Tonkin+Taylor

Job No: 1011469
2 September 2021

Otago Regional Council
Private Bag 1954
Dunedin 9054

Attention: Hilary Lenox

Dear Hilary

Technical Review to Inform Notification Decision: Smooth Hill Landfill - Appendix 8 - Groundwater Report

Introduction

1 Dunedin City Council (DCC) proposes to establish a new Class 1 landfill, to be located at Smooth Hill to the south of Dunedin Airport. DCC has applied to Otago Regional Council (ORC) for a range of resource consents required for the establishment and operation of the proposed landfill.

2 Tonkin & Taylor Ltd (T+T) has been engaged by ORC to undertake a technical review of the air quality assessment lodged by DCC in support of its resource consent applications.

3 The purpose of this report is to set out the findings of our technical review of DCC's groundwater assessment to inform a decision to be made by ORC regarding notification of the resource consent applications.

4 The following documents have been considered as part of this technical review:

- **Dunedin City Council - Proposed Smooth Hill Landfill: Section 92 Review - Requests for Further Information:** *Report prepared for ORC by T+T, September 2020.* (Herein referred to as the s92 request').
- **Revised Appendix 8 - Groundwater Report:** *GHD August 2020 (Updated May 2021). Waste Futures Phase 2 – Work Stream 3. Smooth Hill Landfill. Assessment of Effects to Groundwater. Report prepared by GHD Limited for Dunedin City Council..* (Herein referred to as the 'Groundwater Report').
- **Smooth Hill Landfill Further Information.** *Provided by ORC as part of its s92 response of 4 August 2021.* (Herein referred to as the 'further s92 response').
- **Smooth Hill Landfill – Additional s92 Question Responses – Groundwater**. GHD provided a pdf of Figure 6 (Conceptual Groundwater Model), a jpeg of 'Conceptual proposed landfill toe cross section' and a jpeg of 'potential for groundwater during excavation' on 10 August 2021, previously not included in the Groundwater Report. *Provided by ORC as part of its further s92 response of 4 August 2021.* (Herein referred to as the 'conceptual groundwater model figures').
- **Smooth Hill Landfill Draft Conditions.** *Provided by ORC as part of its further s92 response of 4 August 2021.* (herein referred to as the 'draft conditions').

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5 An on-line meeting was held between Sally Lochhead (T+T Senior Hydrogeologist) and Zoe Pattinson (GHD Hydrogeologist), Antony Kirk (GHD Principal and Technical Director) and Nick Eldred (GHD Technical Director) on 28 July 2021 to discuss aspects of the Groundwater Report and s92 response relating to the conceptual groundwater model. The meeting satisfactorily clarified a number of matters.

6 This technical review has been undertaken by Sally Lochhead, Senior Hydrogeologist at T+T. It has been prepared in accordance with T+T's letter of engagement with the ORC dated 12 November 2019.

Description of the proposal

7 The proposed Smooth Hill municipal landfill is intended to replace the existing Green Island landfill located in Dunedin. The Smooth Hill Landfill is reduced in scale from the original application as follows:

- A footprint of 18.6 ha instead of the original 44.5 ha.
- A gross capacity reduced form 7.9 million m³ to 3.3 million m³.
- Net waste capacity of 6.2 million m³ to 2.9 million m³.
- The predicted landfill life reduced from 55 years to 40 years.

8 The construction of the proposed landfill will include the placement of a landfill liner, designed to minimise leakage of the leachate into the underlying ground and groundwater, and a leachate drainage system to control the leachate head within the landfill, reported to be controlled with a maximum head of 300 mm.

9 The construction of the proposed landfill will control/intercept shallow groundwater beneath the landfill. A network of subsoil drains will be constructed beneath the landfill lining system with drainage taken to an access manhole before discharge to the Otokia Creek catchment. A groundwater discharge rate of 87 m^3/d is predicted from the sub-surface drains.

10 The Groundwater Report provides a technical assessment of the potential effects on groundwater which includes consideration of the hydraulic connectivity with the surface water, and the effects of leachate leakage on groundwater quality.

11 The key discharge from the proposed landfill has been identified in the Groundwater Report as being leachate. A resource consent for the discharge of leachate onto land that may result in contaminants entering groundwater has been proposed.

12 The proposed landfill requires a resource consent for the taking of groundwater from the landfill groundwater collection system and use for non-potable water supply.

Receiving environment

13 The site is located within a range of hills between the Taieri Basin and the coast. This rural site setting is bounded by forestry land to the north and west, and farmland to the northeast.

14 Section 2 of the Groundwater Report describes the existing environmental setting for the proposed landfill, noting that until recently, the majority of the site was covered by forestry. Following the on-line meeting between T+T and GHD, the applicant confirmed that the forestry had been cleared up to 5 years prior and scrub/gorse covers most of the area.

15 Figures in the Groundwater Report of the site location show the application site and the Smooth Hill Designation (2GP) being a wider area which extends over multiple valleys. The landfill footprint is located in one valley in the eastern part of the wider area.

16 The proposed landfill footprint is shown to extend up a valley with side gullies between approximately 95 m above mean sea level (amsl) and 150 m amsl based on the contours included in figures of the Groundwater Report. Most of the site and upper reaches of the gullies are reported to be dry with ephemeral stream flows.

17 The proposed landfill footprint and associated infrastructure is located within the upper reaches of the Otokia Creek Catchment which sits within the McColl Creek surface catchment. The Otokia Creek is dry immediately downstream of the proposed landfill and is reported to be an ephemeral watercourse. Perennial stream flows of the Otokia Creek occur approximately 1 km downstream of the proposed toe of the landfill.

18 The proposed landfill footprint is identified by the applicant to be in an area of limited groundwater resource. The McColl Creek surface water allocation is identified as the groundwater allocation catchment for the proposed landfill footprint. There are no bores or consents shown on the provided Figure 5, within the McColl Creek Catchment.

19 Site investigations with the drilling of boreholes have been undertaken to identify the geological and hydrogeological conditions at the site. Following an on-line meeting held between Andrew Stiles (T+T Geotechnical Consultant) and Samantha Webb (GHD Technical Director Engineering Geology) on 29 July 2021, the applicant advised that another borehole is currently being drilled mid-way between two existing bores to further inform the geotechnical investigation within the proposed landfill footprint.

20 Two groundwater systems (shallow and deep) are reported to exist at the site. The applicant has identified that the shallow groundwater system is limited to the valley setting and does not fully overlie the deeper groundwater system. The receiving groundwater system from the potential landfill discharges (leachate) has been identified predominantly as the shallow groundwater system.

21 Rainfall data provided in the Groundwater Report uses data within 25 km of the site and this is reported to vary significantly in rainfall amounts. During the on-line meeting between T+T and GHD, the applicant emphasized that the catchment is relatively dry and this is confirmed by the rainfall amounts recorded at the on-site meteorological station which has been established at the site since mid-2020.

22 Overall, we agree with the Groundwater Report description of the receiving environment.

Assessment of hydrogeological setting

23 The site-specific investigations have shown the proposed landfill site is underlain by the Upper Cretaceous Henley Breccia (sandstone, siltstone and breccia units). The weathering of the Henley Breccia has been identified by the applicant in two groups; completely weathered to highly weathered, and unweathered to slightly weathered, although reference to moderately weather bedrock is also referred to. The Henley Breccia is overlain by loess deposits which cover much of the existing slopes, with alluvial deposits and colluvium in the valley and gullies. The proposed landfill construction will remove the loess deposits, alluvial deposits and colluvium from the landfill footprint.

24 The proposed landfill footprint is located in the McColl Creek Catchment, of which the Otokia Creek drains to the north from the proposed landfill. The application site boundary identified on Figure 1 of the Groundwater Report includes other surface water catchments. These are not discussed in the Groundwater Report because the landfill footprint is not sited in the other surface water catchments. Although the southeast boundary of the landfill extends to the top of the McColl Creek Catchment and borders to the Fern Stream Catchment.

25 A shallow groundwater system within the alluvial deposits, colluvium and shallow Henley Breccia has been identified at the proposed landfill site in the valley. (Comments on further details are provided below).

26 A deeper groundwater system has also been identified within the deeper moderately weathered to unweathered Henley Breccia at the proposed landfill site. (Comments on further details are provided below).

Shallow groundwater system

27 The extent of the shallow groundwater system is limited to within the alluvium, colluvial deposits and the shallow Henley Breccia. The shallow groundwater system sits in the valley and has not been identified to extend toward the ridgelines.

28 The direction of groundwater flow in the shallow groundwater system has been assessed to be controlled by the topography with discharge in the valley. Within the proposed landfill footprint, shallow groundwater flows are inferred to be approximately toward the northwest.

29 The shallow groundwater system is described to locally provide flows to the Otokia Creek. Horizontal hydraulic gradients (flows inwards toward the valley) have been interpreted with minor artesian conditions at valley boreholes.

Deeper groundwater system

30 The deeper groundwater system has been assessed not being topographically constrained and not defined by the surface water catchments. However, this is contradicted by the applicant with comment that inference of a groundwater divide in the deeper groundwater system is along the north-south trending ridgeline of the western portion of the application site.

31 Downward vertical gradients dominate the deeper groundwater flow because the site investigations undertaken by the Applicant have identified horizontal flow paths in the deeper Henley Breccia are restricted by the lack of defects, such as fractures in cores. This has also been assessed based on a comparison of the groundwater levels recorded in the deeper monitoring bores.

32 The initial Groundwater Report quoted two opposing directions for the deeper groundwater flow. Conceptual geological sections provided in the Groundwater Report were updated following the s92 request. Figure 6 'Conceptual Groundwater Model' shows the deeper groundwater flow direction has been assessed by the Applicant to flow southeast toward the Pacific Ocean, and the previous opposing direction has been discounted. This is based on the Applicant's inference that the groundwater divide is along the north-south trending ridgeline of the western portion of the application site.

33 The Applicant advised that an additional borehole is currently being drilled within the proposed landfill footprint which will contain nested groundwater monitoring piezometers. The information gained by the drilling of the additional bore is required to demonstrate this flow direction.

34 Based on the information presented above, T+T generally agrees with the Applicant's assessment of the hydrogeological setting. It is expected that additional site investigations as described above will provide additional information to support the deeper groundwater flow direction and that this information can be used in setting appropriate monitoring conditions.

Groundwater flows

35 Horizontal hydraulic gradients are identified to be "*more influential*" in the shallow groundwater system, although only vertical hydraulic gradients have been calculated in the Groundwater Report which show a range of vertical hydraulic gradients for the groundwater systems.

36 The initial Groundwater Report did not provide detail on groundwater travel times. The subsequent s92 response provided an estimate of shallow groundwater velocities at the toe of the proposed landfill. Indicative groundwater velocities for the deeper groundwater system have been provided based on estimates of hydraulic conductivities of the Henley Breccia based on field testing data.

37 Based on the information presented in the Groundwater Report T+T agrees with the Applicant's assessment of the hydrogeological setting.

Assessment of conceptual groundwater model

38 The site-specific investigations were undertaken to provide information for both geotechnical and hydrogeological purposes which have formed the basis of the conceptual site hydrogeological model. The borehole locations targeted the ridgelines within the application site boundary and the valley locations. The proposed landfill footprint has been reduced in size since the original investigations.

39 The depth to the groundwater surface is shown to vary significantly across the proposed landfill footprint. Groundwater levels in the ridgeline bores are at depths greater than 40 m below top of casing (btoc). Some shallow depth bores in the valley are shown to record artesian conditions, whereby the groundwater level is above the ground surface. Other bores on the lower valley slopes record groundwater depths at approximately 4 m to 5 m btoc.

40 Following the on-line meeting between T+T and GHD, the Applicant provided clarification and further description on the intact nature of the Henley Breccia and the absence of fractures and defects within the cored boreholes at depth. Further satisfactory explanation was provided on how the groundwater flows will be low and slow groundwater travel times would occur within the deeper groundwater system in the Henley Breccia.

41 The conceptual groundwater model figures of the shallow groundwater system at the proposed landfill toe shows the fine-grained low permeability layer (brown silt layer) to act as an aquitard for the shallow groundwater system. This brown silt layer is inferred (by the cross section illustration) to extend toward the north between BH201 and BH03. The Applicant has advised that this stratum has been recorded in the core at one bore location and inferred by observations of the drilling arising at another location. The lateral extent and effectiveness of the fine grained low permeability layer to act as an aquitard is not fully understood.

42 It has been acknowledged by the Applicant that the extent of the shallow aquifer cannot be well defined. Based on the conceptual groundwater model figures (updated Figure 6), the inferred area (width and length) of shallow groundwater system is different to that of the other figures in the Groundwater Report and a large part of the proposed landfill footprint is overlying the deeper groundwater system with groundwater flows toward the southeast. Limited detail has been provided on the 'shallow' part of the deeper groundwater system i.e. within the completed weathered to highly weathered Henley Breccia on the side slopes of the valley. It is expected that the additional site investigations as described above will provide additional information on the groundwater systems in the centre of the landfill footprint.

43 We disagree with the statement "that a more detailed quantification of recharge to the deep groundwater system is not considered to add value to the assessment as the risks associated with this flow path are minimal relative to those of shallow groundwater". This uncertainty can be addressed through a consent condition to monitor the deeper groundwater at the toe of the landfill (as proposed in our consent conditions).

44 Further information needs to be provided through groundwater level monitoring (as per our proposed consent condition) to support the conceptual groundwater model and to provide baseline levels.

45 Overall, clarification was sought on a number of matters through the s92 request for further information and the on-line meeting. Most of these matters have been addressed and given the site context, we are generally satisfied with the conceptual model. However, we expect additional information to the conceptual groundwater model gained from the additional investigation bore to be provided by the Applicant as part of the ongoing conversations or in evidence, should the application be heard.

Assessment of effects

Groundwater quantity

46 Groundwater seepages have been noted at a number of locations around the site. A plan has been provided showing the potential for groundwater to be encountered during excavation (construction of the landfill), predominantly at the valley floor and northeast side slopes in an area of proposed cut.

47 Recharge to the shallow groundwater system will be reduced as a result of the placement of the landfill which will prevent direct recharge to the shallow groundwater system from rainfall. Recharge to the shallow groundwater system is identified (in the Groundwater Report) to continue to occur from runoff and shallow groundwater recharge (upward flows) from within the shallow Henley Breccia. The extent of this recharge is not clearly known, given the uncertainty with the lateral extent of the shallow groundwater system. Section 4.4 of the Groundwater Report states that: "*there will be no further recharge to the shallow groundwater system….*" Therefore, there is some discrepancy with groundwater flow contributions. However, given the site context we consider the differences in groundwater flow contribution will be minor.

48 Groundwater levels in the shallow groundwater system are predicted to lower by 1 m due to the reduced groundwater recharge. This has been assessed to have a knock-on effect on the baseflows to the Otokia Creek resulting in the change in the location (further downstream) of where permanent stream flows will occur. The Applicant is proposing to allow stormwater in the attenuation pond to soak to ground and provide additional baseflow to the surface water.

49 Is has also been assessed that the lowering of the groundwater levels through the reduction of recharge would result in a reduction in groundwater collection through the sub-surface drains to be negligible in the long term.

50 Condition 19 identifies continuous water quality monitoring of the subsoil drainage for pH, electrical conductivity and ammonia, and at a monthly frequency for the parameters set out in Attachment 1 will be undertaken.

51 Although T+T agrees with the statements above, and that the volumes of shallow groundwater calculated would be small based on the site setting and the information contained within the Groundwater Report, there is some residual uncertainty. However, given the site context, we consider the differences in groundwater volumes (associated with the groundwater flows) will be minor. We expect additional information to the conceptual groundwater model gained from the additional investigation bore to be provided by the Applicant as part of the ongoing conversations or in evidence, should the application be heard.

Groundwater quality

52 Limited groundwater (and surface water) sampling has been completed. The water quality results show that the groundwater quality is different to the surface water quality. Further groundwater (and surface water) monitoring needs to be completed to establish the baseline data prior to commencement of the construction works and conditions of consent are proposed to provide such baseline data.

53 The existing groundwater quality has been analysed and reducing (anaerobic) groundwater conditions have been identified in monitoring wells BH02, BH201 and BH04B based on low dissolved oxygen concentrations (BH02) and low concentrations of sulphate and the presence ammoniacal-N. Differences in the groundwater chemistry (analysed parameter concentrations) have been used to support conclusions on groundwater movement such as in the inferred locations of the low permeable silt layer.

54 High levels of nitrate have been identified in the existing groundwater quality obtained from some of the monitoring bores. The source of this has not been confirmed. Whilst a number of reasons have been postulated by the Applicant for high nitrate sources, no evidence has been substantiated. However, any seepage of from the landfill is unlikely to contain nitrate and it is not expected that the presence of the landfill would impact on nitrate levels in the groundwater.

55 Assessment of potential effects to surface water and groundwater have been modelled using the HELP software, which includes assessment of leachate generation and leakage of leachate through the landfill liner during different phase of the landfill operation. The greatest leachate generation volumes have been assessed at Stage 4 of the landfill operations.

56 Greatest volumes of leachate are predicted to be generated during Stage 4 of the operations and after landfill closure. The predicted leachate leakage rate through the landfill liner during this period is 0.26 m^3/yr.

57 We acknowledge that potential leachate ingress to the deeper groundwater system could occur, but is less likely given the location of the deeper groundwater at the site. One upgradient monitoring well GW1 is proposed immediately upgradient of the landfill footprint. No detail has been provided on this monitoring well depth (and any others). The depth of the monitoring well needs to be deep enough to capture groundwater flows in the deep groundwater system and conditions of consent are proposed to provide such monitoring well data.

58 Leachate contaminant flux has been assessed using concentrations from Class 1 Landfills (published data) and the groundwater data obtained from monitoring at the site. Contaminant flux has been modelled during Stage 4 of the operations, expected to be the worst case, and after landfill closure to show long term effects on surface water and groundwater quality. The assessment includes mixing of the shallow groundwater and migration of leachate with groundwater flow as a result of the leachate leakage.

59 Levels of lead dissolved reactive phosphorous (DRP), ammoniacal-N and iron are assessed to increase in concentrations as a result of the potential leachate leakage but not to exceed the adopted water quality criteria presented in Table 9.

60 There are some limitations from the investigation data which has resulted in gaps in the understanding of the shallow and deeper groundwater systems. Based on the current level of information, given the overall indicative low flows and slow travel times of groundwater flows within the deeper groundwater system, we consider that the potential effects on the groundwater quality of the deeper groundwater system will be less than minor.

61 Based on the current level of information, we consider that the potential effects on the groundwater quality of the shallow groundwater system will be minor. Recharge to the shallow groundwater system will be restricted by the placement of the landfill which will prevent direct groundwater recharge from rainfall and the potential leachate volumes are expected to be low.

Mitigation

62 A key focus of the T+T review of groundwater effects has related to the potential for leachate via leakage to reach the receiving groundwater and result in the contamination of the receiving environment. A hydrogeological conceptual model of the wider landfill site is pertinent to understanding the potential impact on groundwater from the proposed activity.

63 The landfill liner will be designed to minimise leakage of the leachate and will comprise either a Type 1 or a Type 2 liner, designed to meet the WasteMINZ landfill guideline specifications.

64 Another borehole is currently in the process of being drilled. Information reported to address the s92 questions for the geotechnical report has identified that the additional investigations

will include installation of nested piezometers into the shallow and deeper groundwater system.

65 Reliance on the landfill management plan (LMP) to address some matters raised by the s92 questions has been made. The Applicant acknowledges that the LMP is incomplete, and information will be included following further investigation and groundwater quality monitoring as part of the baseline monitoring.

66 A further response to the s92 questions provided details that bores GW 1 to GW 6, and BH202 will be the proposed groundwater monitoring bores (shown on Drg C309) to establish the derivation of the groundwater trigger levels prior to landfill construction. No design details of the monitoring bores are provided and these need to be provided by the Applicant to show the target depths and which groundwater system they are monitoring and conditions of consent are proposed to provide such monitoring well data.

67 Further monitoring will be undertaken of groundwater collected in the subsoil drainage and attenuation basin as outlined in the draft Landfill Management Plan.

68 In general, there is some residual uncertainty with some groundwater aspects and further detail on the conceptual groundwater model should be addressed by the Applicant as a part of ongoing communication or in evidence, should the application be heard.

69 Overall, we agree with these mitigation measures subject to the additional conditions below.

Proposed conditions

70 The proposed conditions relating to water quality are broadly appropriate subject to some refinement to address specific matters. However, most of the conditions are sufficiently advanced to reasonably enable this technical review to be completed for the purpose of determining notification requirements.

71 A condition proposed by the Applicant relates to the frequency of groundwater monitoring prior to waste being accepted. In this regard the Applicant has proposed the following:

> *"[17] Groundwater monitoring shall commence at least 18 months prior to waste being accepted at monitoring bores GW1 – GW6……to establish the baseline water chemistry and inform the development of monitoring trigger levels. Sampling of groundwater and surface water shall occur at least every 3 months for the parameters set out in Attachment 1 for those locations".*

72 We recommend that the condition be amended (as per below) to allow for a more comprehensive period of groundwater quality monitoring to establish baseline levels, from which trigger levels will be derived:

> *"Groundwater monitoring to collect groundwater level and groundwater quality data, shall commence at least 18 months prior to construction of the landfill at monitoring bores GW1 – GW6……."* and *"…….Sampling of groundwater and surface water shall occur every month for the 18 month monitoring period for the parameters set out in Attachment 1 for those locations".*

73 A key condition proposed by the Applicant relates to the Landfill Management Plan (LMP) and a list of objectives. In this regard the Applicant has proposed the following relating to the groundwater and surface water quality:

> *"[68 i] Monitoring bores are regularly maintained to prevent the ingress of contaminants".*

74 We recommend that the condition would be more appropriately worded in line with NZS 4411 Environmental Standards[1] as follows, which include the protection of the bore headworks:

> *"Monitoring bores shall be constructed in accordance with NZS 4411 and shall be protected to ensure that physical damage to the* bore headworks *does not occur".*

75 We recommend that the following condition is added:

> *"The Landfill Monitoring Management Plan shall describe, with justification, the target depths and design details for monitoring bores GW1 to GW6"*

76 Other than the above, the proposed conditions of consent are considered appropriate to cover groundwater quality issues for the proposed landfill.

Conclusion

77 We consider that some uncertainty remains with the conceptual hydrogeology model and there is a gap in knowledge between the shallow and deeper groundwater systems. From our review of all of the data, we consider that the potential effects of the landfill development can be appropriately managed through the proposed conditions of consent. The potential effects from construction and operation of the landfill on groundwater will be minor.

Applicability

This Report been prepared for the exclusive use of our client Otago Regional Council , with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

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[1] New Zealand Standard NZS 4411:2001, Environmental Standard for Drilling of Soil and Rock.