BEFORE THE COMMISSION
APPOINTED BY THE OTAGO REGIONAL COUNCIL

UNDER	the Resource Management Act 1991 (RMA)
IN THE MATTER	Of an application by Dunedin City Council for resource consent being processed with reference RM20.280
BY	**BIG STONE FOREST LIMITED, ŌTOKIA CREEK AND MARSH HABITAT TRUST and SOUTH COAST NEIGHBOURHOOD SOCIETY INC** **Submitter**

STATEMENT OF EVIDENCE OF ANDREW JOHN RUMSBY

DATED 17 MAY 2022

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STATEMENT OF EVIDENCE OF ANDREW JOHN RUMSBY

Introduction

1. My name is Andrew John Rumsby. I am a Principal Environmental Chemist with EHS Support New Zealand. I specialise in the fate and transport of chemicals in the environment, contaminated land investigation, environmental geochemistry, environmental and human health risk assessment, and surface water quality assessments.

Qualifications and Experience

2. I hold a Master of Science in Chemistry, and Earth Sciences from the University of Waikato, a Bachelor of Science in Chemistry and Geology from the University of Auckland and a Certificate in Radiochemistry from the University of Auckland, and I am a member of the Australian Land and Groundwater Association, New Zealand Geosciences Society, Society for Environmental Toxicologist and Chemist and Waste Minimization Association. Since I graduated from University, I have received specialised training in ecological and human health risk assessment as well as environmental toxicology and environmental sampling.

3. I have over 25 years of experience in environmental consultancy within NZ and working as an environmental scientist for various environmental and engineering consultancy firms, local government agencies and Crown Research Institutes. I have worked on issues involving environmental chemistry, landfill leachate and water quality since 1997 when I became employed as a Scientific Officer (Environmental Monitoring) for Taranaki Regional Council. I relocated to Auckland to fill an environmental science position at Environmental Science and Research (ESR) Limited Air Quality Group in 2000, where I worked as an Air Quality Scientist/Data Analyst. Since 2001, I have worked for environmental consultancy firms (URS and PDP) and, since February 2020, have been employed by EHS Support as a Principal Environmental Chemist.

4. Some of my work experience which is relevant to this application is as follows:

   (a) Independent Peer Reviewer working on behalf of Environment Southland assessing landfill gas and landfill waste acceptance criteria issues associated with AB Lime Landfill consent renewal.

   (b) Independent Peer Reviewer working on behalf of Auckland Council assessing environmental risks and landfill waste acceptance criteria issues associated with Dome Valley Consent Application.

   (c) Undertaking environmental impact assessments and developing waste acceptance criteria for several managed fills in Auckland and Waikato Region. This included providing specialise advice on the management of acid sulphate soils and site-specific water quality guidelines/ecotoxicity assessments.

   (d) Assessing suitability of disposal methodology and environmental risks associated with the disposal of methyl bromide fumigants for Tasman District Council.

   (e) Undertaking a detail landfill gas risk assessment and developing landfill gas protection measures for the Auckland Northern Corridor project at Rosedale Landfill.

   (f) Undertaken a landfill gas risk assessment on off-site receptors associated with the development of Christchurch Southern Motorway.

   (g) Assessing off-site landfill gas risk of wind rose compositing at Hampton Downs Landfill on Behalf of EnviroWaste Limited.

   (h) Undertaking detailed landfill gas risk assessment on the hazards associated with the sub-surface migration of landfill gas on several industrial and residential properties from the Greenmount Landfill.

(i) Undertaking specialised landfill gas assessment (including modelling) and environmental risk assessment associated with fatty and resin acids from an industrial monofill.

(j) Undertaken environmental monitoring and environmental risk assessment of stormwater discharges from Kauri point armament depot and munitions landfills.

(k) Undertaking the mercury inventory of New Zealand and assessing the impact of mercury on the New Zealand environment of the Ministry for the Environment.

(l) Undertaking a detailed assessment of the impacts of PFAS in NZ ecosystems on behalf of the Ministry for the Environment.

(m) Undertaking long term environmental and landfill gas monitoring of over 50 closed landfills for North Shore and Waitakere City Councils.

(n) Undertaking long term monitoring of the Dow Agrosciences hazardous waste landfill in New Plymouth.

(o) Environmental compliance monitoring of the Colson Road Landfill, New Plymouth.

Expert witness code of conduct

5. Although not necessary in respect of council hearings, I can confirm I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note dated 1 December 2014 and agree to comply with it. I have complied with the Code of Conduct in preparing this evidence, and I agree to comply with it while giving oral evidence before the hearing committee. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

Scope and Structure of Evidence

6. My evidence will address the following matters within my areas of expertise:

   (a) Waste acceptance criteria

      i. Limits on Concentrations of substances

      ii. Prohibited items

      iii. Need to consider more contaminants of concern

   (b) Limited-service life of landfill engineering controls

      i. Lifetime of HDPE Geomembrane Liners

      ii. Failures of Leachate Collection Systems

   (c) Impacts of Sub-surface Landfill Fires on Landfill HDPE Geomembrane liners.

   (d) Landfill Waste Acceptance Criteria and Prohibited items

   (e) Environmental Impact of Persistent and Environmentally Harmful Substances

   (f) Landfill fire risk and landfill gas controls

   (g) Robustness of background data set and details how appropriate trigger levels will be set.

Reports Reviewed to Prepare Statement

a) Boffa Miskell (2020) Smooth Hill Landfill. Assessment of Environmental Effects for Updated Design. Updated May 2021

b) Appendix 8: Groundwater Report

c) Appendix 9 Surface water Assessment Report

d) Appendix 11: Ecological Impact Assessment Report

e) Appendix 17: Draft Conditions of Consent

f) GHD/Boffa Miskell (2021) Smooth Hill Landfill: Draft Landfill Management Plan. 4 June 2021

g) T & T (2021) Technical Review to Inform Notification Decision: Smooth Hill Landfill – Appendix 8 - Groundwater Report. 2 September 2021

h) T & T (2021b) Technical Review to Inform Notification Decision: Smooth Hill Landfill – Appendix 11 – Ecology Assessment

i) UNEP. 2011a. Technical guidelines for the environmentally sound management of wastes consisting of elemental mercury and wastes containing or contaminated with mercury. UNEP/CHW.10/6/Add.2/Rev.1 31 October 2011.

j) UNEP. 2015c. Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF). May 2015

k) UNEP. 2017e. Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls, polychlorinated terphenyls, polychlorinated naphthalenes or polybrominated biphenyls, including hexabromobiphenyl (PCBs, PCTs, PCNs or PBBs, including HBB). May 2017

l) UNEP. 2019. General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (General POPs). May 2019

m) Basel Convention. 2003. Technical Guidelines for the Environmentally Sound Management of Waste Lead-acid Batteries. http://www.basel.int/Portals/4/Basel%20Convention/docs/pub/techguid/tech-wasteacid.pdf

n) Ministry for the Environment. 2004. Module 2 – Hazardous waste guidelines: Landfill waste acceptance criteria and landfill classification. Publication reference number: ME 510. May 2004

o) CAE 2000 Landfill Guidelines: Towards Sustainable Waste management in New Zealand

p) WasteMINZ. 2018. Draft Technical Guidelines for Disposal to Land

q) Hazardous Substance (Storage and Disposal of Persistent Organic Pollutants) 2004 and Amendment Notice 2016

r) Hazardous Substance (Disposal) Notice 2017 (as amended by the EPA Notices (Amendments and Revocations) Notice 2020

s) NZ EPA Fire Fighting Chemicals Group Standard 2021. HSR002573.

t) Statement of Evidence of Richard Coombe

u) Statement of Evidence of Anthony Kirk

v) Statement of Evidence of Matt Welsh

w) Statement of Evidence of Anthony Dixon

x) Statement of Evidence of Paul de Mar

y) S42A report Attachment 1 – DCC responses to pre-hearing questions 18 Mar 22

z) S42A report Attachment 5 -draft conditions ORC edits 20 April 2022

aa) S42A report Attachment 7 – Updated Appendix 9 - surface water Assessment 4 April 2022

bb) S42A report Attachment 14 – Summary of submissions

cc) Statement of Evidence of Ōtokia Creek and Marsh Habitat Trust

Waste Acceptance Criteria

i. Limit on concentration of substances that can be placed within a landfill.

7. The applicants waste acceptance criteria proposed in the applicants AEE, and Fill Management Plan are vague and inadequate as it does not consider all relevant New Zealand legislation or cover modern contaminants which are found within waste streams entering a 21st Century landfill.

8. The applicant has not provided a detailed and specific list of Waste acceptance criteria within its AEE or Draft Landfill Management Plan (LMP). Rather, the proposed consent conditions provide a generic reference to Ministry for the Environment (2004) Module that meets the Ministry for the Environment Module 2: Hazardous Waste Guidelines – Class A.

9. Municipal Solid Waste (MSW) landfills such as the facility being proposed at Smooth Hill are essentially large anaerobic bioreactors that can provide long term confinement and control of waste substances that are biodegradable or have low or moderate environmental toxicity. However, they are not suitable repositories for all types of waste, such as persistent bioaccumulative and toxic substances and highly radioactive substances. Therefore, it is important to put in place appropriate waste acceptance criteria.

10. The UNEP (2019) Technical guidelines on the environmentally sound disposal of hazardous wastes and other wastes in specially engineered landfills state that acceptance criteria should be established, limiting the concentration of hazardous substances that the landfill will receive.

11. These waste acceptance criteria need to be designed to ensure that materials placed within a landfill do not cause adverse effects on the environment or human health (both in the short term (i.e. the operational period of the landfill) and in the long term (i.e. post-closure period)). Waste acceptance criteria need to be developed, considering the lifetime of the consent or the operating life of the landfill and the fact that some toxic compounds do not degrade or degrade very slowly.

12. Contaminants with low water solubility and high adsorption capacity (i.e. high Koc), are not environmentally mobile (Polycyclic Aromatic

Hydrocarbons, etc) can be effectively contained by modern landfill design, even in the event of a leachate collection system or liner failure. But other contaminants (such as Per and polyfluoroalkyl Substances (PFAS) and alkylphenol ethoxylates (APEOs) which are environmentally important have not been considered within the Waste acceptance criteria (see Section on Emerging Contaminants within my statement of evidence).

13. The Ministry for the Environmental (2004) Hazardous Waste Guidelines document is currently out of date with international and Ministry for the Environment policy, regulations, and guidelines such as:

    (a) Hazardous substance (Storage and Disposal of Persistent Organic Pollutants) 2004 and Amendment Notice 2016 (POPs Notice) states that POPs wastes cannot be disposed of into landfills and must be exported for destruction.

    (b) New Zealand Environmental Protection Agency (2017) Safe Management of PCBs: Code of Practice – requires PCB wastes to be disposed of in an environmentally sound manner, as per clause 5 of POPs Notice.

    (c) New Zealand Environmental Protection Agency (2017) Consolidated Hazardous Substances Disposal Notice (Updated in 2021).

14. Waste acceptance criteria need to be set for all POPs to comply with POPs Notice.

15. Waste acceptance criteria should also comply with the disposal requirements for the disposal of legacy and C6 fluorotelomer PFAS fire fighting foams and associated waste products as defined in the Fire Fighting Chemicals Group Standard 2021. This group standard limits the concentration that can be disposed to landfill as follows:

(a) the total concentration for Perfluorooctanoic Acid (PFOA), its salts and PFOA-related compounds does not exceed 50 mg/kg (determined as fluorine).

(b) the leachable concentration for PFAS does not exceed 0.05 mg/kg (determined as fluorine), and the total concentration for PFAS does not exceed 50 mg/kg (determined as fluorine).

16. The PFAS National Environmental Management Plan version 2.0 (2020) prepared by the National Chemical Working Group of the Heads of EPAs Australia and New Zealand in Section 14.6 specifies a landfill acceptance criteria of 50 mg/kg for PFOA and PFOS (Perfluorooctanesulfonic acid) in a landfill which has either a Clay/single composite liner system or a double composite liner system.

17. To meet these requirements, I propose the following waste acceptance criteria:

(i) 50 mg/kg for PCBs as defined in Hazardous Substances (Storage and Disposal of Persistent Organic Pollutants) Notice 2004.

(ii) 50 mg/kg for PFOA and its related compounds as expressed as Total Organic Fluorine.

(iii) 50 mg/kg for PFOA and its related compounds as expressed as Total Organic Fluorine.

(iv) 15 µg TEQ kg-1 for PCDD/F in waste.

(v) 50 mg/kg for all POPs listed in the Stockholm Convention not covered by WAC (i) to (iv) including pentachlorobenzenes, polychlorinated naphthalenes, short chain chlorinated paraffins, pentachlorophenol, tetrabromodiphenyl ether and polybrominated diphenyl ethers (PBDEs).

(vi) A mechanism be included in the consent conditions and/or management plan to ensure waste acceptance criteria remain up to date (especially for new candidate compounds under the Stockholm Convention).

ii. Prohibited Items

18. The lack of specific waste acceptance criteria within the landfill management plan or especially reference within the consent is not best practice. The draft consent conditions only reference the Ministry for the Environment (2004) Hazardous Waste Guidelines and the New Zealand Waste List. Due to the age of the documents, it is highly unlikely that these documents will be able to be accessed for the entire lifetime of the consent creating a risk that the consent will become unenforceable.

19. The proposed list of prohibited items within the consent condition does not include the recommendations of the UNEP (2021) Technical guidelines on the environmentally sound disposal of hazardous wastes and other wastes in a specially engineered landfill. The UNEP technical guidance specifies that the following wastes are not deposited into landfills:

    a. Reactive wastes that generate large quantities of gas when in contact with air or water.

    b. Wastes that are easily soluble in water that produces highly contaminated leachate.

    c. Wastes containing, consisting, or contaminated with persistent organic pollutants (POPs).

    d. Wastes consisting of, containing, or contaminated with organ halogen compounds above limits values specified in acceptance criteria.

    e. Waste tyres.

20. The list of prohibited items proposed by the applicant does not specifically mention prohibited phenols and phenol derivatives,

including chlorophenols waste, which the draft Wasteminz (2018) guidelines indicate are unsuitable for disposal at a Type 1 landfill.

21. Since several POPs (including SCCPs, PCNs, decarbromodiphenyl ether), are commonly found in electrical wiring, plastics and textiles found in automobiles, automotive shredder residues are not allowed to be deposited into the landfill unless demonstrated not to contain POPs residues.

22. Lithium-ion batteries should also be prohibited from the landfill due to environmental toxicity concerns around cobalt and the potential for lithium-ion batteries to cause landfill fires. Recycling lithium-ion batteries, in particular, reduces energy consumption and greenhouse gas emissions and results in 51.3 per cent natural resource savings compared to landfilling[1].

23. Untreated acid sulphate soils should also be prohibited from the Smooth Hill landfill. These soils can generate very low pH and high sulphate leachate (less than pH 3), which:

    a. Is highly toxic to any wildlife that encounters the leachate.

    b. Can increase the mobilisation of metals from the landfill and within the leachate (Potentially exceeding trade waste bylaws).

    c. Results in low pH leachate which can attack the landfill geotextile and clay liners resulting in an increasing the permeability of the liner and potentially resulting in a liner failure.

    d. Increase the potential for fouling of the leachate collection system due to mineral precipitation.

    e. Increase the potential formation of hydrogen sulphide within the landfill, potentially resulting in odour complaints.

[1] See section in my evidence regarding landfill fires.

24. The Waste Acceptance Criteria (WAC) need to prohibit organic peroxide compounds and explosive compounds. This will ensure that the WAC complies with the Basal Technical Guidelines, HSNO regulations, and draft Wasteminz guidelines (2018).

25. Based on the evidence above, I recommend that both the proposed consent conditions and the landfill management plan be updated before consent for this site is given, with the following items listed as being prohibited as part of the Waste Acceptance Criteria:

    i. Reactive wastes that generate large quantities of gas when in contact with air or water such as Class 1 substances (explosives), Class 2 and 3 substances (flammable gas and liquids), Class 4 substances[2] and Class 5 substances (particularly organic peroxides).

    ii. Wastes that are easily soluble in water that producing highly contaminated leachate.

    iii. Wastes consisting of, containing, or contaminated with organic halogen compounds above 50 mg/kg unless otherwise specified in the waste acceptance criteria.

    iv. Waste tyres.

    v. Refrigerators, freezers, and air conditioning units, unless they have been degassed and lubricating oil has been removed.

    vi. Lithium-ion batteries.

    vii. Mercury-containing batteries, mercury lamps and elemental mercury-containing wastes.

    viii. E-waste containing mercury, including fluorescent and Compact Fluorescent Lights, as well as LCD displays.

[2] Particularly class 4.12 substances (self-reactive flammable solids), class 4.1.3 substances (solid desensitised explosives), class 4.2 substances (substances liable to spontaneous combustion pyrophoric substances and self-heating substances) and class 4.3 (substances dangerous when wet).

ix. Automotive shredder residues unless they have been demonstrated not to contain POPs residues.

x. Phenols and phenol derivatives, including chlorophenols waste.

xi. Used oil.

xii. Radioactive wastes.

xiii. Legacy PFAS firefighting foam or a legacy PFAS fire fighting foam waste product (as defined by the Fire Fighting Chemicals Group Standard 2021).

xiv. Acid-generating tailings from the processing of sulphide ore or coal waste.

xv. Acid generating soils that have not been verified as being neutralised in accordance with the Government of Western Australia Department of Water and Environmental Regulation (2015) Treatment and management of soils and water in acid sulfate landscapes.

xvi. Mine tailings waste containing hazardous substances.

xvii. Waste containing hazardous substances from physical and chemical processing of metalliferous minerals (including aluminium smelting).

xviii. Wastes containing hazardous substances from physical and chemical processing of non-metalliferous minerals

xix. Waste from aluminium manufacturing processes[3].

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[3] Aluminium manufacturing waste are known to generate high temperatures within landfill cells (up to 100℃) which could potentially damage an HDPE Geomembrane liner (See paragraphs 54-56 and 78 for more information on temperature effects on HDPE geomembrane liners)(also see (Jafari, 2014) for more information on heat generation in landfills from aluminium production wastes).

xx. Oil-containing drilling muds and wastes

xxi. Drilling muds and other drilling wastes containing hazardous substances

Emerging Contaminants

26. The applicant AEE does not cover the potential emerging contaminants of concern (i.e. pharmaceutical compounds, personal care products, anti-microbial agents and persistent, bioaccumulative toxic substances (and candidate compounds Stockholm Convention) in leachate or the impact on the downstream ecosystems/human health. In addition, substances of very high concern have been identified by the European Union (i.e. highly environmentally mobile substances such as nonylphenol, alkylphenols and alkylphenol ethoxylates (APEOs), bisphenol A, PFAS compounds and substances listed as being listed PBT/vPvB by the EU Reach program) as well as 1,4-Dioxane have not been discussed within the AEE.

27. PFAS, nonylphenol, alkylphenols and alkylphenol ethoxylates (APEOs) are water-soluble and highly environmentally mobile. These compounds are known or suspected endocrine-disrupting compounds, and some are known or suspected reproductive toxins or carcinogens. Overseas studies ((Danon-Schaffer, 2014) (Eggen, 2010); (Gallen, 2017); (Kalmykvoa, 2013); (lang, 2017); (Masoner, 2015); (Ramakrishnan, 2015) (Qi, 2018)) have found these compounds present in landfill leachate at concentrations ranging from several 100 ng/L to <50,000 ng/L.

28. APEOs and PFAS are surfactant compounds and can form micelle, which are environmentally stable arrangements of these molecules, resulting in the long-range transport of these compounds.

29. In the Statement of Evidence of Anthony Kirk (paragraph 92) he states that he considers the risk associated with this contaminant [PFOS] to be less than minor given the various controls and the environmental settings. However, nowhere within the AEE or in any of its supporting documents has a detailed human health risk assessment been

undertaken on PFOS, any of the other PFAS compounds or any bio accumulative substances even though the Ōtokia Creek is a sensitive receiving environment where gathering of Kai occurs for human consumption. For the Dome Valley consent application, a human health risk assessment was undertaken to determine if there would be a human health risk.

30. From my experience investigating several PFOS impacted sites (including Woodbourne AFB, Ohakea AFB, Whenupai AFB, Devonport Naval Base, Bulls water supply plus other confidential sites) and reviewing overseas literature (Oakley Army Aviation Centre, RAAF base Williamstown and other sites within the US) PFAS compounds can travel many kilometres and accumulate to levels in aquatic organisms such as eels, gastropods and various crustacean at concentrations where it could be harmful to human health.

31. I also disagree with the statement in the Technical Review: Smooth Hill Landfill – Appendix 9 -Surface Water Assessment (Paragraph 56) which states that "Some parameters (such as Total Volatile and Total Semi-Volatile Organic Compounds, "PFAS") appear to commit the Applicant to an ongoing programme of monitoring of groundwater and surface water with possibly very little environmental benefit". In my opinion PFAS compounds make ideal warning compounds of potential leachate impacts because:

    (i) They do not occur naturally and therefore the background concentrations should be zero.

    (ii) PFOS does not breakdown and it can be regarded as a conservative trace compound.

    (iii) The analytical detection limit of these compounds is very low 1 to 10 parts per trillion which allows these compounds to be detected early when there is a very small leak (thereby giving advance warning of a significant problem).

32. Some of these other emerging contaminants/PFAS compounds are known to bioaccumulate within aquatic food chains and pose a health

risk to human consumers. While there is incomplete information regarding the bioaccumulation potential of emerging contaminants within NZ aquatic ecosystems, preliminary information indicates that the bioconcentration factor (BCF) for some PFAS compounds may be greater than three orders of magnitude (i.e. BCF much greater than 100 times).

33. Once substances begin to bioaccumulate within a food chain, dietary-borne toxicity must be considered an independent pathway to direct toxicity from sediments and water. If macro-invertebrate and fish species migrate (or are washed downstream) downstream (i.e. from the wetland into the Ōtokia Creek) or there is significant biomagnification, then dietary-borne toxicity may be independently more significant than direct toxicity from exposure to water or sediments. Currently, the applicant AEE does not assess the risk of dietary toxicity.

34. In the evidence of my colleague, Mr David Ife, the estimated PFOS concentration in the groundwater would be 0.000636 µg/L, which exceeds the 99% ecosystem species protection value (0.00023 µg/L) to protect wildlife from chemicals that bioaccumulate and biomagnify in the environment. It should be noted that from Australian and New Zealand Defence Forces studies on the impact of PFAS compounds in the environment that significant bioaccumulation in eels and freshwater species has been observed at concentrations below 0.0001 µg/L of PFOS, which have resulted in PFOS concentrations in fish tissues which exceed Food Standards Australia and New Zealand as well as biota protection guideline values.

35. The proposed location for the Smooth Hill landfill does not meet the above criteria. Therefore, there is a potential risk to aquatic life and human consumers of the wildlife (particularly eels).

36. Due to the risk of bioaccumulation-biomagnification, the NEMP version 2 recommends that landfills be not sited within 1000 m of a surface water body that supports an aquatic environment (including groundwater-dependent ecosystems) or within 1000 m of a surface

water drain that is connected to groundwater and/or discharges directly into an aquatic environment (including groundwater-dependent ecosystems) or a water body that supports fish or other fauna species that may be caught and consumed from within the Ōtokia Creek or potentially the Coastal Marine Environment.

37. It should also be noted the Victorian EPA s Best Practice Environmental Management Publication 788.3: Siting, design, operation and rehabilitation of landfills (BEPM) recommends that Type 1 landfills be not situated within a valley (as proposed for the Smooth Hill Landfill) “as they have inherent environmental problems such as unstable slopes, water infiltration and leachate seepage”.

38. The EU Reach programme identifies several compounds as being Substances of Very High Concern due to their environmental persistence, bioaccumulation potential, and toxicity. If substances are listed as PBT/vPvB, the precautionary principle should be applied. Unless otherwise demonstrated, it should be assumed that those other emerging contaminants are as environmentally harmful and mobile as PFAS compounds and POPs controlled by the Stockholm Convention.

39. These emerging contaminants come from several sources, including household waste, plastics and biosolids. It may be difficult to control the concentration of emerging contaminants in household waste and plastic. However, control could be put in place to control the number of emerging contaminants in biosolids, and strict waste acceptance criteria could be imposed on the landfill.

40. There is currently no published waste acceptance criterion for these compounds. Therefore, waste acceptance criteria that limits the leachable concentration for APEOs and nonylphenol to below 0.05 mg/kg is proposed. In addition, the total concentration for APEOs and nonylphenol below 50 mg/kg should be adopted.

41. Regular monitoring of the stormwater within the underdrain for highly environmentally mobile compounds such as APEOs, boron, nitrate, and PFAS compounds should be undertaken monthly to ensure that

emerging contaminants are not discharged into the wetland and thereby the headwaters of the Ōtokia Creek.

42. Biota monitoring involving measuring bioaccumulative substances in tissue samples from species collected within the Ōtokia Creek should also be undertaken every five years once landfilling has commenced.

43. Substances of very high concern, which the EU Reach Programme has identified as persistent and bioaccumulative, should be prohibited from the landfill unless appropriate waste acceptance criteria could be set.

44. I note that even with this monitoring in place it is very difficult to deal with these issues if monitoring identifies that an issue is arising. The only solution available is to increase monitoring frequency and endeavour to identify pathways of escape as early as possible to facilitate appropriate action to close them down. If a significant breach does occur, affected environments may need to be identified and the public advised of the health risks. This obviously does not avoid the effects on those ecosystems themselves. Effectively the only way to address the issue would be to remove material from the landfill to prevent further escape. Obviously, that would be extremely costly and difficult to achieve and reinforces the need to ensure that landfill sites are carefully selected, that the landfill design is secure with appropriate redundancies and that waste acceptance criteria are very robust.

45. There should be a mechanism to develop Waste Acceptance Criteria for emerging contaminants identified over time. Conditions should require a process for the Landfill Operator to identify any new emerging contaminants on a regular basis and update the Waste Acceptance Criteria accordingly. Under these conditions it is likely that contaminants have already been discharged and so monitoring criteria should be updated at the same time as the Waste Acceptance Criteria to assist in identifying their presence in the surrounding environment. Before any new Waste Acceptance Criteria and/or monitoring processes are adopted, they should be independently peer reviewed and then submitted for certification by the Otago Regional Council.

The Limited Service Life of Landfill Engineering Controls

i. HDPE Geomembrane Liners

46. MSW solid waste landfills are permanent waste depositories; however, they are built with engineering controls with a finite operational life.

47. The life expectancy[4] of engineering and containment measures for MSW landfills is limited, with estimates varying between decades and centuries[5]. Estimates of the functional life of synthetic landfill liners range from 40 to 100 years. A study of landfill liners in Italy found a cumulative failure rate of almost 100% of landfill liners after 40 years[6].

48. Within the Statement of Evidence by Mr Richard Coombe (paragraph 70) he indicated that the HDPE membrane will last 400 years. This design life is found in several manufacturer brochure for HDPE liner and appears to be based upon the work undertaken by Professor Kerry Rowe of Queen's University and the Geosynthetic Research Institute White Paper #6 (Koerner, 2005). However, I do not believe that the service life of 1.5 mm HDPE membrane within a MSW will last for 400 years for the reasons listed below.

49. The industry standard for service life of a geomembrane is defined as the half-life, the geomembrane still exists and functions (although at a reduced performance level) beyond the 50% degradation point. The geosynthetic institute white paper estimate of HDPE geomembrane liner life is for a liner that the non-exposure (to leachate/chemical oxidation), based upon a 2.0 mm thick geomembrane at a temperature of 20℃. The Geosynthetic White Paper #6 (Koerner, 2005) notes that the lifetime is strongly dependant on service temperature (see Table 1) and gives different predicted liner lifetime for a 2.0 mm thick geomembrane not exposed to landfill leachate at different temperatures.

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[4] In this context life expectancy is the period of time when the facility is expected to remain robust and perform as it is designed to do.

[5] UNEP (2012) Guidance on best available techniques and best environmental practices for the recycling and disposal of articles containing polybrominated diphenyl ethers (PBDEs) listed under the Stockholm Convention on Persistent Organic Pollutants

[6] Pivato (2011) Landfill Liner Failure: An Open Question for Landfill Risk Analysis. Journal of Environmental Protection, 287-297

Table 1. Geosynthetic White Paper #6 predictions for liner life for a 2.0 mm HDPE geomembrane not exposed to landfill leachate.

In Service Temperature (°C)	Stage "A" (years)			Stage "B" (years)	Stage "C" (years)	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT			
20	200	215	208	30	208	446
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40	45	47	46	10	13	69

*Total = Stage A (average) + Stage B + Stage C

50. White Paper #6 (Koerner, 2005) states that its in-house is corroborated by other research, notably Sangam and Rowe (Sangam, 2002). However, when I have a reviewed the other research on aging of HDPE geomembranes including Sangam and Rowe (Sangam, 2002) they offer a range of service life ages, some of which a significantly lower than those predicted by White Paper #6 (Koerner, 2005).

51. Professor Rowe has published several laboratory aging studies over the ageing of HDPE geomembranes (Sangam, 2002) (Rowe K. R., 2008)(Rowe K. I., 2009) (Rowe K. R., 2009b), (Rimal, 2009) (Rowe K. A., 2013). Professor Rowe's research indicates that factors such as exposure to UV light (photo-degradation), membranes thickness, leachate concentration (oxidative degradation and chemical degradation) and temperature all effect the service life of HDPE geomembranes.

52. Sangam and Rowe (2002) undertook a series of Laboratory-accelerated ageing tests to estimates the depletion of antioxidants from HDPE geomembranes in various environments. The laboratory tests estimate ranges from 12 years to 390 years depending on the type of exposure of the HDPE membrane. Sangam and Rowe (2002) stated that within an MSW landfill that the most likely exposure environment was leachate (on top of the HPDE liner and unsaturated soil beneath (see column 8 of Table 2) (40 to 160 years depending on temperature).

Table 2 Estimated antioxidant depletion time (years) for a primary HPDE geomembrane (thickness 2.0 mm)

Temp. (°C)	Air	Water	Leachate	Leachate–air [(air + leachate)/2]	Leachate–water [(water + leachate)/2]	Unsaturated soil [(air + water)/2]	Leachate – unsaturated soil [(leachate + unsaturated soil)/2][a]
13	390	190	40	210	110	290	160
15	330	160	36	180	100	250	140
20	230	120	26	130	70	180	100
25	160	80	22	90	50	120	70
33	90	44	12	50	28	70	40

Note: After completion of all calculations, times greater than 45 years were rounded to the nearest decade. Initial OIT_0 = 133 min and final OIT = 0.5 min.
[a]This is an average of the values of air and water alone and does not really account for the presence of the soil particles (which could have a beneficial effect, since contact with soil particles reduces contact with air and (or) water). This also assumes an oxygen concentration in the air of 21%, whereas in reality it may be lower than 21%.

53. In 2009, Rowe and Islam undertook a more detailed investigation on the effect of temperature on liner service life. In this study they found considerable range of service life estimates based upon the time-temperature history of the landfill ranging from 20 years (maximum linear temperature of 60℃ (range 20 to 60 ℃) to 3,300 years (maximum linear temperature of 37℃ (range 10℃ -37℃).

54. In 2014, Jafari, Stark and Rowe (Jafari, 2014) undertook a more detail assessment of the service life of HDPE Geomembranes subjected to Elevated Temperature and found that the service life of 1.5 mm thick HDPE geomembrane is significantly less than 150 years.

55. Rowe and Islam (Rowe K. I., 2009) found that the temperature of liner within the landfill depends on various factors such as waste type, moisture content of waste (wetter waste produces higher temperatures), biomass consent, rate of filling, thickness of waste and climatic condition of region. The aerobic and anaerobic decomposition of waste produces heat (1770 $kJmol^{-1}$ and 100 $kJmol^{-1}$ respectively), therefore the waste inside the landfill (and therefore the temperature of the liner) can be considerably hotter than the surround air temperature.

56. Rowe and Islam (2009) reviewed the liner temperature of a number of landfills around the world and found it to be generally between 35-45℃. In wet landfills the temperature within the cells rose rapidly to 50℃ within 6 years of filling. Therefore, is likely that the temperature of the liner in the Smooth Hill landfill could be above 40 ℃ and based upon the work done by Rowe the service life of the HDPE membrane could be less than 40 years.

57. In the 2002 paper Sangam and Rowe have stated that the most reliable method of determining the service life of geomembranes would be from exposure under actual field conditions.

58. Field tests of geomembranes indicate that their service life could be as little as 10 years (Sun, 2019). Pivato undertook a review of literature and found that many researchers report failures of geomembrane liner systems after 10 to 30 years (Pivato, 2011). Pivato undertook a failure distribution analysis of almost 30 sites in northern Italy and found that the cumulative curve for failure of landfill liners almost reach a probability of 1.0 after 40 years (Figure 1).

59. Research on the service life of HDPE liners was reviewed by Lavoie et al in 2020 (Lavoie, 2020). Lavoie reviewed a number of different field studies of HDPE geomembrane durability. These studies found that HDPE geomembranes service lives were generally less than predicted from laboratory studies. Studies found evidence of increases in the melt flow index after 30 months and predicted service life (depletion of antioxidants) of between 47 to 60 years. However, under very cold environments (Canadian Arctic) service life was estimated to be over 140 years.

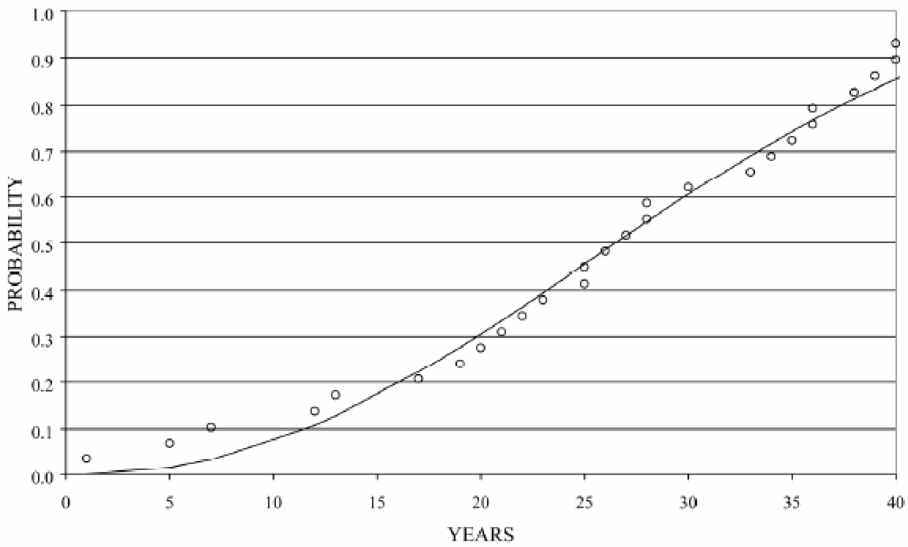

Figure 1 Cumulative curve of failure of contained landfills in the north of Italy

60. Research undertaken by Sun et al (Sun, 2019) looking at the effects of aging on the landfill capping layer (and therefore infiltration rates) and aging condition and defects in the HDPE geomembrane found that landfill leakage rates were measured to be up to 32.5 m^3/day (long term)[7]. This leakage rate is significantly higher than the model leakage rate used within the AEE or presented in the evidence of Anthony Kirk (1.4 m^3/day).

61. The literature and anecdotal evidence indicate that the performance of landfill liners degrades over time, resulting in an increased leakage rate. This increased leakage rate is likely to be higher than indicated in the applicant's AEE and may occur at or soon after the applicant predicts peak leachate generation.

62. As the lifetime of the HDPE geomembrane is temperature dependant thermal monitoring of each waste cell is important to ensure that conditions that peak temperature within the landfill do not exceed the design criteria. Currently the Fill Management Plan does not propose thermal monitoring above the liner, nor any trigger limits for liner temperatures where remediation action should be undertaken. An example of such trigger limits is outlined in Ontario Regulation 232/98[8].

63. The Fill Management Plan currently does not contain sufficient detail around what remedial measures are to be used (beyond intercepting the underdrain water). Detail is also required around possible remedial measures (and the timeframe that they will be undertaken) if sustained elevated temperatures are measured on or near the liner system. Jafari et. al. (Jafari, 2014) outlines a number of possible remedial measures which could be undertaken.

64. A detailed probabilistic risk assessment should be undertaken which should assess the risks and potential impacts of a HDPE

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[7] Note: The landfill leakage rate during a failure mode is site specific and will depend on things such as the assumed size of the failure, cell dimensions, waste depth, leachate depth above liner. Estimates of landfill leakage during failure can be determine by either adjusting literature values or undertaking a detail probabilistic failure mode analysis.

[8] See https://www.ontario.ca/page/landfill-standards-guideline-regulatory-and-approval-requirements-newexpanding-land

geomembrane liner failure on groundwater and surface water quality due to either aging, fire or seismic event. The information from this risk assessment should inform the design of the landfill liner system, monitoring requirements and the fill emergency response management plan.

ii. Failure of Leachate Collection systems

65. Leachate collection systems also have a limited practical service life as biomass growth, deposition of suspended particles, and precipitation of minerals within the pore spaces can substantially decrease the permeability of granular drainage material, causing the leachate mound to exceed the design criteria.

66. In New Zealand, the collapse or fouling of leachate collection systems in several landfills (Greenmount, Rosedale and Tuhora) has resulted in the leachate mound exceeding the design criteria by several metres. The higher mounding of leachate in the landfill can result in an increase leachate leakage resulting in a higher than anticipated impact on groundwater quality. In the case of the proposed Smooth Hill Landfill an increase in the landfill liner leakage rate could result in contamination of the stormwater being discharged into the wetland.

67. The applicant has not provided an estimate of the service life of the leachate collection systems. However, Rowe and Yu (2013) estimate that the average service life of the leachate collection systems is approximately 56 years. Rowe and Yu (2013) state that the clogging of the leachate collection system could begin in as little as 5-6 years. In a more recent paper, Rowe and Yu (2021) found that the disposal of waste that contains high concentrations of leachable minerals (i.e. coal ash) can reduce the service life of landfill leachate collection systems.

68. To minimise the impact of clogging, the leachate collection system needs to be accessible to permit regular cleaning. No conditions have been proposed in relation to this and there does not appear to be any detail regarding this process included in the Draft Landfill Management Plan.

Landfill Gas and Fire Risk

69. Landfill fires are a real risk that needs to be managed. As noted above landfill fires have occurred at several different New Zealand Landfills (i.e. Central Hawkes Bay District Council landfill (2021), Puke landfill at Pukemiro (2020), Broadland Roads in Taupo (2020), Puwera Landfill in Northland (2020), Hampton Downs Landfill (2019) and historically at Ngaruawahia landfill).

70. In the evidence presented by Anthony Dixon he clearly shows that there have been a number of small or minor fires at the Green Island landfill in the last few years. This indicates that the likelihood of such a fire is high and with increasing use of lithium batteries the risk are increasing.

71. Mr Dixon however, does not present the concept of the fire tetrahedron model.

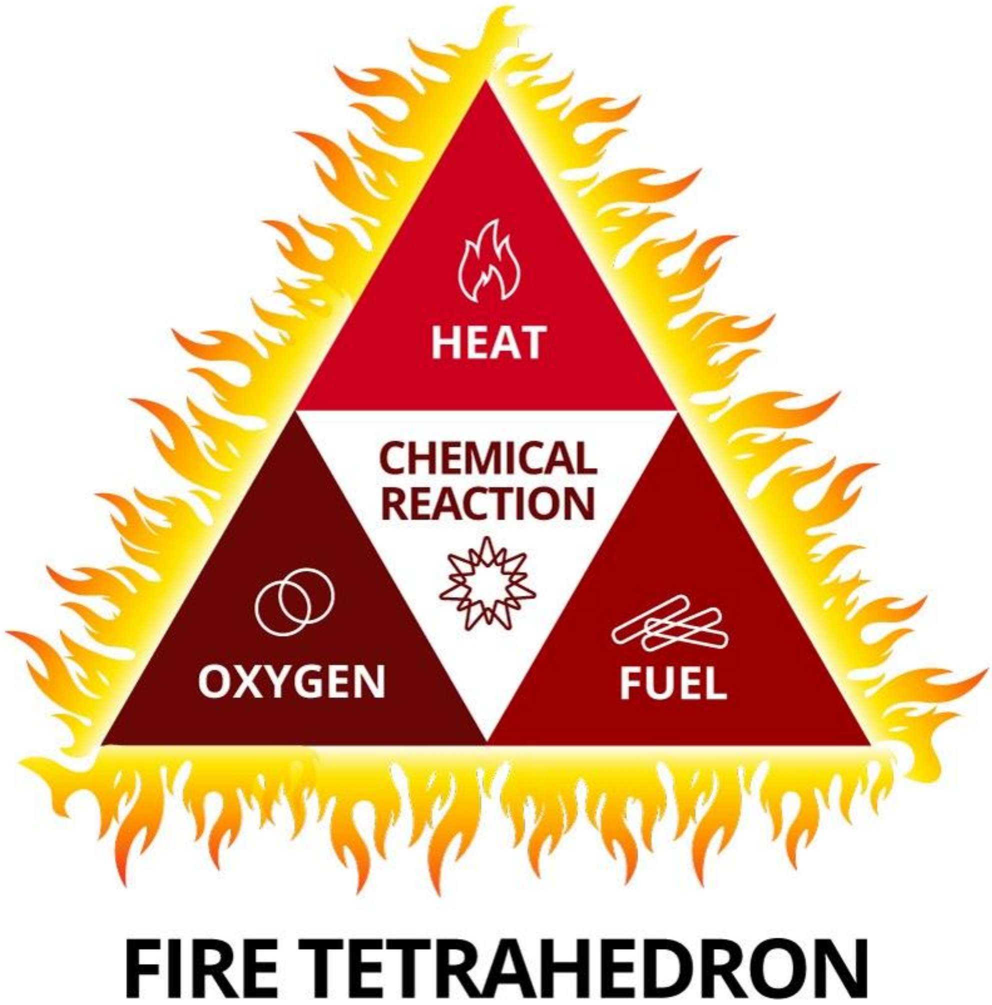

Figure 2. Fire Tetrahedron model outlining the four critical elements of fire.

72. The fire tetrahedron model outlines the four critical elements that must be present in or for a fire to exist. One of these elements is oxygen.

73. There is the obvious safety risk of landfill fire to those working at the landfill. Landfill fires can also have significant adverse effects on the surrounding community:

(a) The smoke from a landfill fire can contain harmful volatile and semi-volatile compounds, respiratory irritants such as sulphur dioxide and acidic gases, and cause offensive odours that can impact off-site receptors, especially those with respiratory conditions such as asthma.

(b) The fire itself could escape and cause a forest fire.

74. Several fires at landfills and transfer stations have been linked to lithium batteries as the ignition source in recent years. A fire at a landfill site at Pukemiro, west of Huntly, burnt for several months and resulted in many complaints from nearby residents relating to the impact of smoke and objectionable odour. Waikato Regional Council issued a health notice to pregnant or breastfeeding women to move out of the area due to concerns regarding toxins within the smoke.

75. Currently, the controls proposed by the applicant are inadequate as they aim to minimise the impact of a fire once it occurs rather than preventing a fire. In the evidence of Mr Dixon he indicates that lithium batteries are an increasing cause of landfill fires but does not pose any control measures around the acceptance of lithium batteries.

76. Specifically, the applicant's draft consent conditions do not seek to impose an oxygen concentration limit within the landfill extraction well/system. Controlling the oxygen concentration within the landfill is a key mechanism for managing potential fire risks.

77. In the evidence of Mr Dixon he states that over extraction of the landfill gas extraction system. However, neither he nor Mr Matthew Peter Welsh proposed mechanisms or control points to prevent over-extraction. Mr Welsh does indicate the regular oxygen monitoring and assessment criteria are important but again does not propose any.

78. In my experience, all Type 1 landfills in New Zealand and overseas set a maximum oxygen concentration level, which is similar to the approach taken to limit the potential for explosions caused by methane. These levels are generally set at 20 to 25% of the flammability limit of oxygen. The flammability limit of Oxygen is 12%.

79. Typically, a limit of five percent oxygen by volume has been set at other landfills in NZ such as Kate Valley, Hampton Downs and AB Lime. I propose that a consent condition be drafted in terms similar to the AB Lime condition i.e. “The landfill gas in all operating extraction wells shall not exceed five percent oxygen by volume”.

Impacts of Sub-surface landfill fires on HDPE geomembrane liners

80. Sub-surface landfill fires and deposition of exothermic waste such as hydrated lime or organic peroxides could generate much higher liner temperatures. Landfill fires and strong exothermic reactions can considerably reduce the liner life in the affected cells or if temperatures exceed 125℃ can result in melting of the HDPE liner. Leachate temperature of over 140℃ have been reported within some landfills receiving aluminium industry wastes (Lavoie, 2020).

81. A landfill fire or exothermic reaction does not need to exceed the melting point of the liner to cause significant degradation of the HDPE. HDPE, like all plastic, has a glass transition temperature (T_g), which is approximately 100℃. Exceeding the T_g can cause loss of tensile properties, stress cracking and oxidative degradation. These significant changes in HDPE geomembranes properties can be observed at temperatures as low as 85℃ (Abdelaal, 2015). Other effects such chain scission and decrease cross linking were also observed at high temperatures, which potentially weaken the strength of geomembrane and decrease service life (Jafari, 2014).

Robustness of background data set and details how appropriate trigger levels will be set

82. In Mr Anthony Kirk's evidence (paragraph 64) he states that quarterly monitoring for 36 months (12 data points) is sufficient enough for statistical and trend analysis to be undertaken on the dataset. However, he does not provide any justification for this claim, what statistical tools will be used, data quality objectives or a detailed method how trigger values will be developed for each parameter.

83. Water quality data typically has the following characteristics (Helsel, 1992):

    (a) Presence of outliers – observations which are considerably higher or lower than most data which occurs infrequently but regularly

    (b) Positive skewness of data – due partly to outliers

(c) Non-normal distribution of data – therefore statistical technique that do not assume a normal distribution. These statistical techniques typically require larger datasets than those which assume a normal distribution to produce a scientifically defensible conclusion.

(d) Data may be censored (i.e. have an analytical detection limit below which the results can not be reported). Most statistical and trend analysis techniques require un-censored data (discrete variables) or less than a certain percentage of the data set to be censored to produce a scientifically defensible result. This typically means that if some censored data is expected then the dataset needs to be larger to account for it.

(e) Seasonal Patterns. Values tend to be higher or lower in certain seasons of the year.

(f) Autocorrelation: Consecutive observations tend to be strongly correlated with each other (i.e. high values tend to follow high values and low values tend to follow low values).

(g) Dependence on other uncontrolled variables. i.e. some parameters are strongly controlled by other variables (i.e. pH, redox, temperature, time of day, flow, hydraulic conductivity, sediment grain size or some other variable.

84. Due to the above factors, in my opinion, 12 data points will be insufficient to undertake statistical and trend analysis of the background groundwater and surface water quality.

85. Currently, in New Zealand there are no standards specifying minimum size of the data set nor the length of time that the monitoring should be undertaken to define background as part of an assessment of environmental effects for consent applications. However, there is international guidance on minimum dataset requirements:

(a) US EPA ProUCL recommends 8 to 10 discrete (non-censored) data points before undertaking statistical analysis on a normally distributed dataset and 15-20 discrete (non-censored) data points when using non-parametric statistical analysis.

(b) The European Union Water Framework Directive recommends that at a minimum at least 20 datapoints over a two-year period (preferably monthly) are collected to adequately define background.

(c) In air quality assessment and hydrological assessments, a minimum of 5 years' worth of data is required to take into account of seasonal variation in meteorological and hydrological conditions.

(d) Land and Water Aotearoa (LAWA) (Ballatine, 2012) recommends a minimum of 5 years' worth of data, and it states that quarterly monitoring the standard error may occasionally be large enough to discount a trend that becomes evident when using monthly data. Therefore, it recommends that monthly monitoring is undertaken.

(e) ISO 19258:2018 recommends that more than 30 samples should be taken to estimate a reliable standard derivation with an acceptable reliability and allow for unexpected problems and censored data.

(f) Statistical techniques such as seasonal Kendall tests and autoregression integrating moving averages require at least 4 seasonal data points (i.e. minimum dataset over four seasons of 16 datapoints of discrete data).

86. The robust of an environmental dataset is also dependant of the types of decisions that it is being used for (i.e. what is an acceptable rate of type 1 or type 2 errors). As the background datasets will be used to make decisions regarding if there is an unacceptable discharge from the proposed landfill, I believe that a robust background dataset is required.

87. Based upon the above reasons outlined in above, I believe that 12 datapoints (3 datapoints per season) as proposed by Mr Kirk is insufficient.

88. I propose that groundwater and surface water monitoring is undertaken monthly for a period of 36 months before construction commences.

Conclusion

89. The applicants proposed waste acceptance criteria within the FMP is in some cases incomplete, vague and undefined. Having defined waste acceptance is important as it allows an independent reviewer to understand the potential contaminants of concern, ensure that the liner design is adequate and will be effective for those contaminants and understand if the impact on the environment has been adequately assessed.

90. The proposed waste acceptance criteria do not meet the requirements of NZ legislation nor overseas best practice/guidance and additional waste acceptance criteria and restriction of substances that can be deposited into the landfill need to be added as outlined in paragraph 48 of my evidence.

91. The proposed waste acceptance does not adequately restrict materials which could cause sub-surface landfill fires which could damage the HDPE geomembrane and/or cause adverse off-site effects. Additional controls should be placed on receiving aluminium manufacturing wastes, organic peroxide compounds and lithium batteries.

92. The applicant has not adequately assessed the potential impact of various persistent and bio accumulative chemicals on potentially the aquatic receiving environment nor on any potential human consumers of aquatic life.

93. The applicant assumes that the geomembrane liner will have a service life of over 400 years but has not undertaken a detail risk assessment assessing how the proposed waste acceptance criteria, landfill temperature, sub-surface fires and potential other hazards may affect

the service life of the liner. In reviewing literature, I believe the service life of the liner could be between 40 to 100 years. Therefore, additional waste acceptance criteria need to be added, particularly for substances which are persistent and bio accumulative to minimise the risks to aquatic life and downstream users of the Ōtokia Creek.

94. The applicant has not adequately assessed the potential impact of mounding of landfill leachate on leakage rates. Several landfills within NZ have had mounding of leachate of greater than 10 m, which results in an increased liner leakage rate.

95. Due to the risk of bioaccumulative substances entering the stormwater beneath the geomembrane high frequency monitoring (weekly) of key indicator compounds (Including PFAS) should be undertaken.

96. A mechanism should be put in place which allows independent review (including by a community representative) of WAC to impose new WAC for substances of very high concern as scientific information around the risks of these compounds evolves.

97. Biota monitoring involving measuring bioaccumulative substances in tissue samples from species collected within the Ōtokia Creek should also be undertaken every five years once landfilling has commenced.

98. A consent condition which states that “The landfill gas in all operating extraction wells shall not exceed five percent oxygen by volume” shall be included to prevent landfill fires caused by over extraction of landfill.

99. I believe that 12 datapoints (3 datapoints per season) as proposed by Mr Kirk is insufficient to characterise the groundwater and surface water background and that monthly monitoring for a period of 36 months (36 data points) should be undertaken.

100. The application as it currently stands, given its paucity of detail in a number of areas including the Fill Management plan, lack of adequate background monitoring or proposed trigger values, lack of an adequate assessment of a failure of the HDPE geomembrane liner will have on the environment, lack of adequate assessment of bio accumulative

substances on consumers of aquatic plants and animals and the fact that the proposed Waste Acceptance Criteria (as well as the AEE) do not consider contaminants of concern for a modern 21st century landfill it is not possible to determine with any certainty that the management measures adopted by the site will give an adequate level of protection to the environment or the public.

Andrew Rumsby

5 May 2022

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