving environment as a result of the construction activities.

Refer to responses in Section 7.

31 The EcIA states that noise can have adverse effects on birds. Bittern, for example, are for known to be prone to significant adverse effects relating to noise and has been well documented in Eurasian Bittern. The effects of noise on Bittern was discussed a length in ENV-2016-AKL-000174 Pierau v Auckland Council - Decision [2017] NZEnvC090. The EcIA fails to fully assess and comprehend the adverse effects from noise disturbance on wetland birds within the WMNZ landholdings; especially for the construction of over-burden and borrow areas. Furthermore, it is unclear as to what appropriate mitigation measures could be employed to alleviate these effects, especially during the breading season. Please provide a robust assessment of the effects of construction and operational noise on wetland bird species within the WMNZ landholdings and recommend suitable mitigation measures.

There is a paucity of evidence relating to the direct or indirect effects of noise on wetland bird species that are known or potentially present within the WMNZ landholdings. Broadly speaking, construction and operation related noise can potentially have direct or indirect effects on wetland birds through:

- Changing the natural behaviour of wetland birds, such as increasing avoidance responses; and,
- Increased levels of stress for birds, with resultant fitness costs;
- Masking of communication between conspecifics (individuals of the same species), especially during wetland bird breeding season of September to December inclusive, potentially lowering reproductive success;
- Reducing the ability for birds to hear potential predators and/or prey, resulting in higher predation rates or food resources for birds; and,
- Decreasing habitat 'quality' – a noisy habitat even while intact is likely to be considered of lower habitat quality by wetland birds than a quiet habitat.

Despite the above, we consider the likely level of noise effects on wetland birds to be low in regard to the proposed Auckland Regional Landfill. As set out in detail below this is because:

- In the case of Australasian bittern, wetlands on WMNZ landholdings are likely to be used intermittently but are less likely to be used for breeding, as suggested by monitoring results and habitat suitability.
- Acoustic modelling suggests that construction and operational noise will be similar to background/existing noise levels and for spotless crake and fernbird, project-related noise frequencies do not overlap with (i.e. interfere with) breeding call noise frequencies

<u>Wetland bird monitoring results</u>

To date we have undertaken monitoring at Stockpile 1 wetlands and at Wayby Wetland South by deploying Automatic Bird Monitors (AuBM) during peak bird breeding season for two weeks from 23 October to 6 November 2018 (as described in Section 6.2.5 of the AEcE). Over 800 hours of data were analysed from the AuBM using Raven Lite 2.0 software, which is an interactive sound analysis tool for animal bioacoustics. In addition to the use of AuBM, dawn and dusk bird surveys were undertaken at Wayby Wetland South between mid-September to mid-October 2018 to assess wetland bird presence, using playback calls for spotless crake and fernbird.

Native wetland birds observed or expected to be present onsite are listed below and include nationally 'Threatened' or 'At Risk' species[17]:

- Australasian bittern (Botaurus poiciloptilus) (Threatened – Nationally Critical);
- Spotless crake (Porzana tabuensis) (At Risk – Declining); and,
- Fernbird (Bowdleria unctate) (At Risk – Declining).

Spotless crake and fernbird were found to be abundant throughout WMNZ wetlands surveyed, while evidence for Australasian bittern presence is inconclusive. Results from analysing sound recordings from AuBM indicated possible Australasian bittern through two incidences of a single boom. Despite the booms being within the typical calling frequency of an Australasian bittern, there were no repeated booms, and the call signatures were without the typical 'in breath' of a bittern boom, (however we note that this 'in breath' can be easily masked by other noise or not heard at larger distances from the animal; Bardeli et al., 2010). Other explanations of noise at this frequency may be vehicle noise (such as a car horn) or other animal noises. Furthermore, dawn and dusk surveys resulted in no Australasian bittern identifications.

Wetlands classified as exotic or degraded across WMNZ landholdings are not considered suitable breeding habitat for Australasian bittern, although bittern may intermittently use these habitats for feeding. The two wetlands that are considered Significant Ecological Areas (SEA), Wayby Wetland

[17] Robertson, H. A., Baird, K., Dowding, J. E., Elliott, G. P., Hitchmough, R. A., Miskelly, C. M., McArthur, N., O' Donnell, C. F. J., Sagar, P. M., Scofield, R. P., Taylor, G. A. (2016). Conservation status of New Zealand birds. New Zealand Threat Classification Series 19. 27 p.

South (SEA_T_629) and Wayby Wetland North (SEA_T_6456) are outside of the ARL project footprint.

Wayby Wetland North consists of a raupō wetland monoculture and may provide habitat for bittern feeding. Wayby Wetland South consists of habitat which may be suitable for Australasian bittern breeding and feeding. It is large and intact, with a diverse assemblage of wetland habitats. However, a number of factors limit the suitability or importance of the wetland for Australasian bittern including:

- The wetland network within WMNZ holdings is isolated at a landscape level, with the nearest wetland of a similar size to Wayby Wetlands being at least 10 km away[18];
- The nearest known bittern breeding wetlands are more than > 20 km from the site, i.e., Ngamotu Island, Makarau and Te Arai[19,20]; and,
- Nesting/breeding sites are usually surrounded by deep water (O'Donnell, 2010) and only a small area of relatively deep water is present at the western edge of Wayby Wetland South; and
- Ideal foraging habitat consists of mosaic of wetland habitat types which include shallow open water coupled with marsh (non-woody) and/or swamp (woody) vegetation. However, shallow open water foraging habitat is limited in Wayby Wetland South rendering the wetland less suitable than comparable sized wetlands for Australian bittern foraging.

Due to the amount of sampling effort undertaken in 2018 and the landscape context of WMNZ landholdings, we consider it unlikely that there was a resident population of breeding Australasian bittern present on the WMNZ landholdings during the 2018 breeding season and that Australasian bittern may not breed in this wetland. Nevertheless, we consider it likely that individuals use this wetland for foraging and as a stepping stone between other wetlands – bittern have been found to have flown over 100 km in New Zealand.

<u>Construction and operational activity timeframes (Marshall Day Report (Sept 2019) (Appendix Y))</u>

Overall noise levels will vary across the construction period and during operational activities. Noise is also expected to vary in persistence (e.g. sudden noise vs constant noise) and amplitude (loudness).

Noise is expected to be most persistent and loud during:

- 7.00am to 8.00pm Monday to Saturday for stockpiles outside of the landfill valley;
- 6.00am to 8.00pm Monday to Sunday for seasonal construction;
- Construction season, from 1 October to 1 May (with noise levels expected to be reduced in intensity outside of this timeframe); and,
- Temporarily above background noise levels in the non-breeding season during degraded wetland vegetation removal.

Furthermore, operation of stockpile 1 and the clay borrow area will be ongoing throughout the life of the landfill, however activities are not expected to be every day.

<u>Acoustic monitoring purpose and approach</u>

Noise receptor analysis was undertaken by Marshall Day Acoustics (2019) within wetland habitats across WMNZ landholdings (Appendix Y) to:

[18] Landcare Research (n.d.). OurEnvironment Maps. Wetland overlay. Accessed on 25.09.2018 from https://ourenvironment.scinfo.org.nz/maps-and-tools/app/
[19] iNaturalist (www.inaturalist.org)
[20] ebird (www.ebird.org)

- Assess the noise profile of likely ARL operations relative to background noise levels (LA90); and,
- Assess the likelihood of potential effects of construction and operational noise on wetland birds.

Noise levels within wetlands were assessed across WMNZ landholdings including where wetland birds had been observed during field surveys, and in Wayby Wetland South, where bittern are considered most likely to be present.

Predicted noise levels within wetlands associated with the proposed ARL project were compared to existing noise levels, and an analysis of the predicted noise levels at the frequency of 125 Hz (the approximate frequency at which bittern boom) was also undertaken.

<u>Acoustic monitoring results and implications</u>

- Predicted noise levels at most of the receivers (within key wetlands) during ARL construction and operation are expected to be within the range of current background noise levels (25 - 45 dB L_{A90}) with maximum noise levels as high as 65 dB at 125 Hz L_{eq} (but such maximum noise levels are expected to be temporary, with average noise levels at key times such as dawn and dusk between 30 -35 dB at 125 HZ L_{eq});
- Predicted noise levels at 125 Hz (which ranged between 20-40 dB L_{eq}) are in all cases expected to be lower than the predicted overall noise levels (38-53dB L_{eq}) but similar to existing background noise levels (25-45 dB L_{A90});
- Existing/background noise levels at 125 kz are already likely to affect bittern breeding behaviour (on the assumption that Australasian bittern and Eurasian bittern breeding behaviour is similarly affected).
- Existing/ background noise levels and projected noise levels associated with the proposed ARL are unlikely to affect spotless crake or fernbird. Spotless crake and fernbird generally call above the frequency range of typical road and traffic noise (600 – 4000 Hz and 3000 – 4000 Hz respectively).
- Anecdotal evidence for North Island fernbird and spotless crake does suggest that these species can become conditioned to regular background noise (e.g. motorway noise as evidenced by their presence in wetlands close to motorways). However, anecdotal evidence also suggests that they can be startled when subject to loud un-expected noises, e.g. plant starting up next to a wetland. Anecdotal evidence for Australasian bittern response to noise is scant.

<u>Implications (effects and effects management needs)</u>

While we consider the noise effects of the proposed ARL to be low, it is acknowledged that the wetland birds present, or likely to be, are threatened species and uncertainties exist. To this end, our proposed measures to avoid or minimise potential noise effects have been included in our Avifauna Management Plan (AMP) and Vegetation Clearance Management Plan (VCMP). In summary these measures include

- Seasonal constraints on vegetation clearance for native forest and all wetland habitats during peak bird breeding season (September to December inclusive);
- Designation of vegetation clearance exclusion/buffer zones during peak bird breeding season; and,
- Time constraints on hours of operation either side of dawn and dusk to avoid noise effects during peak breeding call times (i.e. avoidance of construction or operational noise near the SEA and indigenous wetlands one hour either side of dusk and dawn) during the peak breeding season (September to December inclusive).

32 The EcIA identifies Whitehead (Mohoua albicilla) being found within the WMNZ landholdings. This is potentially a regionally significant observation. Figure 9 identifies only wetland bird species. Please update, or provide additional mapping, to include all non-wetland birds with "Threatened" or "At-Risk" classifications.

Refer to Figure 9A (Appendix Z), which has been prepared to show where NZ pipit (*Anthus novaeseelandiae, At Risk - Declining*), long-tailed cuckoo (*Eudynamys taitensis, At Risk – Naturally Uncommon*), whitehead (*Mohoua albicilla, At Risk - Declining*) and black shag (*Phalacrocorax carbo, At Risk - Recovering*) have been observed on the WMNZ landholdings.

33 The EcIA does not provide a robust bird survey for the area of Landfill (eastern-block), in relation to threatened / at-risk species; for example, it is well documented that Fern Bird (Bowdleria punctata) and Whitehead (Mohoua albicilla) are known to populate exotic forest habitats, especially the margins of haul roads (e.g. Fern Bird), which contain a mixture of native and exotic habitat. Please provide additional survey for all "Threatened" or "At-Risk" bird species, so that a thorough survey will have been completed within the footprint of the entire proposed operation(s).

In all, our results suggest that whiteheads and fernbirds are uncommon or only occasionally present in the exotic forest (i.e. the area of landfill in the Eastern Block) and native habitats within the proposed ARL. Over 100 person hours have been spent within the Eastern Block undertaking stream, fish, snail, frog and lizard surveys. During this time incidental visual and call observations were undertaken by ecologists, with a particular focus on identifying 'At Risk' and 'Threatened' species. During these surveys no whiteheads or fernbirds were heard or observed within exotic or native forests in the proposed Auckland Regional Landfill impact area. Whiteheads are a relatively conspicuous species, as they have a clear and distinctive call. Furthermore, a significant number of hours of bird call data has been analysed, with no whitehead calls noted.

We have based our assessment of effects on the assumption that whitehead and fernbird are occasionally present within the forested habitat within the proposed ARL and consider the level of effects on these species to be low in these habitat types (noting that this differs from our effects assessment with respect to fernbird and wetland habitats).

34 The EcIA section 6.2.4.3 identifies WMNZ landholdings as having a high proportion of bat movement and suggests there may be potential bat roost trees (Home / Maternity), within or close to the operational boundaries of the works. Please expand on this assessment to include areas to the northeast and south of the WMNZ landholdings, for Council to fully appreciate and understand the movement of long-tailed bats (Chalinolobus tuberculatus) through the WMNZ landholding(s); please include the location and mapping of potential roost trees.

The EcIA report does not suggest there is a high proportion of bat movement within the WMNZ landholdings. Bat activity levels recorded across the 15 monitoring locations were **low to moderate** and ranged from 0.2 to 5.7 mean bat passes/night (Table 6.4, p68). The data recorded indicates that bats are present and utilising the site but does not indicate a "high proportion of bat movement".

Based on a high-level roost tree assessment, which involved looking for roost characteristics (i.e. cavities, hollow limbs, loose bark), potential roost trees were identified within the WMNZ landholdings. Very few potential roost trees were identified in the Project footprint and the vast majority of potential roost trees observed are located in the wider WMNZ landholdings and will be retained.

As discussed with Council experts, we do not consider undertaking additional surveys outside of the WMNZ landholdings to be necessary because:

- We have undertaken acoustic bat monitoring within the WMNZ landholdings, with a focus on the areas that will be impacted;
- We have identified that bats are present within the WMNZ landholdings and are using the site for foraging and commuting at low to moderate levels (during the survey period);
- Acoustic monitoring techniques record presence/absence and activity levels of bats only. Movement of bats can only be established via radio-telemetry techniques, which would require years of data collection and considerable costs to achieve any meaningful information; and
- Based on the habitat available in the wider landscape beyond the Project footprint, there are several areas of mature native vegetation (including several SEAs) and mature pine forest stands which likely offer potential roosting areas for bats. As such, it is probable that any bats utilising the WMNZ landholdings area are also utilising these areas.

35 The EcIA section 6.3.1 notes a tree felling protocol be developed in relation to long-tailed bats (Chalinolobus tuberculatus). Council has significant concerns regarding the implementation of such measures. Please provide an assessment and appropriate measures relating to tree-felling and the effects on long-tailed bats (Chalinolobus tuberculatus).

We understood from the meeting with Council on 16 August 2019, that the 'significant concerns' relate to issues on other sites, where good practice tree felling practices have not been followed. We were advised that provision of a Bat Management Plan (BMP) including good practice industry standard tree felling protocols would be sufficient to provide confidence that an appropriate approach was being proposed. The BMP is provided in Appendix U as per Q3 and is consistent with industry good practice for safeguarding long-tailed bats during vegetation clearance.

Vegetation Removal Protocols (VRP), as outlined in the BMP, will be used as a precautionary measure to avoid effects on potentially occupied bat roosts during tree clearance activities. The protocols are consistent with good practice guidelines which have been used on many large infrastructure construction projects[21],[22],[23].

The VRP aim to:

- identify potential bat roost trees that exist within key habitats within the Project footprint prior to vegetation clearance;
- provide clear, concise procedures that are to be followed prior to removal of all trees within the Project footprint, with the aim of avoiding mortality or injury to bats in the event that they are found; and
- set out how any bat injury or mortality that may occur will be dealt with.

36 There are no peripatus records shown on figure 12 in Appendix B, however section 6.2.8 identified that 3 peripatus were detected during the invertebrate surveys. Please amend figure 12 accordingly, for all records

[21]Smith, D., Borkin, K., Jones, C., Lindberg, S., Davies, F. and Eccles, G. 2017. Effects of land transport activities on New Zealand's endemic bat populations: reviews of ecological and regulatory literature. NZ Transport Agency research report 623. 249pp

[22] Connolly, T. 2015. Draft bat management plan part 1 and 2 WAIKATO EXPRESSWAY HUNTLY SECTION contract no: NZTA 2/09-007/601. Report prepared by Opus International Consultants Ltd, Hamilton for NZ Transport Agency and the Fulton Hogan-HEB Joint Venture

[23] Davies, F, T Matthews and K Borkin. 2013. Waikato Expressway: Tamahere – Cambridge section bat management plan (stage one: enabling works). Report prepared by URS and Wildland Consultants Ltd for HEB Construction Ltd

N.B - also, for Figure 12 there are some blue and brown dots without identifying notation; can these also be updated

We recognise this was an error where some of the symbols on maps did not transfer through into the PDF version of the maps. We have identified several other Figures where this occurred and so we have appended a complete new set of Figures, referred to as Rev 4, which replace the ones in the Ecology Report and have been checked for symbols (Appendix Z).

37 The EcIA section 6.27 identifies Hochstetter's frog (Leiopelma hochstetteri) as being present within the proposal footprint(s) (confirmed onsite by Council Ecologists). Tables 6.14 6.15 & 6.16 provide further clarity on effects on this threatened species. However, the EcIA suggests only 10% of frogs will be salvaged, and that they may not survive; this is considered to be unacceptable in avoiding adverse effects on native biodiversity, including but not limited to AUP:OP Section B7; Auckland Council Indigenous Biodiversity Strategy; RMA Pt2 (s5 & 6); and, recent Environment Court rulings on At-Risk species. Please revise the assessment of effects, and mitigation measures, on the indigenous Hochstetter's frog population, ensuring that any adverse effects will be will be 'minimised' by the proposal. Auckland Council advises collaboration and consultation with the DOC Biodiversity/Native Frog Recovery Group.

Every effort will be made to avoid adverse effects on frogs through salvaging. Our proposed salvage methodology will include the searching of all suitable frog habitat with the proposed Auckland Regional Landfill. Most of the frogs will be present under rock refugia and some within cascade rock crevices. We propose to undertake salvage within all rocky areas that can be feasibly searched and removed (i.e. habitat reduction) until there is no refugia left that can practicably be searched. We expect to salvage a large (but unknown) proportion of frogs in this manner.

However, it is acknowledged that an unknown proportion of frogs will not be able to be salvaged. This is most likely to occur:

- In habitat that is not possible to search (e.g. in rocks that are too large to lift or within bedrock crevices or cracks from which frogs are detected but cannot feasibly be removed); or
- In areas that do not appear to be suitable habitat and are therefore not searched.

The proportion of frogs expected to be salvage was very conservatively estimated at 10%. It is key to note however, that we would expect to salvage an unknown but considerably higher proportion of frogs than this initial conservative estimate and that all frogs that are present within suitable habitat and that can feasibly captured will be salvaged. We have been discussing frog relocation methodology and relocation sites with the DOC frog recovery group. This is ongoing and will inform the Hochstetter's Frog Management Plan.

38 The EcIA states that, "salvage and relocation operations and habitat enhancement of proposed relocation site within the Sunnybrook Reserve (TBC), which will include Long-term mammalian pest control". As discussed on-site, Auckland Council, in collaboration with multiple landowners and Stakeholders (including DoC), are undertaking a significant piece of pest animal control throughout 4,313.5 Ha in the area, including Sunnybrook reserve. This has implication relating to Q1 (additionality) and effectiveness of salvage / relocation.

a **Please evaluate the proposed location of salvage / relocation and provide Council an understanding, through providing baseline data survey, of the holding capacity of habitats suitable for Hochstetter's frog. For avoidance of doubt, this baseline should anticipate the pest animal control work (to be carried out) to an RTC rate of ≤3%;**

b **This assessment should extend to all habitat proposed for species to be salvaged / relocated; i.e. lizards, snails etc.**

c **Please provide mapping of the proposed salvage / relocation areas.**

d **Please provide landowner approval (certainty), and legally enforceable surety, of the ongoing protection of salvage / relocation areas outside of the ownership of WMNZ landholdings.**

Through discussions with Auckland Council we are aware that there are pest control operations underway and/or planned for Sunnybrook Reserve and the wider Dome Valley area. To our understanding the pest control is geared towards possum control using a combination of anti-coagulants and encapsulated cyanide along with trapping where needed. Rodent control is also undertaken to protect the encapsulated cyanide. Council's contract with Feracon requires a 3% or lower Residual Trap Catch result from the post control monitor. The current programme is pulsed with the last pulsing in 2014/2015. Currently the RTC % in the area of the program is at 8.79% (pre monitor completed April) which is considered high and a risk to flora and fauna in the area.

We consider there to be potential for improved or 'additional' biodiversity gain for native fauna, through sustained stoat and feral cat control and most importantly, more intensive and sustained rodent control coupled with an appropriately low RTC target. A complimentary, sustained and more intensive multi-pest control programme is expected to result in potential gain for native fauna and flora that will be affected by the proposed ARL).

Comments on 38 a – d are as follows:

a We have submitted a Wildlife Act Authority permit application to the Department of Conservation (DOC) to undertake additional surveys within the WMNZ landholdings, both within and outside of the project footprint to 1) better understand effects and salvaging methodology and 2) determine the best site option(s) and approach for relocation operations. Information from these surveys, coupled with consultation with the DOC frog recovery group and Auckland Council will be used to develop salvage and relocation protocols including the best location of relocation site(s).

b Agreed -frog surveys will also be used to assess relocation sites for snails and lizards

c Maps will be provided in due course, i.e. once survey findings have been completed and relocation site(s) have been confirmed

d Landowner approval and protection of relocation site(s) will be provided. The sites and mechanisms for protecting these will be provided in due course, following further fieldwork and discussions with DOC.

39 The EcIA section 6.2.3 identifies Kawaka (Libocedrus plumosa) and Kaikomako (Pennantia corymbosa) as being present in the WMNZ landholding, and that "No kawaka will be affected by the project", and, "possible that some Kaikomako will be affected by the project in some areas." This appears contrary to Figure 6, where the new access will impact on a number of these trees / shrubs. In particular, the number of Kawaka trees and their distribution appears locally significant, within the proposed access corridor. Please update this assessment of effects to detail the number of trees / shrubs affected by the proposal. It is recommended that an additional survey is carried out to identify the full extent of Kawaka (Libocedrus plumosa) and Kaikomako (Pennantia corymbosa) within the landholding and development footprint.

A single kawaka tree (approximately 40 cm DBH) and approximately six additional seedlings in close proximity to the parent tree will be affected by the ARL Access Road. A vegetation survey (site walkover) has been undertaken over the entire access track of native regenerating forest, and we are confident the single kawaka tree and associated seedlings are the only kawaka affected within the project footprint.

Drone footage has identified 11 additional large kawaka trees throughout WMNZ landholdings which will not be affected by works, and it is assumed that numerous seedlings are established near the parent trees which cannot be seen by drone footage. Seedlings have been confirmed beneath kawaka in the fenced bushlot at the centre of WMNZ landholdings. Furthermore, three of these trees have been identified within the 'regenerating native forest' which are close to the Access Road but which will not be impacted by the access track. Therefore it is considered that the majority of the local population will not be affected by works, and proposed pest control is expected to benefit its population.

A total of three kaikomako have been identified within the project footprint, one of which was a seedling less than 30 cm in height and the other two of which were no larger than 1.5 m in height. In contrast, numerous kaikomako trees have been identified in WF8 forests throughout WMNZ landholdings that are not within the footprint of construction works however only their presence or absence in each forest block has been noted. Kaikomako trees are overall relatively abundant throughout WF8 forests on the Western Block. Because kaikomako trees are numerous across the WMNZ landholdingse, it is not considered that the proposed works will adversely affect their population. Protection of these forests through pest control and covenant is expected to enhance the onsite kaikomako populations.

40 EcIA Appendix B, figure 14, Forest and Wetland Compensation package identifies a few degraded wetlands, highlighted for restoration efforts. It is unclear as to how the restoration measures will achieve the outcomes sought by AUP:OP (Chp B7), "improving the quality, functioning and extent of these areas", while they remain disconnected from surrounding habitats. Please reassess and identify, on Figure 9, additional restoration efforts to meet the outcomes sought by AUP:OP (Chp. B7).

We understand from our meeting with Auckland Council specialists, that this request relates primarily to the wetland located up gully systems on the northern/north eastern side of the Western Block.

The proposed onsite enhancement aims to connect stream, wetland and terrestrial habitats as much as possible. The majority of this enhancement is within the flatter land as this land is available for enhancement. Hill country within the Western Block is proposed to be planted with pine forestry and consequently restoration efforts have avoided these areas.

41 Green-hooded orchids: There are no recording for the specific green-hooded orchid species found on site. Pg. 62 of the EcIA (pg. 71 of the pdf) notes that green-hooded orchids were present within some of the vegetation types; however, green-hooded orchids were not listed in the species list (Appendix H) and therefore it is unknown whether the green-hooded orchids are a threatened species. Please update the EcIA accordingly, including relevent appendices.

The green-hooded orchid identified on the WMNZ landholdings is tutukiwi (*Pterostylis banksii*), classified as Not Threatened. Please refer to Photo below.

Other *Pterostylis* species have been identified in Dome Valley (iNaturalist, NZPCN plant distribution database), all of which are Not Threatened (*P. agathicola, P. alobula, P. graminea, P. trullifolia,*).

We haven't updated our AEcE, however, we will capture this species in the relevant management plans.

42 Vegetation mapping: Please provide a figure showing the vegetation types they have classified according to Singers et al. (2017) - Table 6.1 of the Ecological assessment discusses the vegetation types and area that is proposed to be removed but it is not shown on an appropriate appendix sheet (figure).

Please see the newly created Figure 5A (Appendix Z).

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Appendix A: Engineering - Geofabrics

Appendix B: Development Engineering – Stormwater pipe

Appendix C: Development engineering - Stormwater pond sequencing

Appendix D: Borehole 15 specification

Appendix E: Stormwater pond damming

Appendix F: Stormwater drawings

Appendix G: Humes Specifications

Appendix H: Updated sediment calculations

Appendix I: Economics

Appendix J: Traffic

Appendix K: Additional Traffic response

Appendix L: TCLP Limits

Appendix M: Redvale Landfill - Locations of complaints

Appendix N: SO2 dispersion modelling

# Appendix O:	PM10 dispersion modelling

Appendix P: NZTA Screening tool

Appendix Q: Risk Management Assessment

Appendix R: Further clarification of Risk Management Assessment

Appendix S: Revision 1 of Health Risk Assessment Appendix G

Appendix T: Draft Landfill Management Plan

Appendix U: Draft Ecological Management Plan

Appendix V: Off-site stream compensation plan

Appendix W: Alternative road alignment options and Bin Exchange Area

Appendix X: Native Freshwater Fauna Management Plan

Appendix Y: Assessment of potential noise levels in wetlands

Appendix Z: Figures

Appendix AA: Clause 23 responses