Under	the Resource Management Act 1991 (**RMA**)
In the matter of	an application by **Dunedin City Council** for resource consents for the operation, closure and aftercare of the Green Island Landfill, Dunedin.

Statement of evidence of Dusk Mains

4 March 2025

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Qualifications and experience

1 My name is Dusk Lily Mains.

2 I am currently employed by GHD as a Technical Director specialising in hydrogeology, groundwater-surface water interactions and water quality.

3 I have over sixteen years' experience in hydrogeology and environmental science. My experience includes assessment of effects on groundwater over a wide range of applications and project settings, in both New Zealand and Australia. My project experience includes dewatering assessments (infrastructure and mining), groundwater supply and aquifer characterisation, surface water interactions (wetlands, stormwater basins, and streams), and water quality assessments (wastewater discharges, landfills and contaminated sites).

4 I have the following qualifications and relevant experience:

(a) Bachelor of Science with Honours in Geology from the University of Otago;

(b) Master of Science in Hydrogeology from the University of Western Australia;

(c) I have provided assessment of effects to groundwater for a variety of projects including landfills, quarrying and mining, wastewater discharges, and infrastructure. In undertaking these projects, I have been required to interpret a wide range of desktop and field information in order to conceptualise the groundwater system and assess the effects of the activity;

(d) I prepared the Groundwater Effects Assessment and presented evidence at the hearing for the Green Island Resource Recover Park, which is relevant to this application;

(e) I have led the groundwater investigations into several stormwater and flood management projects for the Christchurch City Council. I have undertaken groundwater modelling to understand the groundwater and tidal interactions with proposed stormwater basins and wetlands including the impact of sea level rise. One of these projects, included characterising the groundwater flows through a historic landfill. In these investigations I utilised a 2D groundwater modelling approach to characterise groundwater and surface water interactions as I have done for the Green Island Landfill assessment.

5 My assessment is based upon the description of the Application as contained in Section 2 of the AEE.

6 I have visited the Green Island Landfill site in August 2022.

7 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2023. This evidence has been prepared in accordance with it, and I agree to comply with it. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of evidence

8 I have been asked to prepare evidence in relation to the groundwater effects of the proposal. As per the directions set out in the Commissioner's minute[1], this evidence is focused on potential areas of contention in relation to leachate migration and groundwater monitoring.

9 My evidence includes:

(a) an overview of the site history and operation of the leachate interception trench;

(b) the existing environment and characteristics of groundwater at the Green Island Landfill;

(c) the key findings of my assessment of effects on groundwater,

(d) matters raised by the technical review and submitters on the application; and

(e) comment on proposed conditions of consent.

Executive summary

10 I have provided a brief overview of the site setting and provided a response to matters raised by the groundwater technical review and subsequent evidence completed by Mr Tim Baker. I have also provided comment on potential leachate mitigation options in response to the matters raised in the evidence of Mr James Elliot. I have also considered matters raised by submissions from Otago Fish and Game Council and Te Rūnanga o Ōtakou (Aukaha).

11 Leachate head within the landfill is expected to decrease over the coming years as the landfill is progressively capped and closed. The design of the

[1] RM23.185 Directions of the Commissioner, Minute 1. 21 January 2025.

cap, as described in the application and the evidence of Mr Adrian Roberts, will reduce rainfall infiltration and generation of leachate. Other mitigation measures are also proposed including the continued installation of horizontal leachate drains within the waste and pumping of leachate from installed Landfill Gas wells.

12 I consider that the presence of ammoniacal nitrogen, boron and metals outside the leachate interception trench can be explained by natural conditions. On that basis I consider that these analytes are generally not suitable for use as landfill leachate indicators in this environmental setting.

13 I have reviewed the monitoring dataset and the available evidence indicates that the leachate trench is effective in managing leachate from the landfill. The surface water dataset does not suggest that discharges from the landfill into the Kaikorai Stream have resulted in contaminant impacts in surface water that are readily discernible from those that are associated with the broader catchment, as discussed further in the evidence of Ms Kylie Dodd.

14 I support the proposal of additional monitoring wells at the southwest edge of the site to characterise the groundwater in this area. I consider that the proposed monitoring, triggers and adaptive management associated with the residual uncertainty of leachate migration is best captured within the Landfill Development Management Plan, Landfill Closure Plan and also an Adaptive Management Plan if it is demonstrated that leachate migration is occurring.

Sections as set out in scope of evidence above

15 My evidence is based upon the information reviewed to inform the groundwater assessment of effects which I prepared. This information includes environment monitoring data and other site reports relating to the landfill history and previous investigations. I have focussed my evidence on matters raised by the groundwater technical review (supporting the ORC notification report) and subsequent evidence prepared by Mr Tim Baker. However, I have also included background information where I think it is useful to provide context.

Site Description and Landfilling History

16 A brief overview of the site and landfilling history is provided below:

(a) Waste disposal first occurred at the Green Island site in 1954 with the disposal of industrial waste and the site has been used for waste disposal since that time.

(b) Landfilling commenced at the south-east corner of the landfill site and has continued north and west over the decades

(c) The pre-existing landform for the Green Island landfill was tidal estuary associated with the upper reaches of the Kaikorai Estuary.

(d) Waste was originally end dumped directly onto the estuarine muds and up against the southeastern estuary edge where the pre-existing landform rises gently to the southeast.

(e) A soil bund has been constructed around the edges of the landfill in the early 1990's to constrain waste placement.

(f) Leachate is managed via a leachate trench which was commissioned in 1995.

17 The leachate trench was installed around the perimeter of the site with the exception of the southern boundary and between MH8 and PS9. In these areas, the landfill abuts areas of low permeability Abbotsford Formation siltstone and mudstone

18 The trench creates a hydraulic barrier for groundwater and leachate migration offsite. The continuous dewatering of the trench is required to maintain this barrier, with the pump stations set to maintain water levels at low levels to create the hydraulic gradient which directs groundwater and leachate flow to the trench. Pumped leachate is piped to the Green Island Wastewater Treatment Plant (WWTP) for disposal.

19 The leachate trench was constructed within the Upper Kaikorai Estuary Formation (UKEM), an estuarine sedimentary deposit comprising silty fine to medium sand and sandy silt as shown in Figure 1. The UKEM is underlain by low permeability organic silt and silty clay of the Lower Kaikorai Estuary (LKEM) formation. Abbotsford mudstone and siltstone underlies the estuary sediments, acting as a barrier (aquitard) to groundwater flow. In some locations a thin layer (~0.5 m) of sand or gravel was encountered between the LKEM and mudstone.

20 The weight of the landfill is likely to have compressed the estuarine sediments underlying the waste further reducing the permeability of the sediments and likely the cause of increasing groundwater levels in MW4D (installed in the LKEM).

21 I have reviewed the monitoring dataset and the available evidence indicates that the leachate trench is effective in managing leachate from the landfill. The surface water dataset does not suggest that discharges from

the landfill into the Kaikorai Stream have resulted in contaminant impacts in surface water that are readily discernible from those that are associated with the broader catchment as discussed in the evidence of Ms Dodd.

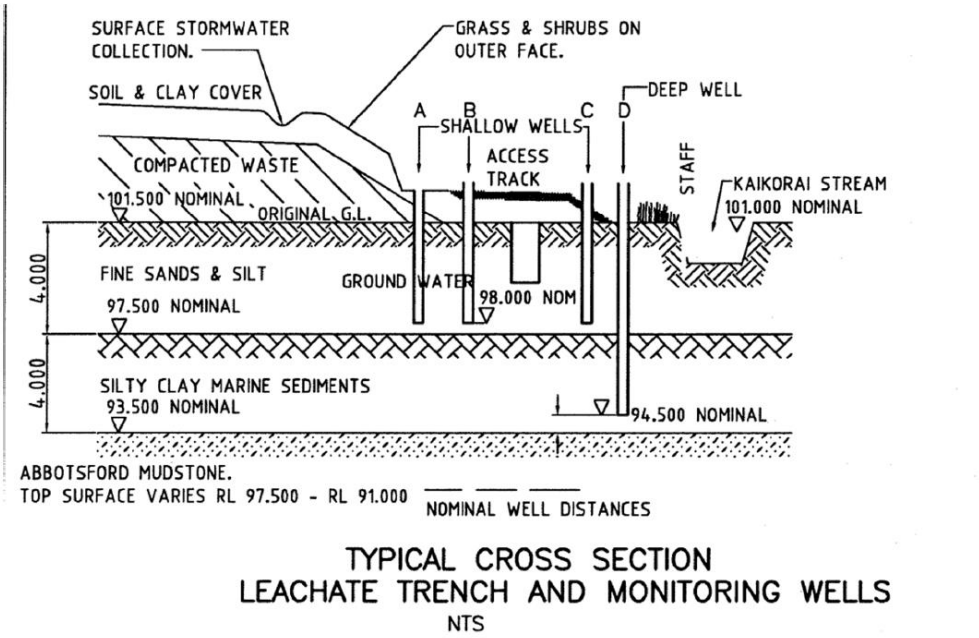

Figure 1 Schematic of leachate trench (MWH, 2004)

Matters raised by ORC technical review

22 I have reviewed the ORC notification report (prepared by Ms Shay McDonald), associated technical reviews and evidence. In particular, I have addressed the matters raised in the Groundwater Technical Review and evidence prepared by Mr Tim Baker.

23 Both the ORC notification report and Mr Baker's review state that the Groundwater Assessment (GHD, 2024) assumes that the leachate trench intercepts all groundwater and prevents offsite migration. My assessment concluded that the leachate trench was effective at intercepting leachate. This is based on following lines of information:

(a) Review of groundwater level monitoring records which shows hydraulic gradient is maintained with lowest groundwater levels recorded adjacent to the trench suggesting groundwater and leachate movement from the landfill is towards the trench.

(b) Surface water monitoring does not suggest any significant discharge of leachate to the receiving environment (surface water), as discussed in the evidence of Ms Dodd. If the trench was not operating effectively I would expect to see an impact to surface water quality as discussed in the application.

24 Mr Baker has outlined concerns with regards to the offsite migration of leachate within the deeper estuarine sediments (LKEM) and in particular at the southwest edge of the landfill. This area is considered to be hydraulically down gradient of the landfill based on the flow paths of historic channels on the estuarine sediments as shown in the 1942 aerial photographs (Figure 2).

Figure 2 1942 Aerial photos showing pre existing landform

25 There are currently only two compliance monitoring wells (MW2D and MW4D) that intercept the LKEM. These wells are located on Line 2 and Line 4 respectively (see Figure 3). I agree that the monitoring well coverage in the LKEM is limited and have proposed that BH103 (installed in 2022) is included in the future monitoring programme.

26 Mr Baker has also proposed a monitoring well cluster to characterise the groundwater environment at the down gradient edge of the site with three wells each screened in different layers (UKEM, LKEM and mudstone) to be located at the southwestern edge of the site. I support this proposal as it will provide further information of the groundwater environment. However, due to access issues I suggest that the wells are constructed on the bund between the two ponds as shown in Figure 3.

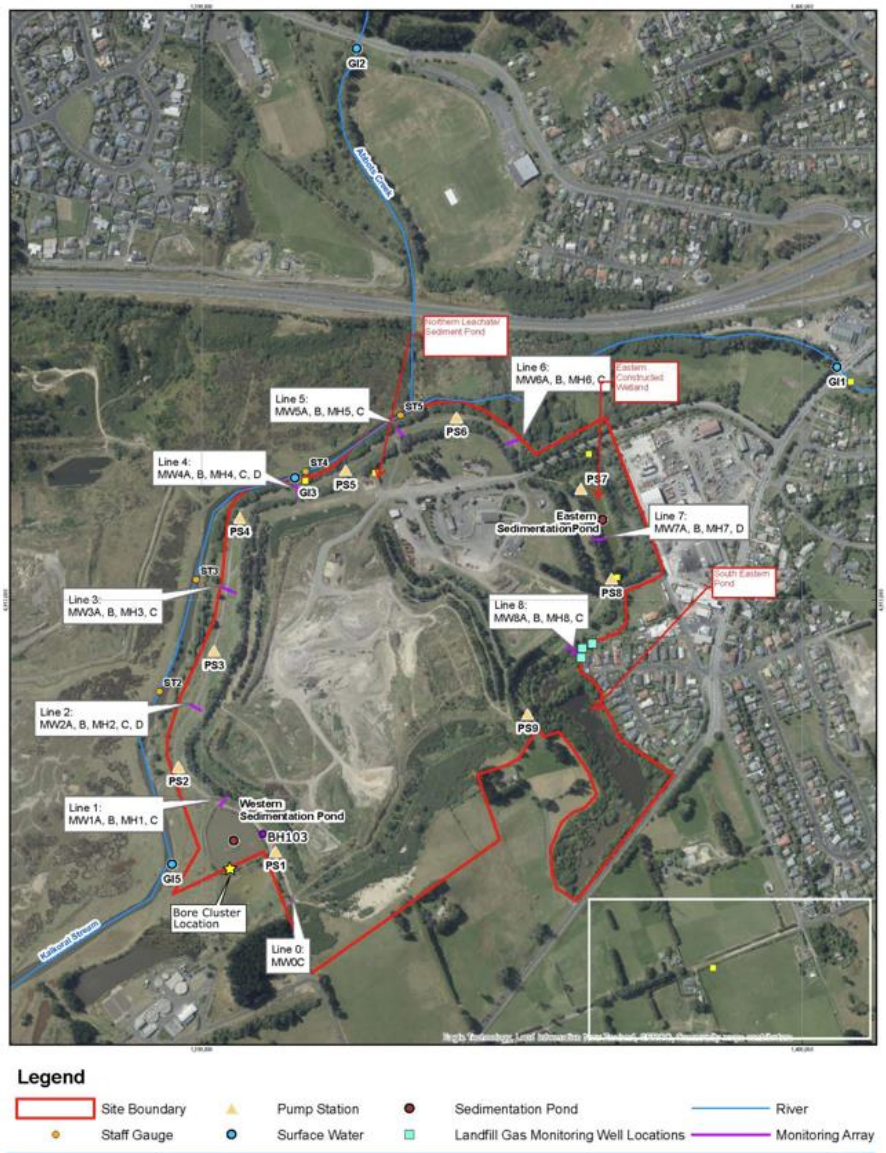

Figure 3 Location of proposed monitoring well cluster, revised location shown by yellow star.

27 Mr Baker has also proposed additional deep wells at Line 1 and Line 3. I consider that with the addition of BH103 and the proposed well cluster, there is sufficient spatial coverage at the southwest boundary of the site (near Line 1). The northwest boundary is covered by deep wells on Line 2 and 4 (MW2D and MW4D), while an additional well may provide some more information about the LKEM in this area, I consider it lower risk in relation to any historic flow paths. However, this could be reassessed following a review of monitoring data from new wells (after three years) as part of the site management plan as discussed below.

28 Mr Baker has requested that an adaptive management plan is developed for the site. I support this in principle but would note that any mitigation and/or contingency actions are reasonable and appropriate for the site. I consider that the proposed monitoring, triggers and adaptive management associated with the residual uncertainty of leachate migration is best captured within the Landfill Development and Management Plan, Landfill Closure Plan, and Adaptive Management Plan if leachate migration is demonstrated to be occurring. I support an adaptive and collaborative approach with the regulatory body to ensure that the monitoring plan is fit for purpose and does not result in unnecessary monitoring or costly actions that do not achieve a meaningful outcome for the wider environment.

29 Mr Baker's review highlights the risk of leachate breakout on the face of the landfill due to high leachate levels. I acknowledge that the landfill leachate levels are high in some parts of the landfill and in the past leachate breakouts have occurred. However, leachate levels are expected to reduce with time as approximately a third of the main landfill has been capped with a low permeability cap. This cap was completed in 2022. Up until this time rainfall was allowed to infiltrate into the waste generating a significant leachate head. This cap will be progressively extended over the whole landfill through to closure. Additional mitigation measures being undertaken include:

(a) Installation of horizontal leachate drains within the waste

(b) Pumping of leachate from landfill gas wells.

For these reasons, it is expected that the leachate level will reduce in the coming years as discussed in the evidence of Mr Roberts.

30 Mr Elliot has also raised concerns with regards to the leachate level in the landfill and the potential for leachate migration and has proposed conditions relating to a leachate pumping trial. While leachate management is required to manage geotechnical risk as discussed in the evidence of Ms Debbie Fellows, I do not think that a trial is necessary given the proposed

monitoring conditions (including additional wells). Given the low permeability of the estuarine sediments, it is likely that if leachate migration occurs, the movement will be very slow. Should the monitoring data suggest significant leachate migration from site, there are number of mitigation measures available that could be employed to intercept or form a barrier to leachate flow. These include, but are not limited to:

(a) Installation of physical barriers to groundwater flow such as sheet piling

(b) Extraction /pumping of leachate from affected area via well points or similar.

31 If the monitoring data identifies a significant leachate breakout, it is recommended that further characterisation of any potential leachate plume is undertaken (i.e additional ground investigations and monitoring wells) to determine the best mitigation option or combination of options for the location. Targeted reduction of leachate head within the landfill (through pumping), may also be undertaken. Although I note that the effects of this action at the boundary will be delayed due to the low permeability conditions of the underlying geology.

32 The technical review discussed the groundwater quality in the deeper C and D wells and noted similarities to the groundwater monitoring undertaken at the closed Fairfield Landfill, located on the other side of the estuary from Green Island landfill. The groundwater assessment for the Fairfield Landfill identified elevated boron, ammoniacal nitrogen and zinc in monitoring wells beyond the site boundary and attributed these to landfill leachate. I have not seen the data in question. I understand that the Fairfield landfill is similar to Green Island in terms of the geological setting and also controls leachate via a boundary interception trench. However, the presence of these analytes at elevated concentrations does not necessarily indicate the impact of leachate and may be explained by the geological setting as discussed below.

33 Groundwater quality in LKEM[2] wells (MW2D, MW4D and BH103) is characterised by high electrical conductivity, dissolved ions (in particular chloride and sodium), elevated ammoniacal nitrogen and iron. Nitrate nitrogen and sulphate are comparatively low. These results suggest a highly reducing environment (with the influence of a marine setting). While not measured it is assumed that sulphur is primarily in the reduced sulphide

[2] Monitoring well MW7D is thought to be installed within waste and is not considered representative of the LKEM.

form. Elevated dissolved iron concentrations suggests that Fe^{2+} is the dominant iron species due to the low solubility of the oxidised iron species (Fe^{3+}). The reducing conditions also mean that any metals (such as zinc) are typically in a more soluble ionic form, allowing these metals to be dissolved from the aquifer materials and remain present in naturally high concentrations.

34 The high concentration of dissolved ions (chloride and sodium) are consistent with the estuarine setting and interaction with sea water during the deposition of the sediments. I note that these ions are at higher concentration in deep groundwater than in leachate (represented by the sample from Leachate Pumping Station 3 (PS3)). It is considered likely that salts within the sediments and/or salt water within pore spaces continue to influence the groundwater quality in the deeper monitoring wells. Boron occurs at a concentration of 4-5 mg/L in sea water and is elevated in clay rich marine sediments. Therefore, groundwater in estuarine and marine sediments commonly has elevated boron concentrations, relative to other freshwater environments. In the deep wells, the concentration of boron is typically ~0.8 mg/L. Likewise, the elevated nitrogen (as ammoniacal nitrogen) in monitoring wells may reflect the presence of organic matter within the estuarine sediments. Such processes are naturally occurring and consistent with the geological setting.

35 I consider that the presence of ammoniacal nitrogen, boron and metals outside the leachate interception trench can be explained by natural conditions. On that basis I consider that these analytes are generally not suitable for use as landfill leachate indicators in this environmental setting.

36 Mr Baker notes that PFAS compounds are present in some monitoring wells as potential evidence of leachate migration. The PFAS sampling to date has been limited (three sampling rounds) and results have been inconclusive. PFAS has not been detected in some wells located in areas of historic waste, conversely low concentrations have been measured in wells outside of waste affected areas. The low level PFAS contamination in areas outside of historic deposition activities or in deep wells (MW4D) may relate to historic activities within the landfill and catchment prior to the installation of the leachate trench. PFAS concentration in surface water (Kaikorai Stream GI1, GI3 and GI5) are in a similar range to or greater than most groundwater samples with a significant amount of the PFAS present originating from upstream of the landfill. However, I note that the concentrations detected in monitoring wells are at least an order of magnitude (or more) lower than the sample from Leachate Trench Pumping Station 3 (PS3) which represents a mix of leachate and groundwater. Given

the limited site data on PFAS distribution, I support the inclusion of this parameter within the monitoring suite.

Matters raised by submitters

37 I have reviewed submissions on the application, two submissions, Otago Fish and Game Council and Te Rūnanga o Ōtakou (Aukaha), have raised concerns in relation to the matters covered by the groundwater assessment.

38 Both the Otago Fish and Game and the Te Rūnanga o Ōtakou submissions expand on concerns raised by Mr Baker in his technical reivew. In particular:

(a) Whether the leachate trench intercepts all leachate at the site boundary.

(b) Whether the current and proposed monitoring network sufficiently covers the areas of highest risk to groundwater.

(c) Whether elevated levels of ammoniacal nitrogen, boron and zinc are natural or indicative of landfill leachate.

39 I have discussed these key issues in my response to Mr Baker‘s technical review. Furthermore, I support the proposal of additional monitoring wells at the southwestern edge of the site to provide further information on the groundwater conditions in this area and the development of a adaptive management plan.

40 Otago Fish and Game have raised concerns with regards to the leachate head within the landfill. While it is high in some areas, I expect that the level will start to decrease with the progressive capping of the landfill and implementation of drainage systems as discussed in paragraph 29. I have provided further comment on potential leachate mitigation measures in paragraph 30.

41 Te Rūnanga o Ōtakou have requested that, in colloboration with mana whenua, measures to avoid or mitigate the impacts of leacahte on the environment. I have provided discussion on potential mitigation options in paragraph 30 should significant leachate breakout occur. Any mitigation measures adopted would need to be site specific and based upon the information obtained from additional investigations.

Conditions of consent

42 I have reviewed the proposed conditions of consent. As discussed above I support the addition of a monitoring well cluster at the downgradient end of the site (General Condition 41). I question and do not support the need for an additional monitoring well at Line 1 given the proximity to the new well cluster and BH103. I consider Line 3 to be a lower risk in relation to historic flow paths, but I am open to a review condition following 3 years of monitoring of the new well cluster and BH103.

43 General Condition 42 includes the monitoring schedule for both groundwater and surface water. These parameters have been combined into a single table (Table 1 of the general conditions of consent). I think that not all the parameters are necessary or applicable to groundwater. In particular, total suspended solids (TSS) is generally only of concern in surface water environments. Furthermore, microbiological parameters such as E.coli are only of concern to surface water environments (where contact may occur) or drinking water. As the aquifer is not used for groundwater supply I do not think it is necessary to include microbiological parameters in the groundwater monitoring suite.

44 Conditions 45 and 46 relate to the setting of trigger levels in groundwater and surface water. For groundwater, the trigger levels are to be determined based on historical data. I consider that trigger levels should only be set for contaminants of concern. I note that the surface water trigger levels included in Table A1 of the general conditions of consent includes major ions such as chloride, calcium and sodium. While these general water chemistry parameters can be useful in assessing water types and water quality trends they are not contaminants of concern in the environment therefore a trigger level should not be defined for these parameters.

45 Condition 5 of the Water Permit (Section C - RM23.185.02) requires that the telemetry is installed to record the combined groundwater and leachate flows at 15 minute intervals and that this unit sends all the data to the Consent Authority. My assessment concluded that the groundwater take associated with the trench is very small, in the order of 1-2 L/s, with no impact on other groundwater users and a negligible effect on surface water flows. On that basis, I do not think that detailed monitoring of flows is warranted as the effects of the take are negligible. The proposed conditions already include a requirement to measure and report leachate pumped volumes as part of the annual report. I consider this to be appropriate for the scale of the activity. In addition, the data is available to the ORC upon request.

Dusk Mains

4 March 2025