TE NEHENEHENUI

SUBMITTER INFORMATION
Name: Samuel Mikaere
Organisation: Te Nehenehenui
Address: PO Box 36, Te Kūiti 3910
Email: Sam@tnn.co.nz
Phone: 078786234
Contact: Tramaine Murray, Settlement Protection, Rights and Interests Manager
Email: Tramaine.murray@tnn.co.nz

10 September 2025

TABLED STATEMENT

JOINT HEARING AUTH146952 | LU/0231/24 | LU/0232/24
WAIKATO REGIONAL COUNCIL & WAIPĀ DISTRICT COUNCIL

Te Nehenehenui is the post-settlement governance entity under the Maniapoto Claims Settlement Act 2022, which represents and acts on behalf of Maniapoto (inclusive of all within Te Nehenehenui).

Te Nehenehenui acknowledges its partnership with Waipā District Council and Waikato Regional Council under the Ngā Wai ō Maniapoto (Waipā River Act) 2012 and Maniapoto Claims Settlement Act 2022 Joint Management Agreement.

Tabled Statement

Te Nehenehenui (TNN) acknowledges the Hearing Commissioners and appreciates the opportunity to participate in the hearings. Te Nehenehenui lodged submission points in both support and opposition of the proposal and was not seeking to be heard. We have attended several meetings with Toitū Te Whenua Land Information New Zealand, the most recent being 8 August 2025. We appreciate the applicant's willingness to engage with us and to provide additional information.

Subject to the following statement, we are now comfortable that our concerns have been addressed or will be addressed through the imposition of consent conditions.

As a result, we will not be pursuing our submission points further. Rather than withdrawing the submissions, we will leave the points 'live' to ensure that the appropriate conditions can be imposed as deemed necessary by the Hearings Commissioners.

While we are satisfied that our technical concerns have been addressed, we defer to mana whenua as kaitiaki of the area to address any cultural concerns, noting the significant progress that has been made in terms of the cultural support proposed for the project. A hui is planned for 16th September 2025 and TNN have assessed the planned cultural support measures. At this stage, we are satisfied that the measures proposed address our concerns, while acknowledging that this does not predetermine any final outcome.

Technical points

In Attachment 3 the applicant:

- Proposes to reduce the period when the diversions around the Wharekōrino Stream, can be in place from 16 weeks to up to 3 weeks per culvert, in order to provide additional certainty that there will be minimal effects on flow rates.
- Indicates that the permanent works will not adversely affect the stream base flows.
- Plans to have cultural support in place for the life of the project, including proposing to expand the scope of cultural monitoring to include all works in proximity to the Wharekōrino Stream.
- Proposes high-quality native planting in the areas of culvert 2 and 3, where the proposed works and riparian vegetation removal are to occur.
- Includes additional planting within the riparian margin of the Wharekōrino Stream between culverts 2 and 3 (weed removal, planting additional natives in the understorey and planting additional native trees in any appropriate gaps).
- Indicates that the soil intended for on-site disposal contains low to moderate levels of contaminants, primarily lead, zinc, and asbestos. At the concentrations identified at site and adopted as the site-specific standards, states that these substances do not pose a risk to groundwater and this soil is considered suitable for commercial or industrial land use.
- Notes the Crown will be responsible for the monitoring and compliance of the upgraded landfill in perpetuity and proposes twice yearly ground and surface water monitoring.
- Commits to inspecting the integrity of the landfill annually, noting the Crown will be responsible for undertaking any additional or remedial works required promptly.

In Attachment 4 and 5 the applicant:

- Assesses the culvert (3) design and states it is feasible for fish passage, based on both depth and velocity thresholds.
- Notes the culvert and new stream design feature a number of other features to promote fish passage, including the stream alignment, naturalisation using 150-300mm deep pools, rocks and logs; low flow channel; riparian planting; and resting pools at the culvert inlet and outlet.

- Concludes that the daylighting of culvert 2, the re-design of culvert 3 and the new section of channel that will divert Wharekōrino Stream around the landfill area has been designed to promote ecological values and will not result in any barrier to native fish passage.

In Attachment 6 the applicant:

- Notes that water quality monitoring has found that there are elevated dissolved boron levels within groundwater that passes through the landfill, leading to increased boron concentrations in the stream, but that the stream boron levels are well within ANZECC 95% freshwater trigger levels.
- Finds that boron discharges to the Wharekōrino Stream should significantly reduce by an estimated 72-92% over a medium-term period as a result of proposed improved landfill capping and groundwater diversion from the landfill.

It is our preference that as far as possible, these matters are included as consent conditions or existing conditions are amended to encapsulate the above points.

The section 42A report:

- Summarises our submissions at 9.2.1 and notes that many of the points raised in the submissions can be addressed through recommended draft conditions.
- Concludes the proposed erosion and sediment controls will mitigate the discharge of sediment during works if the controls are monitored and maintained for the entire works programme.
- Recommends a number of environmental monitoring conditions to ensure leachate discharge is managed and appropriate measures are employed during the landfill upgrade to ensure that no elevated leachate discharges occur.
- Notes that the proposed landfill upgrade includes the removal of the most offensive waste for offsite disposal, consolidation of waste to specific cells, diversion of freshwater around the landfill areas and improved capping which is expected to reduce discharge of contaminants overtime. Considers that this an improvement of the existing landfill management and the resulting leachate discharge.
- Considers that the proposal is consistent with the Vision and Strategy – Te Ture Waimana o Te Awa o Waikato and demonstrates that the required betterment can be achieved with improved water quality through the landfill upgrades, improved landfill capping and reducing consolidating waste areas.
- Is satisfied that the assessment provided by the applicant is not inconsistent with the Maniapoto EMP and the proposal will not adversely affect natural resources or taonga in the area.

We are supportive of the report's findings and recommended conditions in so far as they align with technical points raised above.

Once more, thank you for the opportunity to participate in the hearing. We wish to extend our best to all the parties in facilitating a positive and constructive outcome.

Nāku noa, nā

Sam Mikaere
Group CEO
Te Nehenehenui

Attachment 1: TNN Submission to Waipā District Council
Attachment 2: TNN Submission to Waikato Regional Council
Attachment 3: LINZ consideration of TNN's submission
Attachment 4: LINZ confirmation of fish passage measures (ecology)
Attachment 5: LINZ confirmation of fish passage measures (engineering)
Attachment 6: LINZ confirmation of improvements in dissolved boron levels

Attachment 1

TE NEHENEHENUI

Waipa District Council
Private Bag 2402
Te Awamutu 3840
submissions@waipadc.govt.nz

23 June 2025

CC Toitū Te Whenua Land Information New Zealand
bdaly@linz.govt.nz

SUBMISSION ON LU/0231/24 & LU/0232/24 – Toitū Te Whenua Land Information New Zealand (LINZ)

Te Nehenehenui thanks Waipa District Council for the comprehensive notification reports which have greatly assisted with the interpretation of these applications.

This submission relates to the applications by Toitū Te Whenua Land Information New Zealand (LINZ) as listed below, to remove underground infrastructure and remediate the 79 hectare former Tokanui Psychiatric Hospital site at 149 Te Mawhai Road, Tokanui:

- Undertake the below ground works for the remediation of the former Tokanui Hospital Site; and
- For the temporary opening, use and closing of a closed landfill to dispose of medium to low level contaminated soil under the Waipa District Plan; and
- Soil disturbance and change of use under the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.

Role of Te Nehenehenui

Te Nehenehenui is the post-settlement governance entity under the Maniapoto Claims Settlement Act 2022, which represents and acts on behalf of Maniapoto (inclusive of all within Te Nehenehenui). Te Nehenehenui acknowledges its partnership with Waipa District Council under the Ngā Wai ō Maniapoto (Waipā River Act) 2012 and Maniapoto Claims Settlement Act 2022 Joint Management Agreement. Te Nehenehenui is responsible for ensuring that all resource consent applications within the rohe are consistent with the Maniapoto Environmental Management Plan.

Submission details

1. Te Nehenehenui **could not** gain an advantage in trade competition through this submission.
2. Te Nehenehenui **supports** LU/0231/24 and **opposes in part** LU/0232/24.
3. TNN **does not** wish to be heard in support of this submission.

Technical submission points

Te Nehenehenui (TNN) has reviewed the application, associated appendices and the further information provided, and wishes to submit on the following matters:

Cultural Impact Assessment

1. TNN wishes to acknowledge the extensive iwi consultation that has been undertaken over a number of years and the Cultural Impact Assessment prepared by mana whenua, which should help guide the way forward on this project.

Remediation Application LU/0231/24

2. TNN is supportive of the key elements of the site remediation works being:
   - Partial removal of horizontal infrastructure across the site, including underground services up to 800mm below ground level and manholes to a depth of 1,000mm below ground level, roads and paved areas (including coal tar roading materials).
   - Soil remediation which will ensure the majority of the site will meet the site specific rural residential standards.
   - Removal of the foundations of 84 buildings/structures.
   - Reinstatement of the site following earthworks, so that it is free of any debris and stabilised by grassing.

Ongoing monitoring (Maniapoto Settlement Claims Act 2022)

3. The AEE describes the works required under the Property Redress Schedule of the Deed which requires the Crown to demolish buildings and infrastructure and remediate soil contamination to agreed standards before offering the site back to TNN. In particular, the Deed requires the Crown to maintain valid land use resource consents and liability for existing closed disposal sites at all times and in perpetuity. While the Crown has no commitment to carry out remedial works on these sites, it must comply with resource consent conditions. For this reason, TNN requests that both Waipa District Council and WRC carefully consider the monitoring requirements associated with these sites to ensure that any legacy contamination issues associated with leachate, subsidence or similar, are quickly identified and addressed. We are supportive of the ability to undertake cultural monitoring of the site and for mana whenua to be present during critical phases of the project.

Landfill Upgrade Application LU/0232/24

4. LINZ is seeking a discrete package of works to the closed landfill on the eastern portion of the site, referred to as the landfill upgrade application. The applicant's preferred option is for the disposal of contaminated soil from the main hospital site is to utilise this existing landfill and undertake enhancement works to the landfill at the same time. However, LINZ also has the option of disposing of the contaminated soil at an approved

facility offsite, therefore the wider application does not rely on the landfill upgrade application.

5. Noting that long term monitoring data appears to show that boron is leaching from the landfill, this puts TNN in a rather untenable position. Agree the contaminated material can be disposed of onsite in the knowledge that the landfill will be remediated and managed in perpetuity. Disagree and rely on consent conditions and monitoring of an un-remediated legacy landfill. This is a zero-sum game. If the material is transported offsite, the environment could be adversely affected over the longer term by the effects of the legacy landfill. If the material remains on site, this is reasonably offensive to mana whenua's values but there are net gains for the environment. This is not an easy decision as the application appears to force a conflict between cultural integrity and environmental risk. No option is without harm, but the harms differ in kind.

6. Instead, TNN would like Waipa District to consider a negotiated, mitigated option:
   - The landfill upgrade application stands, and remediation is undertaken.
   - Agreed low-level contaminated waste can be disposed of onsite.
   - long-term monitoring is agreed.
   - Offsite disposal is used only for the most offensive material.

In respect of LU/0232/24, we do consider that a compromise can be achieved. The applicant has gathered a huge amount of background information which will be helpful for further discussions. Te Nehenehenui is willing to work with the applicant in advance of a hearing (should a hearing be required, noting we do not wish to be heard) and/or to provide input on draft conditions.

Nāku noa, nā

Sam Mikaere
Group CEO
Te Nehenehenui

SUBMITTER INFORMATION
Name: Samuel Mikaere
Organisation: Te Nehenehenui
Address: PO Box 36, Te Kūiti 3910
Email: Sam@tnn.co.nz
Phone: 078786234
Contact: Tramaine Murray, Settlement Protection, Rights and Interests Manager
Email: Tramaine.murray@tnn.co.nz

Attachment 2

TE NEHENEHENUI

Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
Hamilton 3240

13 June 2025

CC Toitū Te Whenua Land Information New Zealand
bdaly@linz.govt.nz

SUBMISSION ON APP146952 – Toitū Te Whenua Land Information New Zealand (LINZ)

This submission relates to the applications by Toitū Te Whenua Land Information New Zealand (LINZ) as listed below, to remove underground infrastructure and remediate the 79 hectare former Tokanui Psychiatric Hospital site at 149 Te Mawhai Road, Tokanui.

Reference Id	Activity description
AUTH146952.01.01	To undertake earthworks and cleanfill activities within and outside HREA, including National Environmental Standards for Freshwater regulations in association with site remediation (R)
AUTH146952.02.01	To temporarily divert groundwater and take surface water for site works dewatering and subsequent discharge in association with site remediation (R)
AUTH146952.03.01	To temporarily dam and divert water to remove a culvert and maintain a stormwater pipeline in association with site remediation (R)
AUTH146952.04.01	Divert and discharge stormwater into the Wharekorino Stream in association with landfill upgrade (LF)
AUTH146952.05.01	Discharge leachate into land in circumstances that may result in contaminants entering groundwater from landfill activity (LF)
AUTH146952.06.01	To undertake earthworks and cleanfill activities within and outside HREA and within 10 metres of the Wharekorino Stream, including National Environmental Standards for Freshwater regulations in association with landfill upgrade (LF)
AUTH146952.07.01	To install a permanent culvert structure and bed disturbance of the Wharekorino Stream, including National Environmental Standards for Freshwater regulations in association with landfill upgrade (LF)
AUTH146952.08.01	Off stream diversion for groundwater diversion drain Area A1 and temporary damming and diversion during landfill upgrade (LF)
AUTH146952.09.01	Permanently divert the Wharekorino Stream through relocated culvert 3 during landfill upgrade (LF)

Role of Te Nehenehenui

Te Nehenehenui is the post-settlement governance entity under the Maniapoto Claims Settlement Act 2022, which represents and acts on behalf of Maniapoto (inclusive of all within Te Nehenehenui). Te Nehenehenui acknowledges its partnership with the Waikato Regional Council under the Ngā Wai ō Maniapoto (Waipā River Act) 2012 and Maniapoto Claims Settlement Act 2022 Joint Management Agreement. Te Nehenehenui is responsible for ensuring that all resource consent applications within the rohe are consistent with the Maniapoto Environmental Management Plan.

Submission details

1. Te Nehenehenui **could not** gain an advantage in trade competition through this submission.
2. Te Nehenehenui **supports and opposes** aspects of the proposal.
3. TNN **does not** wish to be heard in support of this submission.

Technical submission points

Te Nehenehenui (TNN) has reviewed the application, associated appendices and the further information provided, and wishes to submit on the following matters:

<u>Cultural Impact Assessment</u>

1. TNN wishes to acknowledge the extensive iwi consultation that has been undertaken over a number of years and the Cultural Impact Assessment prepared by mana whenua, which should help guide the way forward on this project.

<u>Remediation Application</u>

2. TNN is supportive of the key elements of the remediation application being:
    - Partial removal of horizontal infrastructure across the site, including underground services up to 800mm below ground level and manholes to a depth of 1,000mm below ground level, roads and paved areas (including coal tar roading materials).
    - Soil remediation which will ensure the majority of the site will meet the site specific rural residential standards.
    - Removal of the foundations of 84 buildings/structures.
    - Works near streams and wetlands, including removal of a culvert 2 underneath a road embankment crossing the Wharekōrino Stream, relining of the existing stormwater trunk pipeline, removal of pipes and cables crossing wetland 2, and removal of redundant wastewater treatment plant infrastructure within and near wetland 1.
    - Reinstatement of the site following earthworks, so that it is free of any debris and stabilised by grassing.

Ongoing monitoring (Maniapoto Settlement Claims Act 2022)

3. The AEE describes the works required under the Property Redress Schedule of the Deed which requires the Crown to demolish buildings and infrastructure and remediate soil contamination to agreed standards before offering the site back to TNN. In particular, the Deed requires the Crown to maintain valid land use resource consents and liability for existing closed disposal sites at all times and in perpetuity. While the Crown has no commitment to carry out remedial works on these sites, it must comply with resource consent conditions. For this reason, TNN requests that WRC carefully consider the monitoring requirements associated with these sites to ensure that any legacy contamination issues associated with leachate, subsidence or similar, are quickly identified and addressed.

Surface water effects

4. It is our view that this application should demonstrate that the activity will not adversely affect the health and well-being of the Pūniu River catchment. Pūniu River Care Incorporated (PRC) have raised concerns relating to the protection of the ecological restoration work that has been undertaken on the Pūniu River and Wharekōrino Stream. The main concern is the potential for the earthworks, diversion activities and sediment retention structures to contaminate, divert or reduce stream flow, potentially altering downstream hydrological regimes, affecting fish passage and compromising habitat stability in Wharekōrino Stream. Further, PRC holds a water take consent to supply irrigation to the nursery operation, which is dependent on flows from Wharekōrino Stream.

5. TNN seeks assurance and associated consent conditions which address the potential for net flow reduction in the Wharekōrino Stream. This may require monitoring of baseline stream flows and monitoring to ensure additional sediment load and contaminants are not entering the stream as a result of the works. We are supportive of the ability to undertake cultural monitoring of the site and for mana whenua to be present during critical phases of the project.

Ecology

6. Biodiversity offsetting and compensation were a matter of contention in discussions leading up to this submission. It is always our view that the removal of indigenous vegetation (and exotic species where it provides a habitat for indigenous species), should be minimised as far as possible and site rehabilitation with indigenous vegetation should occur as quickly as possible to provide for the recolonisation of indigenous species. In this situation we note that the application states that the adverse effects are less than minor meaning there are no residual adverse effects which require biodiversity offsetting or biodiversity compensation. We will rely on WRC to condition any matters which adversely affect indigenous species should this be considered necessary.

Disposal sites

7. This is a matter of contention. LINZ is seeking a discrete package of works to the closed landfill on the eastern portion of the site, referred to as the landfill upgrade application. The applicant's preferred option is for the disposal of contaminated soil from the main hospital site is to utilise this existing landfill and undertake enhancement works to the landfill at the same time. However, LINZ also has the option of disposing of the contaminated soil at an approved facility offsite, therefore the wider application does not rely on the landfill upgrade application.

8. Noting that long term monitoring data appears to show that boron is leaching from the landfill, this puts TNN in a rather untenable position. Agree the contaminated material can be disposed of onsite in the knowledge that the landfill will be remediated and managed in perpetuity. Disagree and rely on consent conditions and monitoring of an un-remediated legacy landfill. This is a zero-sum game. If the material is transported offsite, the environment could be adversely affected over the longer term by the effects of the legacy landfill. If the material remains on site, this is reasonably offensive to mana whenua's values but there are net gains for the environment. This is not an easy decision as the application appears to force a conflict between cultural integrity and environmental risk. No option is without harm, but the harms differ in kind.

9. Instead, TNN would like WRC to consider a negotiated, mitigated option:
   - The landfill upgrade application stands, and remediation is undertaken.
   - Agreed low-level contaminated waste can be disposed of onsite.
   - long-term monitoring is agreed.
   - Offsite disposal is used only for the most offensive material.

Te Nehenehenui is willing to work with the applicant in advance of a hearing should a hearing be required, or if not, to provide input on draft conditions.

Nāku noa, nā

Sam Mikaere
Group CEO
Te Nehenehenui

SUBMITTER INFORMATION
Name: Samuel Mikaere
Organisation: Te Nehenehenui
Address: PO Box 36, Te Kūiti 3910
Email: Sam@tnn.co.nz
Phone: 078786234
Contact: Tramaine Murray, Settlement Protection, Rights and Interests Manager
Email: Tramaine.murray@tnn.co.nz

Attachment 3

Toitū Te Whenua
Land Information
New Zealand

LINZ Notes Re: Te Nehenehenui Submission on LU/0231/24 & LU/0232/24 and APP146952

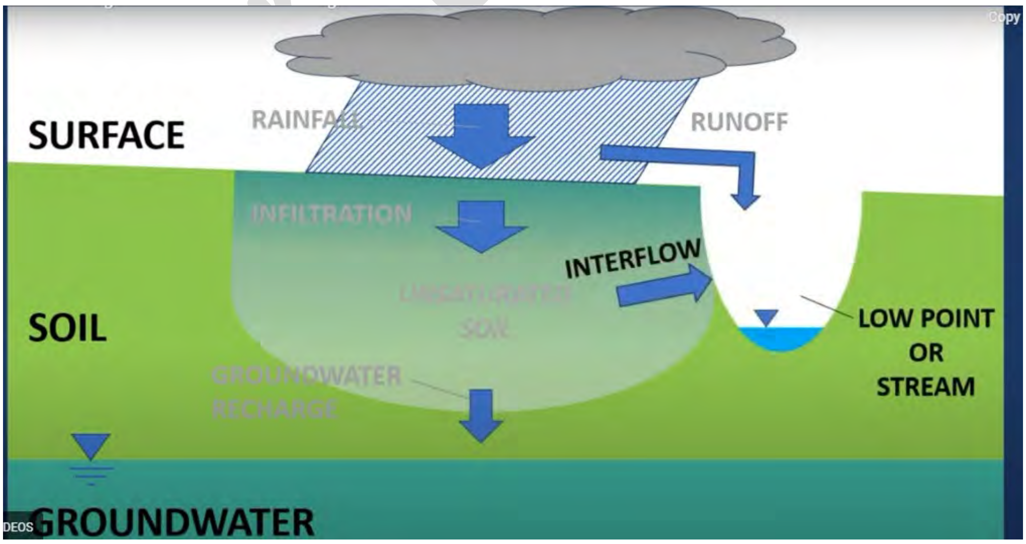
LINZ notes the contents of Te Nehenehenui (TNN)'s submissions on LU/0231/24 & LU/0232/24 and APP146952 dated 23 June 2025. We have provided commentary on matters raised and propose to make the following amendments to assist in addressing concerns.

Surface water effects

We have included proposed conditions with the application requiring that, while works take place in the Wharekōrino Stream, all normal flows must be diverted around the works area, and the diversions must be at a rate that maintains normal downstream flows.[1]

We have also proposed that temporary damming and diversions be in place for no more than 16 weeks; however, this longer period related to the length of time for the culvert works as a whole. The period of actual stream diversion expected for the culvert 2 and 3 works within this time is no more than 2 – 3 weeks per culvert. Following TNN's submission and subsequent discussions, we now propose to reduce the period when the diversions can be in place from 16 weeks to up to 3 weeks per culvert, in order to provide additional certainty that there will be minimal effects on flow rates.

Following our meetings, we have undertaken additional calculations to assess the effect of removing the existing impervious areas (e.g. roading and structures) on the hospital site on the rate of stream base flows. The reduction in impervious coverage when the buildings and hard surfaces are removed is expected to result in a small increase (up to 5%) in stream base flows, as more rainfall will infiltrate into the soil and some of this will seep out into gullies and the stream as "interflow" over a considerably longer period than surface runoff. This is illustrated in the schematic below.



Note: schematic sourced from https://www.youtube.com/watch?v=ZJhvYuY8m2I

[1] Remediation Application Conditions I23 & I24; Landfill Upgrade Application Conditions I20 & I21

In a storm event, peak flows are estimated to decrease by 0.8% to 3%; however, this would occur in the context of high stream flows from the storm. We therefore consider that the permanent works will not adversely affect the stream base flows and may, in fact, enhance them to a small extent.

Cultural monitoring

As per previous commitments to TNN and mana whenua, LINZ plans to have cultural support in place for the life of the project, with the intent to support three key aspects of the works:

1. A Karakia prior to works getting underway;
2. a Cultural Induction[2] to support contractors and consultants understanding of the cultural significance of the site and local history; and,
3. Cultural Monitoring during the life of the project.

As part of the original application, Cultural Monitoring of works undertaken within waahi tapu areas as well as the removal of large native trees were proposed. We are now proposing to expand the scope of cultural monitoring to include all works in proximity to the Wharekōrino Stream, in recognition of the importance that iwi/hapū place on maintaining water quality and protecting taonga species.

As discussed, the previous contractual engagement for the Phase 1: Cultural Support and Monitoring with TAR Block Ltd is no longer possible. We are keen to kōrero with TNN and mana whenua to clarify expectations and ensure the kaupapa is appropriately addressed. To achieve this, we propose to hold a collaborative discussion to ensure alignment on this aspect of the project, confirm contractual requirements and its subsequent implementation.

Fish passage and habitat

The proposed culvert 3 works provide a net gain for native fish through improving the current level of fish passage with a shorter culvert, and a new length of stream habitat.

When we lodged the application, we proposed that the final detailed design drawings of the replacement culvert 3 and the new daylighted stream section of the Wharekōrino Stream would be undertaken post-consent, reviewed by an ecologist and provided to WRC.[3] However, to provide additional certainty to TNN, we've been working with the project ecologists following TNN's submission to design this now.

This design work has involved:

- detailed velocity calculations to ensure that fish species can travel through the culvert, and
- discussing the appropriate configuration of pools, logs and rocks to provide habitat and create a more natural looking stream.

[2] Similar to the one completed for the consultants involved in the initial investigation works
[3] Landfill Upgrade Application Condition I1

The detailed design is due to be completed on 22 August 2025 and will undergo a final ecologist review. These documents will then be provided to TNN for discussion, with the intent to provide the documents to the councils to be incorporated into the application and enable it to be taken into account in the consent decisions.

Ecology

The application proposes high-quality native planting in the areas of culvert 2 and 3, where the proposed works and riparian vegetation removal are to occur to replace existing vegetation that will be impacted as part of the works. Taking this mitigation into account, the Ecological Assessment (SLR, 2024) concluded that the adverse ecological effects of the proposal as it stands are less than minor, and no offsetting or compensation is required.

Nonetheless, there remain opportunities on the site for ecological enhancement. Following TNN's submission and subsequent discussions with LINZ, we are now looking into including additional planting within the riparian margin of the Wharekōrino Stream between culverts 2 and 3. While the existing trees and vegetation here are mostly exotic, our ecologist considers that the mature exotic (non-invasive) trees should remain as they provide some ecological benefits such as shading the stream, habitat values, erosion protection and runoff management. There is, however, the opportunity for weed removal, planting additional natives in the understorey and planting additional native trees in any appropriate gaps – expanding the scope of the original planting plan submitted with the application. Such planting would improve indigenous habitat and further support indigenous biodiversity.

Agreed low level contaminated waste can be disposed of in the landfill; most offensive material to be disposed off-site

Site-specific contaminated soil standards have been developed in collaboration/consultation with mana whenua and consider iwi values and potential future aspirations for the land as described in the Cultural Engagement Report.

These site-specific standards are more conservative than the Ministry for the Environment's (MfE) rural residential land use standards.[4] As a result, approximately 40% more contaminated soil is proposed to be removed than would be required under those standards. This approach also exceeds the soil remedial requirements of the Deed, but it is being adopted because it takes into consideration what LINZ have heard and understood from our engagement from both mana whenua and TNN, and LINZ are committed to ensuring that cultural values are reflected in the project's delivery and outcome.

From a contaminated land soil scientist's perspective, the proposed soil management approach at the hospital site is conservative and precautionary. While low-level contaminated soil is suitable for disposal in the on-site landfill, the most offensive materials,

[4] Ministry for the Environment (MfE) National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health, 2011 (NESCS).

such as coal tar residues in the roading network and pockets of historic demolition waste, will be removed and disposed of off-site.

The soil intended for on-site disposal contains low to moderate levels of contaminants, primarily lead, zinc, and asbestos. At the concentrations identified at site and adopted as the site-specific standards, these substances do not pose a risk to groundwater. Under MfE's standards, this soil is considered suitable for commercial or industrial land use and is not typically regarded as 'offensive.'

To date, no high-level contamination has been identified. If such material is discovered, it will be removed and disposed of offsite. Through our engagement with mana whenua and TNN it has been acknowledged that the existing landfill contains undesirable materials, with medical waste identified as the most offensive. This waste is also proposed to be removed and disposed of off-site.

Long term monitoring of landfill

The Crown will be responsible for the monitoring and compliance of the upgraded landfill in perpetuity.

The landfill upgrade works are expected to prevent any further rain and groundwater from entering the landfill and coming into contact with refuse and contaminants before entering the Wharekōrino Stream.

We have proposed twice yearly ground and surface water monitoring to examine the rate at which water quality improves. It will, however, take some time for existing groundwater in the landfill area to work its way out. Following a recent onsite hui with mana whenua, we are currently doing calculations to estimate how long it will take to see improvements in the level of boron (the only contaminant found to be currently leaching out although still well within guideline levels). These should be available by 22 August 2025.

The integrity of the landfill is proposed to be inspected annually. If there are any issues, the Crown will be responsible for undertaking any additional or remedial works required promptly. The landfill however will remain suitable for a number of activities, subject to future use requirements, including ongoing agricultural use for grazing or arable farming as is done at present. The areas could equally be planted in natives, that do not have extensive, deep root systems.

Attachment 4

Technical Memorandum

To:	Bryan Daly	**From:**	Nicola Pyper, Principal Ecologist
Company:	Toitū te Whenua, Land Information New Zealand	**SLR Consulting New Zealand**	
cc:	Emily Buckingham, Principal Planner, SLR Consulting New Zealand	**Date:**	20 August 2025
	Sean Finnigan, Director, Environmental Engineering, Fraser Thomas Limited	**Project No.**	880.V11547.00001

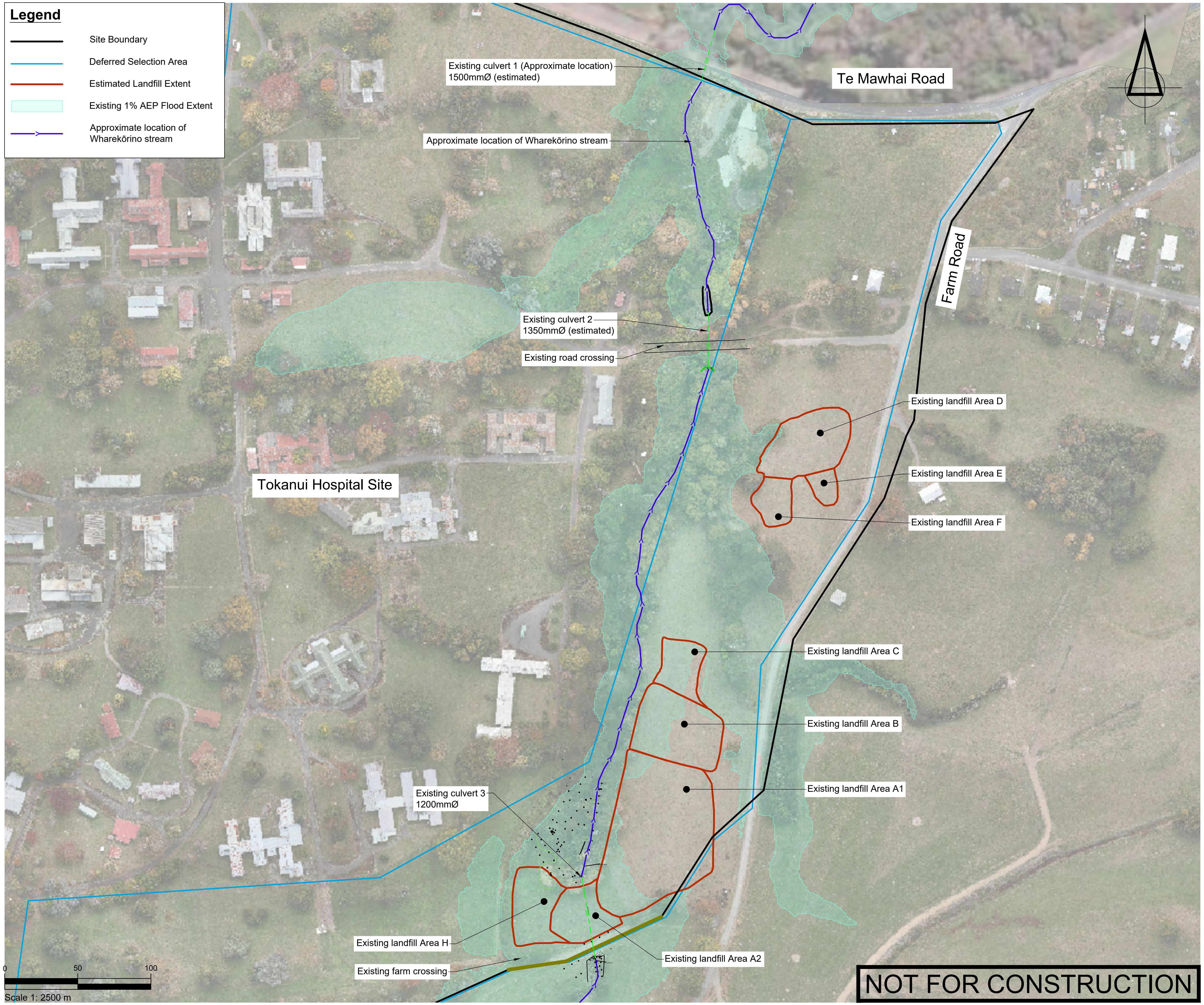
RE: Former Tokanui Hospital culvert remediation Fish passage evaluation

1.0 Introduction

The Tokanui Hospital site is located approximately 14 km south of Te Awamutu in the Waikato Region. The hospital was decommissioned in 1998 and Toitū Te Whenua – Land Information New Zealand (LINZ) are now seeking to remediate the former hospital site. The Wharekōrino Stream, a tributary of the Pūniu River, flows along the eastern boundary of the site in an approximately northerly direction. Several landfill areas are sited to the east of the channel and three culverts intersect the stream within, or just outside of, the site's boundaries. "Culvert 1" is located just beyond the northern site boundary and runs beneath Te Mawhai Road. This asset is managed by Waipā District Council (WDC). "Culvert 2" and "Culvert 3" are located within the site. Culvert 2 runs beneath an embankment that provides access to the former hospital, and Culvert 3 runs beneath a farm crossing (Figure 1). As part of the site's remediation, Culvert 2 is to be removed and Culvert 3 is to be replaced.

This memorandum assesses the proposed remediation design with regard to the provision of fish passage in the length of Wharekōrino Stream that flows through the former Tokanui Hospital site. Culvert design has been assessed against the New Zealand Fish Passage Guidelines version 2.0[1] (the Guidelines).

[1] Franklin, P., Baker, C.F., Gee, E., Bowie, S., Melchior, M., Egan, E., Aghazadegan, L., Vodjansky, E. (2024) New Zealand Fish Passage Guidelines 2.0, 2024157HN: 427. https://niwa.co.nz/sites/default/files/2025-07/NZ%20Fish%20Passage%20Guidelines%20v4.5_July2025.pdf



P:\33 series\33097\03 Drawings\33097-LF001.dwg, ygoh, 20/8/2025 3:57 pm

			APPROVED	DATE
SURVEYED			SF	
DESIGNED	TB	14/08/24	05/11/24	
DRAWN	TB	15/08/24		
CHECKED	SF	05/11/24		

REVISION	CHANGES	CHECKED	DATE
A	COORDINATE SYSTEM CHANGED	SF	23/05/25

NOTES

PROJECT DATUMS:
LEVEL: New Zealand Vertical Datum 2016
COORDINATE: New Zealand Transverse Mercator

CLIENT
TOITU TE WHENUA LAND INFORMATION NEW ZEALAND

PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
EXISTING LANDFILL OVERVIEW PLAN

Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS

AUCKLAND 09 278 7078
HAWKE'S BAY 06 211 2766
CHRISTCHURCH 03 358 5936
BLENHEIM 03 428 3292
NELSON 03 222 1132
TAURANGA 07 220 9277

www.fraserthomas.co.nz

STATUS
FOR RESOURCE CONSENT
Construction works shall commence only on receipt of and in accordance with the Council or Council organisation stamped approved drawings, unless otherwise indicated.

SCALE 1:2500 (A3)

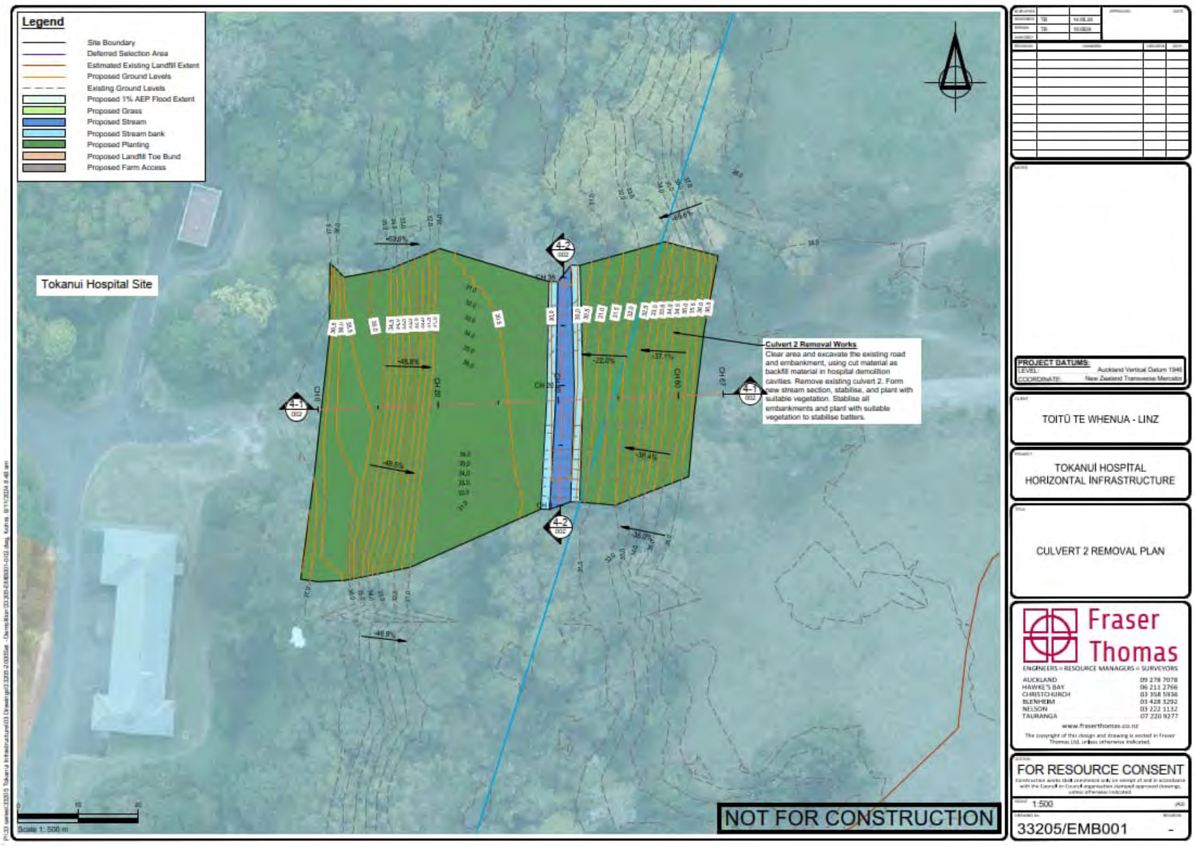
DRAWING No 33097/LF001
REVISION A

2.0 Remediation design

2.1 Culvert 2

LINZ is proposing to daylight the stream reach at the Culvert 2 location, removing all artificial structures from the stream and returning the channel to a more natural morphology (Figure 2). This is considered the optimal remediation option for fish passage and stream function. Therefore, fish passage at the Culvert 2 location has not been considered further in this memorandum.

Figure 2: Proposed removal of road embankment and Culvert 2 on the Wharekōrino Stream at the former Tokanui Hospital site[3].



2.2 Culvert 3

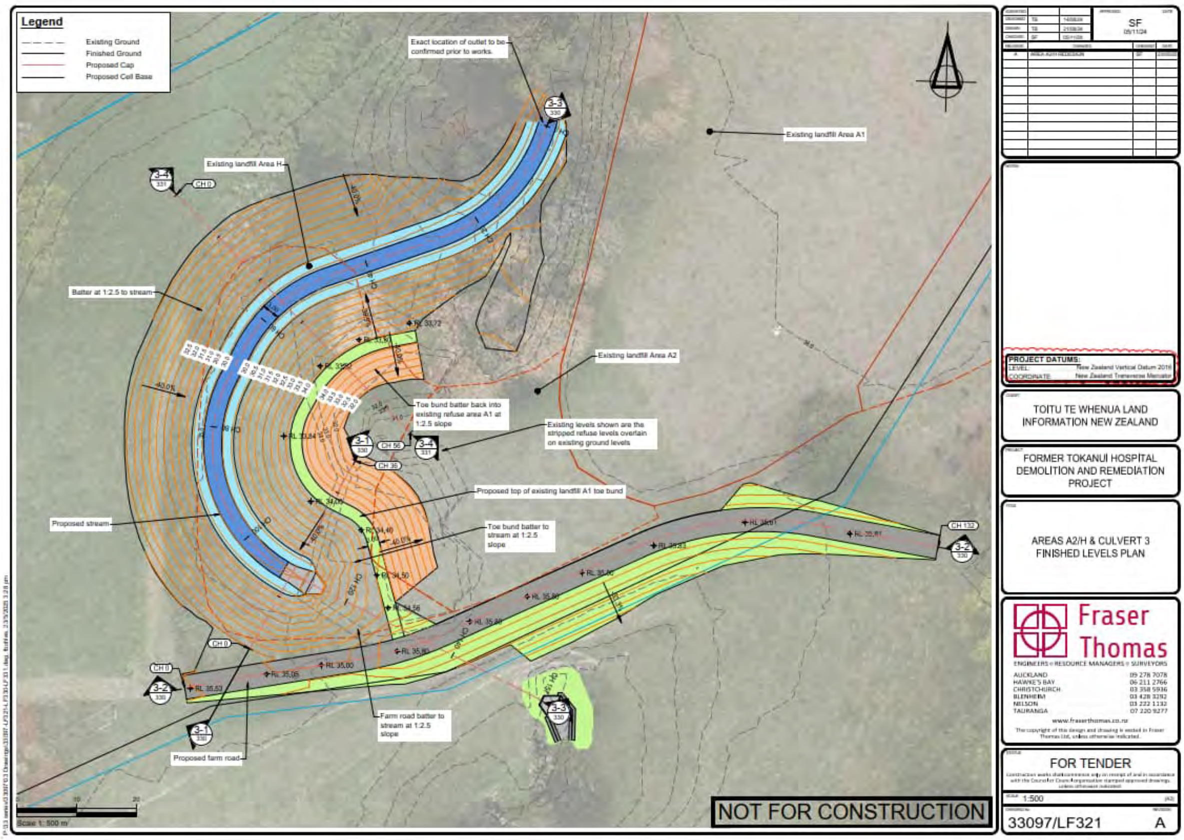
The existing structure at the Culvert 3 site is 60 m long, with a diameter of 1200 mm and a cross-sectional area of 1.13 m^2. LINZ is proposing to replace this culvert with a shorter pipe of 41 m. The replacement culvert has been sized to replicate the existing situation as close as possible. This is for the purpose of holding back floodwaters to provide flood relief benefits for the landfill and to prevent the mobilisation of contaminants during high flow events. However, it is proposed to embed the replacement culvert by 340 mm, meaning the diameter of the new culvert will be wider than the current pipe in order to match the capacity of the existing culvert. The new pipe diameter will be 1350 mm.

The replacement culvert will be aligned at a gradient of 0.49%. This is slightly steeper than the estimated natural streambed gradient of 0.3%. The new culvert will also be installed at a

[3] Snip from Fraser Thomas drawing, Drawing No. 33205/EMB001, 19 August 2024.

slightly different alignment to the existing structure, with the new pipe being oriented from southeast to northwest. Additionally, a new section of channel is to be constructed downstream of the culvert. This section of channel will divert the stream around the landfill area (Figure 3).

Figure 3: Proposed Culvert 3 replacement location and channel realignment, former Tokanui Hospital site.[4]



3.0 Evaluation of fish passage requirements

3.1 Culvert 3

The New Zealand Fish Passage Guidelines outline the process to be followed and features to be considered when designing a culvert that will provide for fish passage. As a first step, the culvert size and grade are to be determined according to the standards of the local authority and, in this case, site-specific requirements have also been considered (cf. Section 2.2 above). Proposed Culvert 3 has been sized to mitigate risks associated with potential flooding of landfill areas and associated risks of water contamination.

3.1.1 Fish passage criteria

The Fish Passage Guidelines provide direction for the design of stream crossings and culverts to provide for fish passage. The different aspects of culvert design that pertain to fish passage have been addressed under the pertinent headings below.

[4] Snip from Fraser Thomas drawing, Drawing No. 33097/LF321, 23 May 2025.

3.1.1.1 Fish passage design flows

The design flows for fish passage are determined based on the bank-full flow of the stream. Bank-full flow is defined as the upper flow threshold (Q_H), and ⅓ of the bank-full flow is defined as the lower flow threshold (Q_L) at which fish passage should be provided. Fraser Thomas Limited (FTL)[5] has undertaken the necessary calculations and hydrological modelling and determined that at the Culvert 3 site, Q_H for the stream is 1.35 m^3/s and Q_L for the stream is 0.45 m^3/s.

In addition to the fish passage design flows, water depth and water velocity thresholds should be defined as hydraulic performance standards to determine whether a proposed culvert will be passable by native fish. At Q_H, the estimated average velocity in the proposed Culvert 3 replacement is 1.39 m/s[5], and at Q_L, the estimated average velocity is 0.56 m/s. Mean cross-sectional velocities often exceed fish swimming speeds and endurance. Therefore, variation in water velocity across the culvert cross section must be taken into consideration when determining whether suitable conditions are available for fish to successfully pass. The depth-averaged vertical slices approach is a practical method to do this and referenced in the Guidelines. FTL have applied this methodology and shown that in a 200 mm 'slice' adjacent to the culvert wall, the average velocity is 0.09 m/s at Q_H and 0.04 m/s at Q_L[5].

The Guidelines also outline that a minimum depth of 150 mm is required at Q_L for native species[1]. Calculations completed by FTL have shown that at Q_L, the slice depth (200 m from the culvert wall) exceeds this significantly at 0.76 m[5].

3.1.1.2 Target fish species

Fish surveys were carried out at the former Tokanui Hospital site in 2022. These surveys resulted in the capture of two species of native eel, the shortfin eel (*Anguilla australis*) and longfin eel (*Anguilla dieffenbachii*)[6]. A review of the National Institute of Water and Atmospheric Research's (NIWA) New Zealand Freshwater Fish Database (NZFFD) resulted in three records, which documented either no fish captured or the presence of shortfin eels. A review of Wilderlab New Zealand's environmental DNA (eDNA) database revealed no relevant records. However, other native species, such as banded kōkopu (*Galaxias fasciatus*) and giant kōkopu (*Galaxias argenteus*) have been recorded in the wider Pūniu River catchment[6]. It is possible that barriers to fish passage downstream of the former Tokanui hospital site are preventing the passage of kōkopu upstream, and this may be the reason none have been recorded. Alternatively, they may be present in low numbers and sampling efforts may not have been sufficient to detect their presence. Remediating fish passage in Culvert 3 will create access to suitable habitat upstream for eel species as well as kōkopu species, if they are present in the stream and/or if downstream barriers are remediated in the future.

The guidance provided in the New Zealand Fish Passage Guidelines directs that fish passage velocity thresholds use the migratory galaxiid, īnanga (*Galaxias maculatus*) as a benchmark[1]. Īnanga have not been recorded in the vicinity of Culvert 3; however, a conservative approach has been adopted and Culvert 3 design has been assessed using īnanga as the target species.

To pass upstream through a culvert, a fish must swim at a speed that exceeds the water velocity within the culvert. The effective velocity of the fish passing through the culvert is

[5] Goh, Y., Finnigan, S. (2025) Former Tokanui Hospital – Evaluation of Fish Passage for Proposed Culvert 3 (Rev 4). 7.
[6] Leitch, K. (2024) Ecological Impact Assessment Tokanui Hospital Remediation. Prepared by SLR Consulting New Zealand for Land Information New Zealand. 113.

determined by subtracting the culvert water velocity from the prolonged speed of the fish. The distance that a fish can swim at the effective velocity must exceed the length of the culvert.

Fish swimming speed can be categorised into three distinct classes:

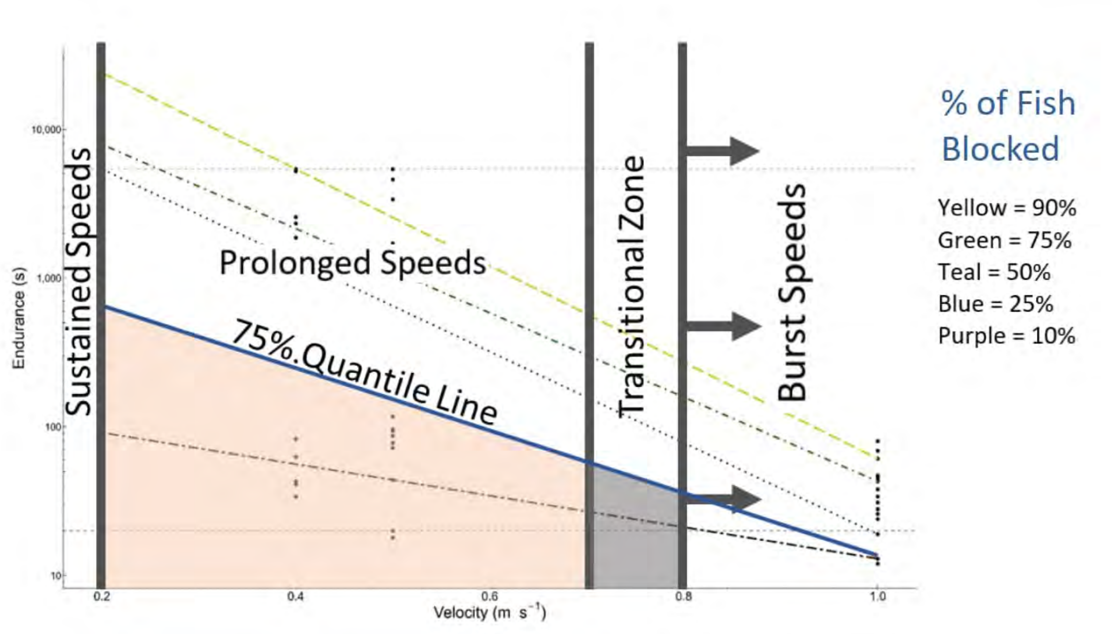
- Sustained Swimming Speed – Velocities that a fish can sustain for longer than 200 minutes, without muscle fatigue[7].
- Prolonged Swimming Speed – Velocities that a fish can maintain for 20 seconds to 200 minutes and that end in fatigue[7].
- Burst Swimming Speeds – Highest velocities that a fish can achieve and that can be maintained for less than 20 seconds[7].

As sustained swimming speeds are lower than typical culvert velocities, and burst speeds have a duration that is generally too short to enable a fish to successfully traverse a culvert, prolonged swimming speed is generally applied for culvert design[1].

Laboratory tests have been carried out to determine the prolonged swimming speed for īnanga[1]. While most guidance recommends that fish passage efficiency targets should be >90% to sustain wider population processes, given the relatively low sample sizes used in studies of New Zealand fish (and hence the high uncertainty in the 90th percentile), the Guidelines recommend that the 75th percentile endurance time (i.e., that which is equalled or exceeded by 75% of fish) be used as the basis for determining the fish passage velocity threshold. Based on this we have used a value of 0.44 m/s as an approximate swimming speed for īnanga (Figure 4). For proposed Culvert 3, this yields an effective swimming speed of 0.35 m/s at Q_H if the fish were to use the first 'slice' of the culvert (200 mm width adjacent to the culvert wall). The proposed culvert is 41 m long. Īnanga would be able to traverse the pipe in 117 seconds at an effective swimming speed of 0.35 m/s. Therefore, īnanga will be able to successfully traverse Culvert 3 at Q_H at the species' sustained swimming speed.

[7] Beamish, F.W.H. (1978) 2 – Swimming Capacity. In: W.S. Hoar & D.J. Randall (Eds.) *Fish Physiology.* Academic Press: 101-187.

Figure 4: Prolonged swimming speeds and endurance for īnanga (target fish species). Reproduced from the New Zealand Fish Passage Guidelines (2024).



FTL also assessed whether fish passage would be provided in situations where the culvert was fully submerged due to high water levels at the culvert outlet. When the culvert is submerged, the hydrological conditions in the culvert will differ from the flow conditions discussed above, which are relevant to situations when the pipe is not fully submerged[5]. Calculations showed that when the culvert pipe is fully submerged, flow velocities would be within the velocity range of the design flows of the stream as discussed above (Q_L = 0.56 m/s to Q_H = 1.39 m/s[5]), with an average velocity of 0.39 m/s at Q_L and 1.17 m/s at Q_H when the culvert is fully submerged. While the depth-averaged velocity modelling method (i.e., using HY-8 software) does not apply under these conditions, it would be expected that fish would be able to traverse the culvert by swimming through the slower flowing areas along the culvert wall, as velocities should be less than the bankfull modelled flow discussed above.

3.1.1.3 Embedment

The Guidelines state that round culverts should have a minimum embedment of ⅓ to ½ of the culvert diameter. The proposed culvert will have an embedment of ¼, slightly less than what is recommended. However, given the low gradient of the culvert and the slow velocities predicted, 25% is considered to be a sufficient level of embedment. It will be important to ensure that the bed material is stable, and regular visual monitoring of the culvert should be carried out to confirm that the culvert functions as anticipated. Any deterioration in or damage to the culvert structure or scour of the culvert or streambed should be remedied as soon as practicable.

3.1.1.4 Ancillary Structures

Contraction of flow at the upstream end of a culvert can result in higher water velocities, which can in turn prevent fish exiting culverts. Similarly, rapid expansion of the flow and a drop in water surface level at the downstream end of a culvert can cause locally increased water velocities that can prevent native fish from entering the culvert[1]. To avoid this issue at

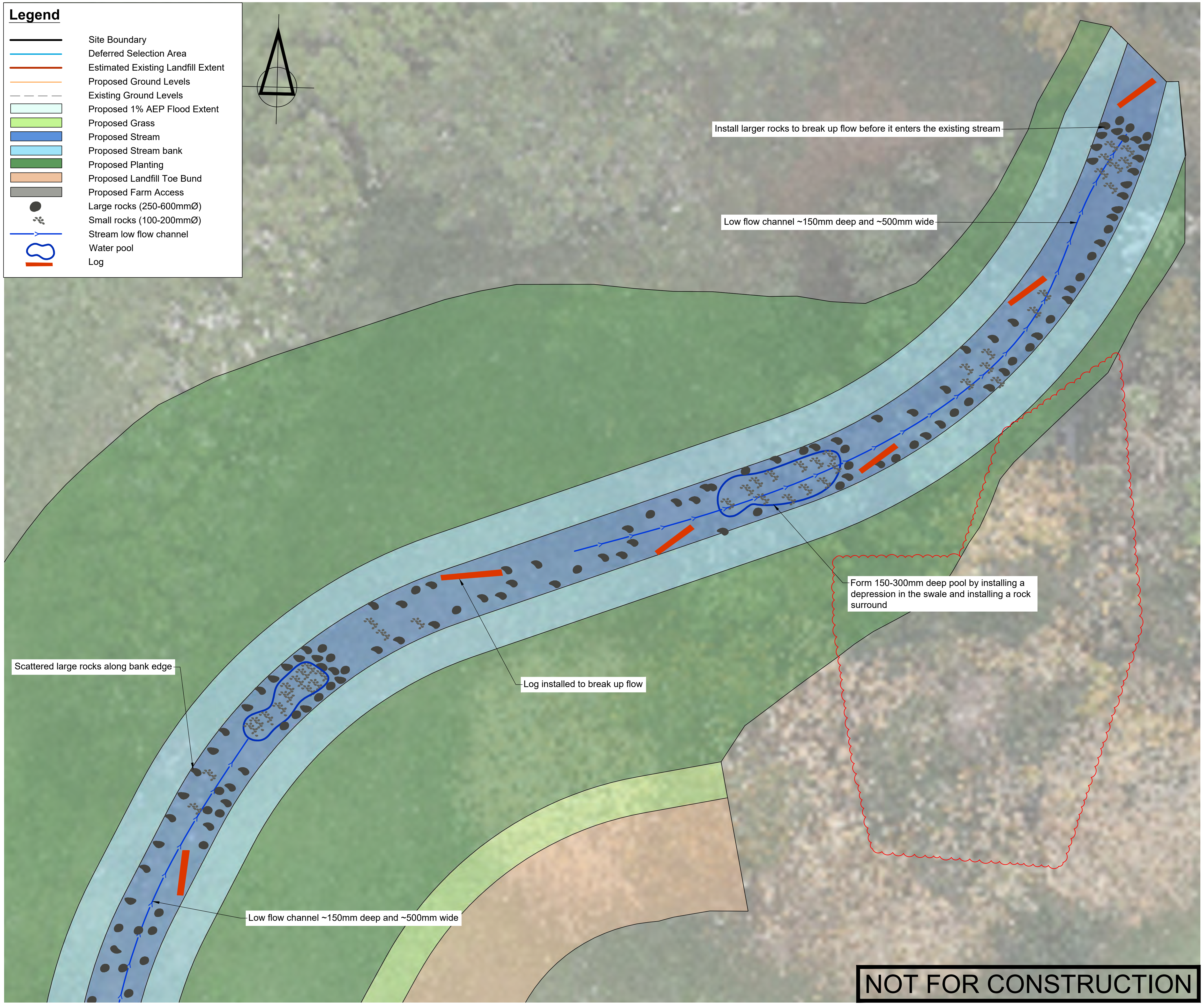
Culvert 3, resting pools (stilling basins) have been designed at both the culvert inlet and outlet. Stilling basins function as resting places for fish as they increase the depth of water that is at a lower velocity. The outlet pool will also function as an energy dissipating basin during storm events.

The Guidelines provide some direction for the use of rip-rap in culvert designs[1]. Under some conditions, stream flows may move through rip-rap, rather than over it, which creates a barrier to fish passage. This is considered unlikely to be a concern at Culvert 3, due to the depth of the water observed in the stream year round. The FTL memorandum states that observations from multiple site visits confirm that the culvert is typically either 'fully drowned or almost drowned'[5]. It is our understanding that this applies during summer as well, when flows are likely to be at their lowest. Therefore, the use of rip rap for the purposes of scour protection at Culvert 3 is considered unlikely to create a barrier to fish passage. However, ongoing visual monitoring should be undertaken to confirm that the culvert functions as anticipated. If stream flows are observed moving through the rip-rap, rather than over it, remediation of the scour protection may need to be undertaken.

3.2 Diversion Channel

In order to mitigate risks of contamination from the landfill, the Wharekōrino Stream will be diverted around the landfill area. This will require the reclamation of a small section of stream, but a longer section of channel will be created to divert the stream around the landfill. The diversion channel will flow from the outlet of Culvert 3 and reconnect to the existing channel approximately 105 m downstream. This diversion channel has been designed with input from both environmental engineers and freshwater ecologists. The stream gradient throughout the diversion channel will be low (in accordance with existing conditions), stream banks will be contoured to have a shallow slope (1:3), and the stream alignment will follow a gentle meander. Therefore no, hydraulic or physical barrier to fish passage will be created by this diversion channel. The channel will also include features that will enhance instream habitat, such as deep pools, rocks, logs, and native riparian planting (Figure 5).

P:\33 series\33097\03 Drawings\33097-LF312-313.dwg, tbohles, 20/8/2025 4:01 pm



			APPROVED	DATE
SURVEYED			SF	
DESIGNED	TB	19/06/25		19/06/25
DRAWN	TB	19/06/25		
CHECKED	SF	19/06/25		

REVISION	CHANGES	CHECKED	DATE
A	CULVERT 3 OUTLET CHANGE	SF	20/08/25

NOTES

PROJECT DATUMS:
LEVEL: New Zealand Vertical Datum 2016
COORDINATE: New Zealand Transverse Mercator

CLIENT
TOITU TE WHENUA LAND INFORMATION NEW ZEALAND

PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
INDICATIVE STREAM CONSTRUCTION PLAN 2

Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS

AUCKLAND	09 278 7078
HAWKE'S BAY	06 211 2766
CHRISTCHURCH	03 358 5936
BLENHEIM	03 428 3292
NELSON	03 222 1132
TAURANGA	07 220 9277

www.fraserthomas.co.nz

STATUS
FOR RESOURCE CONSENT
Construction works shall commence only on receipt of and in accordance with the Council or Council organisation stamped approved drawings, unless otherwise indicated.

SCALE 1:200 (A3)

DRAWING No 33097/LF313
REVISION A

4.0 Closure

In conclusion, the daylighting of Culvert 2 and the re-design of Culvert 3 at the Tokanui Hospital site will result in an improvement in fish passage in the Wharekōrino Stream. The replacement structure for Culvert 3 has been designed to mitigate risks associated with landfill contamination, as well with careful consideration of the recommendations of the latest iteration of the New Zealand Fish Passage Guidelines (2024)[1]. A conservative approach has been used, and the design has allowed for the passage of the weaker swimming native fish species, īnanga, which is not currently known in this part of the catchment.

The new section of channel that will divert Wharekōrino Stream around the landfill area has also been designed to promote ecological values, and will not result in any barrier to native fish passage.

Regards,

SLR Consulting New Zealand

Nicola Pyper, MSc
Principal Ecologist

Fleur Tiernan, MSc
Principal Consultant

Attachment 5

Fraser Thomas Limited
21 El Kobar Drive : East Tamaki : AUCKLAND 2013
PO Box 204006 : Highbrook : AUCKLAND 2161
NEW ZEALAND
TEL +64 9 278 7078 : E-MAIL sfinnigan@ftl.co.nz

ENGINEERS • RESOURCE MANAGERS • SURVEYORS

MEMORANDUM

Date: 21 August 2025 33097

From: Y Goh, S Finnigan

Subject: Former Tokanui Hospital – Evaluation of Fish Passage for Proposed Culvert 3 (V4)

To: Emily Buckingham (emily.buckingham@slrconsulting.com), Nicola Pyper (nicola.pyper@slrconsulting.com)

1.0 INTRODUCTION

This document evaluates the water velocity and depth within the proposed culvert 3 (C3) design and whether it satisfies the fish passage criteria according to the NIWA New Zealand Fish Passage Guidelines Version 2.0. This has been done for both normal (mean) and storm flows, using both spreadsheet and "stream simulation" culvert design software as the most appropriate solution for assessing movement of fish or other aquatic organisms through culverts.

This document summarises the analysis for:

- Section 2 - Proposed culvert details;
- Section 3 – Adopted maximum velocity and minimum depth thresholds;
- Section 4 - Fish passage under actual "mean stream" flows;
- Section 5 - Fish passage in accordance with the NIWA Fish Passage Guidelines

2.0 PROPOSED CULVERT 3 DETAILS

The existing culvert is 1200mm diameter, with an inlet IL of 29.5mRL and outlet IL of 29.44mRL (NZVD2016).

The proposed culvert 3 will be a 1350mm diameter pipe, with a gradient of 0.49% and 41m long. It will be embedded by 340mm (25%) within the stream bed to facilitate fish passage. The culvert itself will have an inlet IL of 29.86m and outlet IL of 29.66m (NZVD2016), while the invert with embedment will be 30.2mRL with outlet IL 30.0mRL.

The proposed culvert 3 has been sized to match the flow area of the existing culvert (1200dia, 1.13m^2) taking the embedment depth into account (1350dia, less 340mm deep embedded area = 1.15m^2) to match the existing situation as close as possible, so as to hold flood waters back for optimum flood relief benefits for the landfill. This has been done using the "stream simulation" culvert design as the most appropriate solution for assessing the movement of fish or other aquatic organisms through culverts.

3.0 MAXIMUM THRESHOLD VELOCITY AND MINIMUM THRESHOLD DEPTH FOR ĪNANGA (*GALAXIAS MACULATUS*)

In the New Zealand Fish Passage Guidelines (Version 2.0), īnanga (*Galaxias maculatus*) is used as a benchmark species for assessing fish passage. Although īnanga have not been recorded in the vicinity of Culvert 3, a conservative approach was adopted, and the culvert design was assessed using īnanga as the target species, as stated in SLR Consulting's "Former Tokanui Hospital Culvert Remediation Fish Passage Evaluation report" (August 2025). The report specifies a maximum velocity threshold based on the prolonged swimming speed of īnanga (0.44m/s). The NIWA guideline also specifies a minimum depth requirement of 150 mm for fish passage. Therefore, these thresholds – a maximum velocity of 0.44m/s and a minimum depth of 150mm were applied to assess the feasibility of fish passage through Culvert 3.

4.0 FISH PASSAGE UNDER ACTUAL "MEAN STREAM" FLOWS

4.1 Determination of Mean Flows

Three methods have been used to estimate the mean flow in the Wharekōrino Stream by the landfill at the Tokanui Hospital. These are briefly described below:

(a) **Catchment Analysis**: Average annual runoff analysis, based on catchment area and annual average rainfall data for the area (30 year average over period 1991-2020 inclusive) from the nearby Waikeria NIWA rainfall gauge site.

(b) **NZRiversMaps**: NIWA NZRiversMaps website, which includes various estimates of stream and river flows across the entire New Zealand river network (https://shiny.niwa.co.nz/nzrivermaps/). This website states that the mean flow was estimated using the Hydrology of Ungauged Catchments method (Ref: *Booker DJ, Woods RA. 2014. Comparing and combining physically-based and empirically-based approaches for estimating the hydrology of ungauged catchments*).

(c) **WRC Flow Gauging**: Waikato Regional Council actual flow gauge data on the Pūniu River at the Bartons Corner Rd bridge, approximately 4.9km NNW, downstream of the site. Mean flow data from this site was then applied to the Wharekōrino Stream on a pro rata catchment area basis.

4.2 Comparative Results

Mean flow comparative results are summarised below.

Table 1: Mean Flow Comparative Results

Method	Wharekōrino Stream (by landfill)	Pūniu River (Bartons Corner Rd bridge)
Catchment Analysis	62.4 L/s	7.4 m^3/s
NZRiversMaps	105 L/s	14.6 m^3/s
WRC Flow Gauging	121 L/s	14.32 m^3/s

Note: Wharekōrino Stream catchment area at landfill = 0.44km^2; Pūniu River catchment area at Bartons Corner Rd bridge = 518.7km^2

The WRC Flow Gauging method is considered the most appropriate to use, as it is based on actual flow measurements. This gives a mean flow for Culvert 3 of 121L/s.

4.3 Depth and Velocity for Mean Flow

Using the adopted mean flow of 121L/s, the proposed culvert 3 was analysed for fish passage performance, starting with no tailwater and incrementally increasing tailwater until the culvert was nearly full. As the culvert is embedded by 340mm, tailwater depth was measured from the embedded level. These results are summarised in Table 2.

Table 2: Velocity and depth at increasing tailwater depth.

Tailwater depth (m)	Outlet Velocity (m/s)	Depth (m)	Threshold met
0.0	1.04	0.18 (inlet control)	No
0.2	1.04	0.18 (inlet control)	No
0.3	1.04	0.18 (inlet control)	No
0.4	0.24	0.22 (outlet control)	Yes
0.6	0.16	0.40 (outlet control)	Yes
0.8	0.12	0.60 (outlet control)	Yes
1.0	0.11	0.80 (outlet control)	Yes

At tailwater depths below 0.4m, the culvert operates under inlet control and the velocity increases above the threshold required for īnanga passage (0.44m/s from SLR Fish Passage Evaluation Memo). At tailwater depths of 0.4m and greater, the culvert operates under outlet control and the thresholds for both depth and velocity are met.

This indicates that when the water level exceeds roughly half the culvert diameter (~0.4m tailwater depth) conditions become feasible for fish passage. This assumes that all water travels through the culvert with a uniform (constant) velocity profile both horizontally and vertically across the water profile. In reality, the velocity profile is non-uniform and increases with distance from the culvert wall (0m/s) to a maximum in the centre of the culvert at the water surface. Hence, fish passage is likely to be feasible over a greater depth and velocity range than summarised in Table 2 based on mean flow.

If the tailwater depth is 1.01m or greater, the 1.35m diameter culvert is in a fully submerged condition and the calculated average velocity is 0.11m/s (=0.121m^3/s/1.15m^2). Fish passage remains feasible under these conditions, as the velocity is below the maximum threshold for īnanga.

4.4 Expected Flow Depths in Culvert 3

Observations from multiple site visits are that Culvert 3 is typically either fully drowned or almost drowned, under both normal and storm flow conditions. This is shown in Figure 1 below, where the top of culvert 3 at the inlet end is just visible.

Figure 1: Culvert 3 Inlet – 29 Feb 2024

Based on an estimated conservative water depth in Culvert 3 of 1m, this gives a water level of 30.5m RL (29.5m IL +1.0m) (NZVD2016).

For the proposed culvert, the effective base of the culvert (at top of embedded material) will be 30.2mRL at the inlet and 30.0mRL at the outlet. Hence, based on a "normal" water level of 30.5m RL from site observations, this means the water depth in the proposed culvert will normally be 0.3m and 0.5m at the culvert inlet and outlet respectively. Under these conditions, the calculated flow velocities in Table 1 are less than 0.44m/s which is sufficient for īnanga. Hence, it is expected that the proposed culvert will provide adequate fish passage during normal flow conditions.

5.0 FISH PASSAGE IN ACCORDANCE WITH NIWA FISH PASSAGE GUIDELINES

According to the New Zealand Fish Passage Guidelines Version 2.0 (June 2024), section 4.5.3, the bank-full flow is defined as the upper flow threshold (Q_H) and ⅓ of the bank-full flow is defined as the lower flow threshold (Q_L) for verifying fish passage in the culvert. Survey data and site observations shows that the stream channel is about 3m wide and 1m deep at the top of bank at the culvert 3 inlet end.

Section 4 demonstrates that fish passage is feasible under actual mean stream flows, while this section assesses fish passage under bank-full flow. Culvert water velocities are typically calculated as mean cross-sectional water velocities, and these mean velocities, often exceed fish swimming velocities and endurance. The guideline states that the best practical way to account for the velocity distribution within the culvert is to look at depth-averaged vertical slices within the culvert at the fish passage design flow. Section 4.5.6 of these guidelines provides a systematic methodology for determining the depth-averaged velocity of vertical slices of the flow within the culvert (Figure 2).

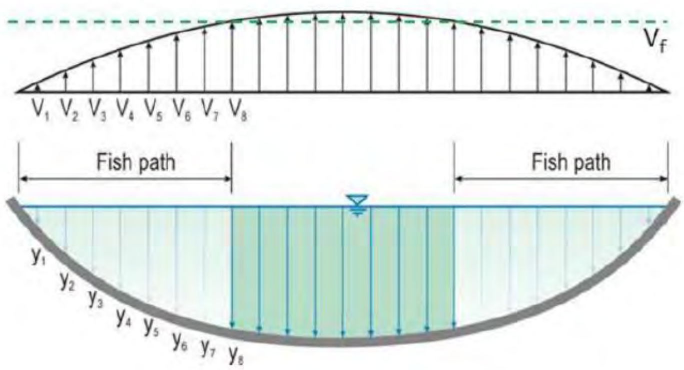


Figure 2: Culvert water velocity distribution with depth averaged velocities in vertical slices.

Figure 3 shows examples of vertical slices over a typical velocity distribution within a rectangular channel. The depth-averaged velocity within the vertical slice outlined in red would be much lower than the vertical slice in yellow. The vertical slice outlined in red would also have a significantly lower water velocity than the mean cross-sectional water velocity.

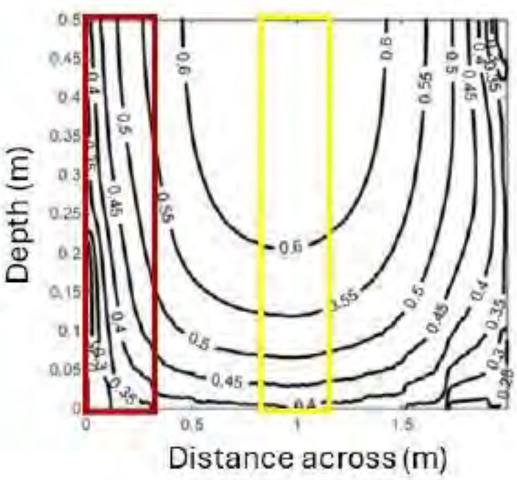


Figure 3: Cross-sectional water velocity distribution within a rectangular channel with example vertical slices. Modified from Cassan et al. (2019).

5.1 Scenario 1: Open channel/culvert not fully submerged - Depth-averaged water velocity analysis using HY8 low flow hydraulics

Based on the HECRAS 2D flood modelling results, the blue line below shows the 'bankfull' flow (Figure 4). At this water level, the bankfull flow is 1.35m^3/s. In this case, Q_H = 1.35m^3/s and Q_L = 0.45m^3/s (calculated from

1.35/3). For these conditions, V_H = 1.39m/s and V_L = 0.56m/s – these are estimated average velocities calculated from modelled flow depths in HY-8 software when the culvert is partially embedded and water is flowing freely and still behaves as an open channel.

It should be noted that the stream bed gradient through this area is relatively flat, with an estimated bed gradient of 0.3%, while water levels at culvert 3 are controlled by existing trees/vegetation within the stream itself below Te Mawhai Road and the Te Mawhai Rd culvert (C1). Removal of culvert C2 between C1 and C3 has been modelled to help reduce stream flood levels upstream of C2 but is unlikely to have an effect on normal stream water levels, due to the stream bed gradient, existing vegetation/trees and C1 all restricting flow, causing water to back up through this area. This is supported by FTL staff who have visited the Tokanui site regularly over the last two years, including during summer, only ever having seen the top of C3 once, with it just visible above the water level, meaning the water depth would have been around 1.-1.1m under low flow conditions, further supporting the above comments (refer photo in Figure 1).

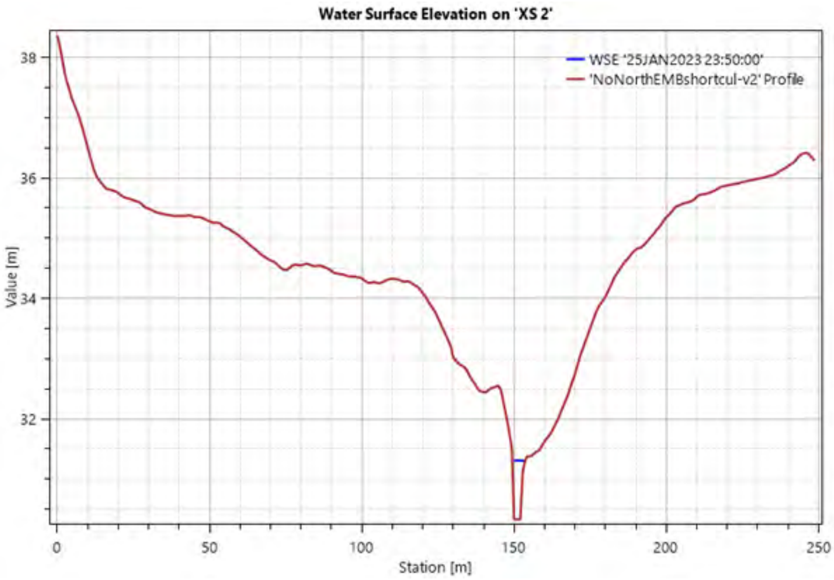


Figure 4: Cross section of stream at culvert 3 and the water level during 'bankfull' flow.

As stated above, C3 has been observed to be submerged under normal flow conditions. Hence, a tailwater depth of 800mm from the stream bed was included in the HY8 low flow hydraulics analysis. In this case, the culvert still behaves as an open channel as the culvert is not fully submerged yet. Figures 5 and 6 show culvert cross-section slices for half of the culvert span and would mirror the same way to the right. The NIWA guideline states that the minimum width of the fish passable vertical slice should be 150mm. About 200mm from both sides of the culvert during low flow and 170mm during high flow meet the threshold for īnanga. The velocity beyond that becomes too fast for īnanga as the slices approach the centre.

Low Flow Results			
Distance from wall (m)	0.00 - 0.20	0.20 - 0.41	0.41 - 0.61
Slice Average Velocity (m/s)	0.04	0.57	0.69
Slice Depth (m)	0.62	0.62	0.62
Threshold	Threshod Met	Too Fast	Too Fast

Figure 5: Low flow results

High Flow Results			
Distance from wall (m)	0.00 - 0.17	0.17 - 0.35	0.35 - 0.52
Slice Average Velocity (m/s)	0.09	1.42	1.71
Slice Depth (m)	0.76	0.76	0.76
Threshold	Threshold Met	Too Fast	Too Fast

Figure 6: High flow results

5.2 Scenario 2: culvert fully submerged – Average velocity analysis

Since the culvert was modelled to be embedded 340mm in the stream bed, the remaining height within the 1350mm culvert is 1010mm. Therefore, when a tailwater of 1010mm depth or more was incorporated, the culvert became fully submerged and behaved as a pipe flowing under pressure. Hence, HY8 low flow hydraulics is not applicable anymore.

In this case for the same peak flows as in section 5.1, the average velocities of turbulent flow within a fully submerged culvert, during low and high flow are v_L (average) = 0.39m/s and v_H (average) = 1.17m/s respectively – calculated from the continuity equation (Q=Av). These average velocities are lower than those calculated in section 5.1. The velocity on the wall of the pipe is zero and increases to maximum as it approaches the centre of the pipe (Figure 7). The HY-8 software is not able to analyse the pipe velocity distribution in this situation. However, based on the calculated average velocities, it is expected that fish would be able to swim along the walls of the pipe during low flow but possibly not during high flow based on the typical velocity distribution shown in Figure 7.

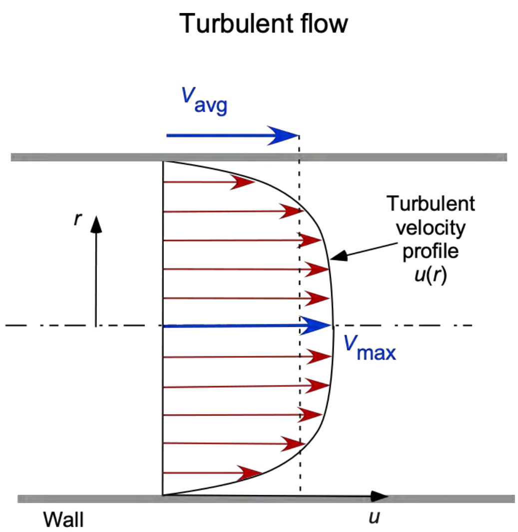


Figure 7: Turbulent velocity profile.

From observing the current permanent ponded/pool condition with slow flowing water at culvert 3, usual flows should be lower than the bankfull modelled flow that was used in this analysis. Therefore, the frequency of a potentially suitable fish passage condition should be higher. High flow conditions should be temporary and of short duration, and fish should be able to pass once the flow reduces.

5.3 Scenario 3: Culvert Fully Submerged and Under Inlet Control

This scenario is when the pipe is flowing full due to storm flows, irrespective of the downstream tailwater level and the analysis is based on a 1200mm culvert, presuming the culvert has the same flow area as the 1350mm diameter with 340mm embedded. Desktop calculations indicate that the culvert would be flowing full for peak flows in excess of 2m^3/s. At a peak flow of 2m^3/s, the average velocity through the culvert would increase to approximately 1.77m/s.

The Fish Passage guidelines (Section 4.5.4) refer to bankfull flow being approximately 50% of the year flood flow (approximately a 1.5 year storm). Hence, on this basis, the 2-year storm would be 2.7m^3/s. Hence, the 2m^3/s criteria is estimated to around the 1.8 year storm or a storm that on average might occur once every 22 months. This means it is a relatively infrequent event and would be expected to be of relatively short duration.

6.0 FISH PASSAGE MITIGATION MEASURES

Design of Culvert 3 and new stream has incorporated several features to promote fish passage. These are summarised in this section:

(a) Embedment of proposed culvert by 340mm (25% of diameter);
(b) Stream alignment to follow a gentle meander and to be naturalised including regular 150-300mm deep pools, rocks and logs.
(c) Low flow channel.
(d) Riparian planting.
(e) Resting pools at the culvert inlet and outlet, with the outlet pool also functioning as an energy dissipation basin for storm events.

These features are shown on the landfill drawings (33097/LF300 series).

7.0 SUMMARY AND RECOMMENDATIONS

The culvert design allows for embedding the 1350mm diameter culvert by 340mm, which is an approved method of providing for fish passage, from the NIWA Fish Passage Guidelines. Fish passage has then been assessed for the embedded culvert for a range of flow conditions.

For mean flow conditions (121L/s), Culvert 3 is expected to be feasible for fish passage, based on both depth and velocity thresholds. This also applies even when the culvert is fully submerged. This is significantly lower than the modelled 2-year lower bank-full flow threshold (QL) of 450L/s (see section 5). This is to be expected as the mean flow represents average conditions, while the 2 year storm flow represents a storm event which has a 50% probability of occurring in any one year.

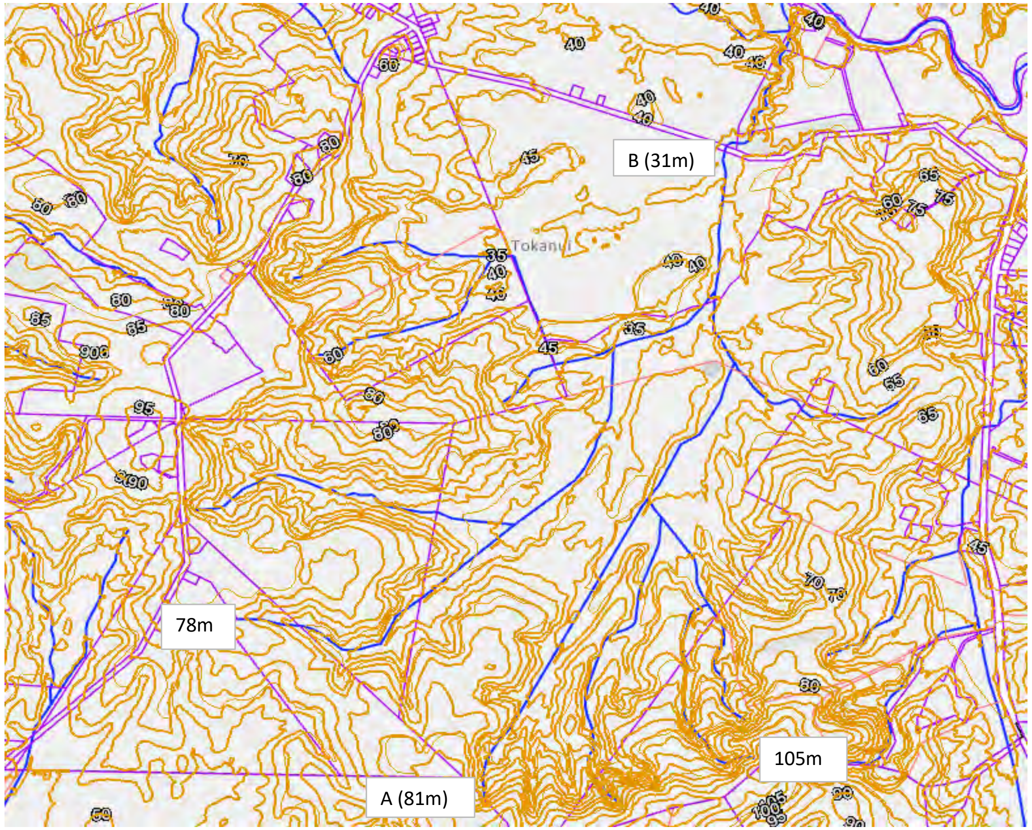
In the bank-full storm scenario, when culvert 3 behaves as an open channel, the "vertical slices" hydraulics analysis shows that it satisfies the minimum width of 150mm, maximum water velocity 0.44m/s and minimum water depth 150mm for īnanga to pass during low and high flow conditions. When the inlet and outlet of culvert 3 are fully submerged due to high tailwater conditions, the culvert behaves as a pressurised pipe with turbulent flow. In this case, the average pipe velocities calculated indicate that fish should be able to swim along the walls of the pipe during low flow, but possibly not during high flow. The culvert will also be fully submerged due to high flow conditions, for events equivalent to approximately a 1.8 year (22 month) storm or more extreme storm events. In this situation, average velocities through the culvert will increase, but for a relatively short duration and fish should be able to pass once the flow reduces.

The culvert and new stream design also feature a number of other features to promote fish passage, including the stream alignment having a gentle meander, naturalisation using 150-300mm deep pools, rocks and logs; low flow channel; riparian planting; and resting pools at the culvert inlet and outlet, with the outlet pool also functioning as an energy dissipation basin for storm events. Collectively, these features together with the culvert embedment should ensure that fish passage along the new stream and culvert 3 is possible under most conditions, except during certain storm events, which will be of short duration.

Stream Flow Assessment
Method 1 (Catchment Runoff Basis)

	Landfill	Bartons Br	
Catchment area	440	51870	ha
Catchment slope	Moderate		
Land use	Mainly pasture		
Runoff coefficient	0.4	0.4	heavy clay soil type, 5-10% gradient (measured off contour plans)
Annual rainfall	1118.7	1118.7	mm
Average annual runoff	1968912	2.32E+08	m3/yr
Average flow per day	5394	635912	m3/d
Average flow per day	62.4	7360	L/s

https://waikatomaps.waikatoregion.govt.nz/Viewer/?map=8d6d6fda779b4e59951953ae97d0ec4a



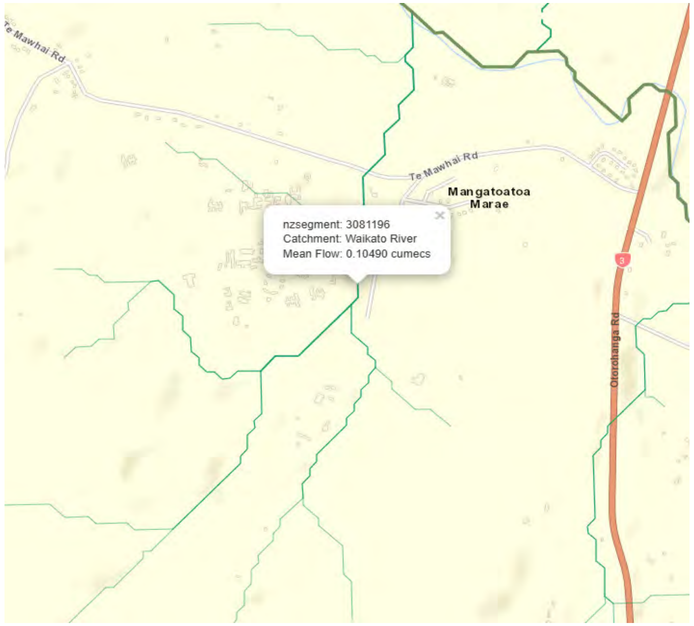
Distance AB = 2860m Gradient = 1.7% (along stream)

Measured overland flow gradients going anticlockwise: Generally in range 5-10%

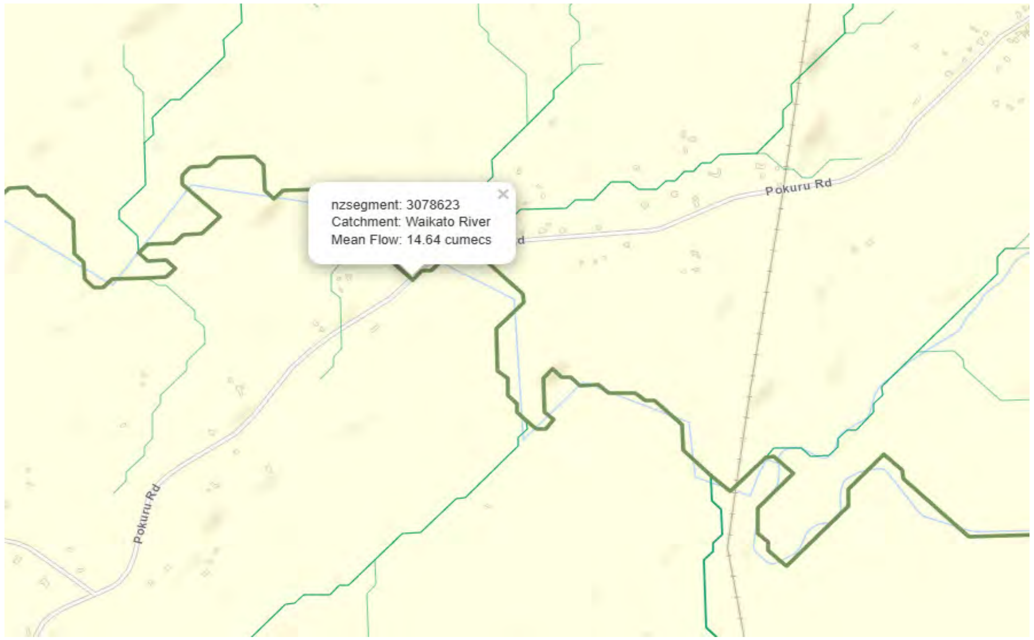
Line	1	2	3	4	5	6
%	5.6	5.6	7.5	5.6	9.3	9.5

Method 2 (NIWA River Maps)

Location	Mean Q	
Wharekorino at Te Mawhai Rd (includes hospital catchment)	124.7	L/s
Wharekorino at landfill	104.9	L/s
Puniu (at Bartons Bridge)	14.64	m3/s

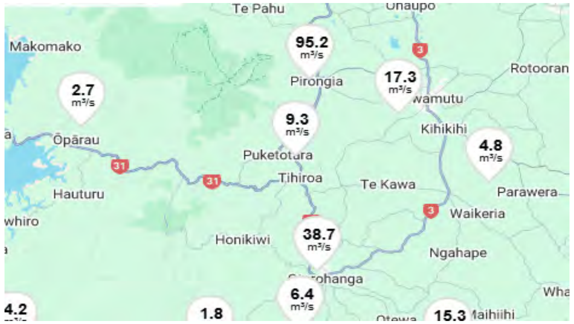


Puniu River, Pokuru Road (Barton's Bridge)



Method 3 (from comparison with WRC flow gauges)

Location	Catch Area (km2)	Mean Q (m3/s)	Spec Q (m3/s/ km2)
Puniu (at Bartons Bridge)	518.7	14.32	0.028
Mangatutu Stream	122	3.79	0.031
Pro rata basis			
Wharekorino at Te Mawhai Rd	6	0.166	
Wharekorino at Landfill	4.4	0.121	

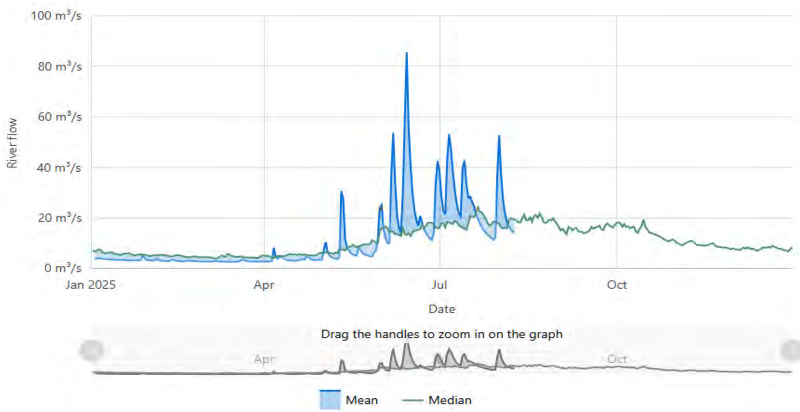


Site information

Site name:	Puniu River - Bartons Corner Rd Br
Site number	818
Station number	2

Additional Information

Mean flow (m^3/s)	14.32
Continuous data since	06/05/1985
Highest recorded flow (m^3/s)	322.19 on 16/10/1989
Lowest recorded flow (m^3/s)	2.14 on 15/02/1992
Data download restriction	No
Altitude (m) above mean sea level (amsl)	30.95
Catchment size (km^2)	518.70
Map reference	NZTM:1801295 - 5788365

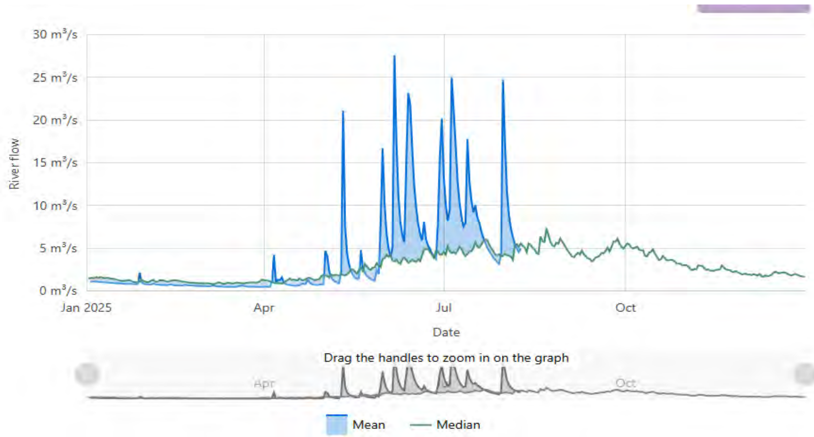


Site information

Site name:	Mangatutu Stm (Waikeria) - Walker Rd Br
Site number	476
Station number	7

Additional Information

Mean flow (m^3/s)	3.79
Continuous data since	08/06/2004
Highest recorded flow (m^3/s)	38.19 on 01/01/2024
Lowest recorded flow (m^3/s)	0.48 on 27/03/2008
Data download restriction	No
Altitude (m) above mean sea level (amsl)	40
Catchment size (km^2)	122.00
Map reference	NZTM:1810109 - 5780575



Comparison

Method	Mean Q (L/s)
Catchment	62.4
NIWA Rivers	104.9
WRC flow gauges	121.5

CLIENT

JOB

CLIENT REF. NO:

JOB No/PAGE

DATE

BY YG

CHECKED

Fraser Thomas

ENGINEERS • RESOURCE MANAGERS • SURVEYORS

Average velocity - culvert not fully submerged

$$V_L = \frac{Q_L}{A_L}$$

$$= \frac{0.45 \ m^3/s}{0.81 \ m^2}$$

$$= 0.56 \ m/s$$

$$V_H = \frac{Q_H}{A_H}$$

$$= \frac{1.35 \ m^3/s}{0.97 \ m^2}$$

$$= 1.39 \ m/s$$

Average velocity - culvert fully submerged

$$V_L = \frac{Q_L}{A_L}$$

$$= \frac{0.45 \ m^3/s}{1.15 \ m^2}$$

$$= 0.39 \ m/s$$

$$V_H = \frac{Q_H}{A_H}$$

$$= \frac{1.35 \ m^3/s}{1.15 \ m^2}$$

$$= 1.17 \ m/s$$

HY-8 Culvert Analysis Report

Culvert Data: Culvert 3

Culvert Data Summary - Culvert 3

Barrel Shape: Circular

Barrel Diameter: 1350.00 mm

Barrel Material: Concrete

Embedment: 340.00 mm

Barrel Manning's n: 0.0130 (top and sides)

Manning's n: 0.0130 (bottom)

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall (Ke=0.5)

Inlet Depression: None

Low Flow Hydraulic Computations

Low Flow Hydraulic Discharges

Low Flow 0.45 cms

High Flow 1.35 cms

Peak Flow 2.00 cms

Threshold

Max Threshold Velocity 0.44 m/s

Min Threshold Depth 0.15 m

Threshold for both Flows Threshold is Met

Model Parameters

Number of Divisions in Flow Top Width: 6

Low Flow Threshold Results

Highest Average Velocity in Culvert 0.56 m/s

Depth in Culvert at Highest Average Velocity 0.62 m

Top Width in Culvert at Highest Average Velocity 1.22 m

Selected Velocity Adjustment Curve Curve 1: Culvert Embedment is greater than 20%

Width of Slice along Culvert Water Surface 0.20 m

Threshold at Low Flows Threshold is Met

High Flow Threshold Results

Highest Average Velocity in Culvert 1.40 m/s

Depth in Culvert at Highest Average Velocity 0.76 m

Top Width in Culvert at Highest Average Velocity 1.04 m/s

Selected Velocity Adjustment Curve Curve 1: Culvert Embedment is greater than 20%

Width of Slice along Culvert Water Surface 0.17 m

Threshold at High Flows Threshold is Met

Low Flow Results

Distance from Wall (m)	**1.00**	**1.67**	**2.34**	**3.00**	**3.67**	**4.34**	**5.01**	**5.67**	**6.34**	**7.01**	**7.68**	**8.34**	**9.01**	**9.68**	**10.35**	**11.01**	**11.68**	**12.35**	**13.02**	**13.68**
Slice Velocity (m/s)	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68
Slice Depth (m)	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68
Threshold	Threshold	TooF	TooF																	

	Met	ast	ast																	

High Flow Results

Distance from Wall (m)	**0.86**	**1.43**	**2.00**	**2.57**	**3.14**	**3.71**	**4.28**	**4.85**	**5.42**	**5.99**	**6.56**	**7.13**	**7.70**	**8.27**	**8.84**	**9.41**	**9.98**	**10.55**	**11.12**	**11.69**
Slice Velocity (m/s)	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69
Slice Depth (m)	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69
Threshold	Threshold Met	Too Fast	Too Fast																	

Attachment 6

Fraser Thomas Limited
21 El Kobar Drive : East Tamaki : AUCKLAND 2013
PO Box 204006 : Highbrook : AUCKLAND 2161
NEW ZEALAND
TEL +64 9 278 7078 : E-MAIL sfinnigan@ftl.co.nz

Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS

MEMORANDUM

Date: 20 August 2025 33097

From: S Finnigan

Subject: Former Tokanui Hospital: Estimated Effect of Landfill Upgrade Works on Boron Discharges (V2)

To: Emily Buckingham (emily.buckingham@slrconsulting.com)

1.0 INTRODUCTION

This memo summarises our assessment of the estimated likely reduction in boron discharges to the Wharekōrino Stream as a result of improved landfill capping and groundwater diversion from the landfill, in response to a question raised by Mana Whenua during a site meeting to discuss the landfill repair and upgrade works.

2.0 BACKGROUND INFORMATION

Long-term monitoring (consent compliance) of groundwater downgradient of the landfill, and surface waters in the Wharekōrino Stream upstream and downstream, has indicated that dissolved boron levels from groundwater sampled at monitoring bore P2 exceed Australian and New Zealand Environment and Conservation Council (ANZECC) trigger levels for the protection of 95% of freshwater species. This results in elevated total boron concentrations in mid-stream and downstream samples of the Wharekōrino Stream, but still well within the ANZECC 95% trigger thresholds. These findings are depicted in Figures 1 and 2 below.

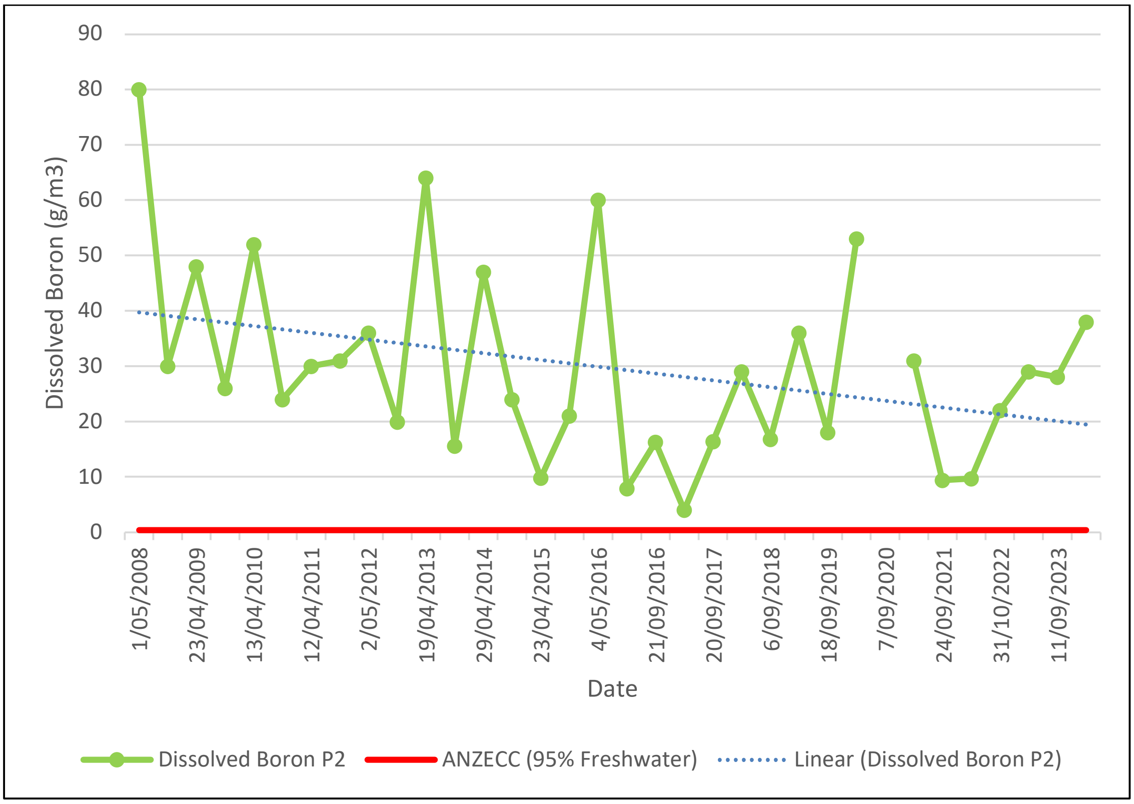


Figure 1: Long term dissolved boron levels (g/m³) within the landfill (P2)

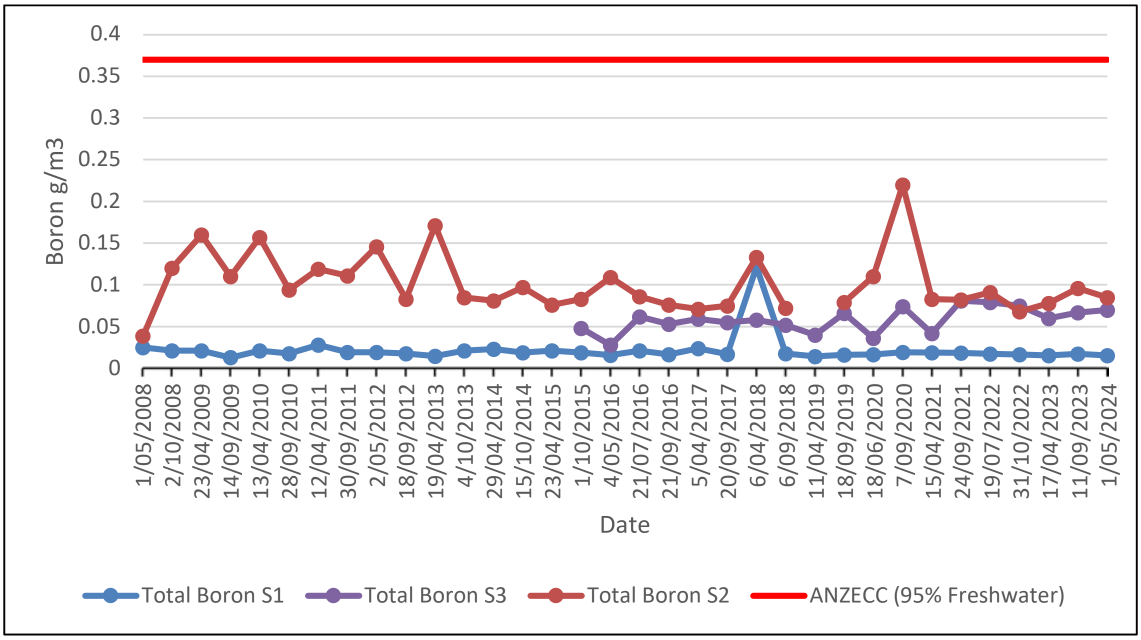


Figure 2: Long-term total boron levels (g/m^3) upstream (S1), midstream (S3), and downstream (S2) of the landfill in comparison to the ANZECC trigger value for protection of 95% of aquatic species. Note that the ANZECC boron trigger referred to above comes from the 2000 guidelines and was increased in 2021 to 0.94mg/kg (approximately 3 times higher) based on errors identified in the 2000 derivation and new data becoming available.

Boron leaching to groundwater and the stream currently occurs via two main pathways:

(a) Shallow groundwater from upgradient travelling through the refuse to the stream.

(b) Rainfall infiltrates through the landfill and passes through the refuse, and then combines with shallow groundwater going to the stream.

The current situation and these pathways are illustrated in Figure 3 below.

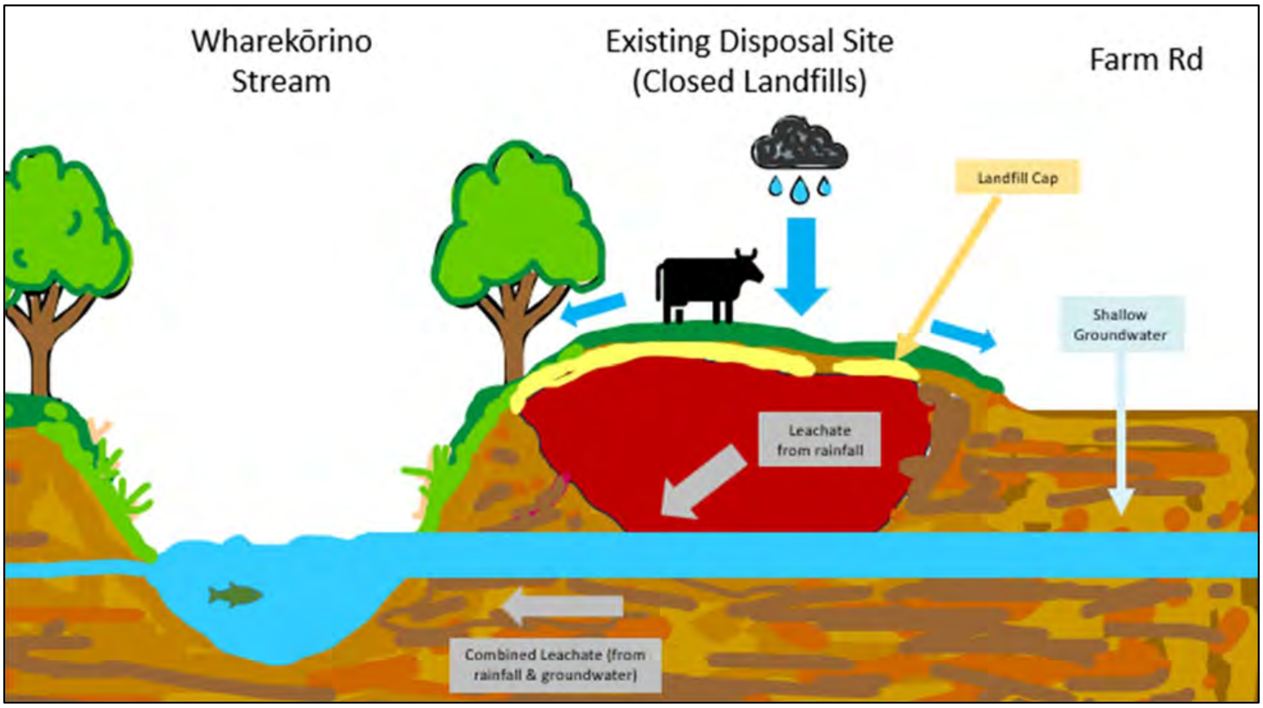


Figure 3: Current Boron Leaching Pathways to Stream

The proposed landfill upgrade and repair works will address both these issues, by:

(a) Installing an improved GCL (geosynthetic clay liner) cap that will significantly reduce rainfall infiltration into the landfill and hence leachate generation from rainfall.

(b) Installing a groundwater cutoff drain upgradient of the southern landfill area that will intercept shallow groundwater and divert it around the landfill to the stream. This will significantly reduce (and potentially eliminate) shallow groundwater contact with refuse in the southern landfill area.

The upgrade situation and the effects of this on boron leaching pathways to the stream are illustrated in Figure 4 below.

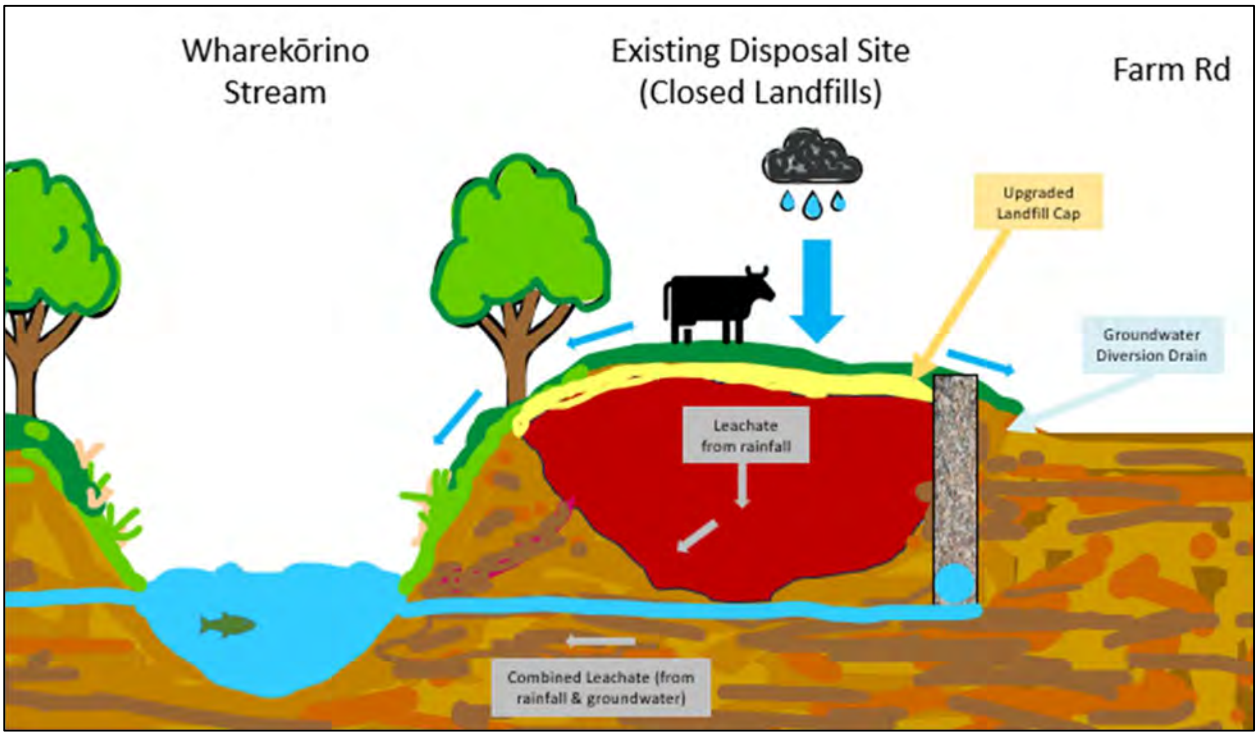


Figure 4: Post-Upgrade Works, Reduced Boron Leaching Pathways to Stream

3.0 METHODOLOGY

The methodology used in this assessment is set out below:

1. Estimate annual average stream flows in the Wharekōrino stream by the landfill, using two methods:
   (a) Catchment analysis, using average annual rainfall data (1,119mm) from the nearby NIWA Waikeria rain gauge – 30-year record (1991-2020).
   (b) Using Waikato Regional Council Pūniu River flow gauge data for mean stream flows to estimate corresponding stream flows in the Wharekōrino Stream on a pro rata area basis (440ha catchment vs 518.7km^2 catchment).
2. Analysing the long-term stream monitoring data over the last 10 years, calculating the difference in boron concentrations between upstream and downstream sampling locations for each sampling event and then calculating the average change (increase) in boron concentration in the stream.

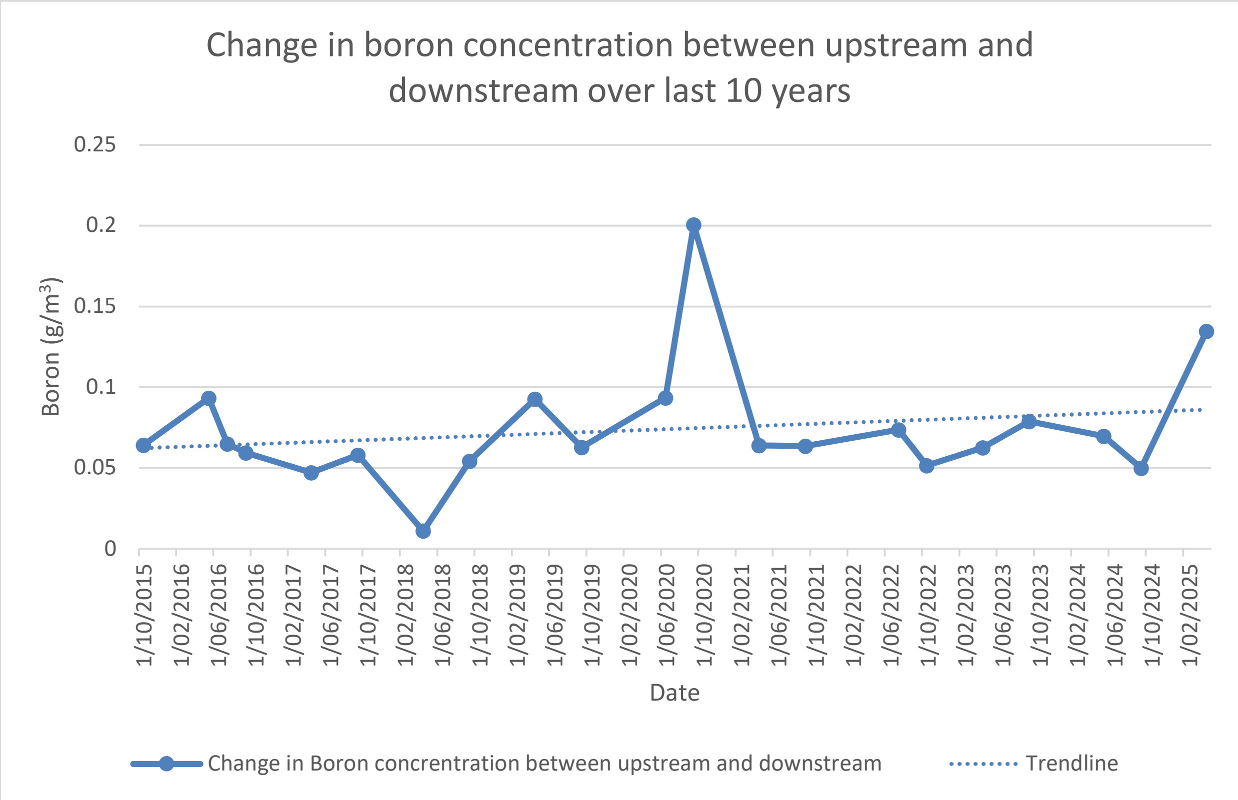


Figure 5: Change in boron concentration upstream and downstream of landfill over the last 10 years

3. Estimating the annual average boron discharge to the stream (kg/yr) as average annual stream flow x average change in concentration for each stream flow method.
4. Calculating the long-term boron concentration from monitoring data in the groundwater monitoring well, P2, and assuming this is representative of the average boron concentration in the groundwater discharge to the stream from the entire landfill.
5. Hence, calculate the average annual leachate flow to the stream as boron discharge to stream/boron concentration in groundwater.
6. Calculate the estimated annual average leachate volume from rainfall onto the landfill, based on measured landfill areas from site investigations, average annual rainfall (Waikeria rainfall gauge) and estimated infiltration rates of 10-25%.
7. Hence, calculate the estimated leachate volume from shallow groundwater flowing through the landfill by difference.
8. Check whether this makes sense by comparing estimated groundwater leachate volumes with theoretical volumes based on Darcy's Law (Q = kiA), where k = refuse permeability, i = hydraulic gradient of groundwater and A = cross-sectional area of groundwater in contact with refuse. Literature values of refuse hydraulic conductivity vary between around 1 x 10^{-3}m/s and 1x10^{-9}m/s (source: LANDSS). For Tokanui, the permeability is considered likely to be at the high end of this range, or even more permeable, based on the age of the landfill, anecdotal information on refuse placement and site observations. The hydraulic gradient was estimated by plotting groundwater level information on representative cross-sections through the landfill. Figure 6 shows a cross-section through the southern landfill area. This information was also used to estimate the average depth and width of groundwater in contact with refuse, thereby determining the cross-sectional area.
9. The effect of the landfill upgrade and repair works on leachate flows and boron discharges to the stream was then estimated, as follows:
   (a) Assume capping reduces the leachate infiltration rate to 2-5% and calculate the revised leachate volume from rainfall.
   (b) Assumed the groundwater intercept trench reduces the amount of groundwater in contact with refuse by 80-90%.
   (c) Calculate the revised average annual leachate volume as the sum of rainfall and groundwater-derived leachate.

(d) Assume that the average annual boron concentration in leachate remains the same as measured at P2.
(e) Hence, calculate the reduced boron discharge to the stream in kg/yr (reduced volume x same concentration).
(f) Calculate the percentage reduction in the boron discharge by comparison with the pre-works discharge.
(g) Calculate estimated revised boron concentrations in the stream, compared with the current situation.
(h) Estimate the time it will take for the reduced concentrations to be achieved, taking into account typical groundwater travel times.

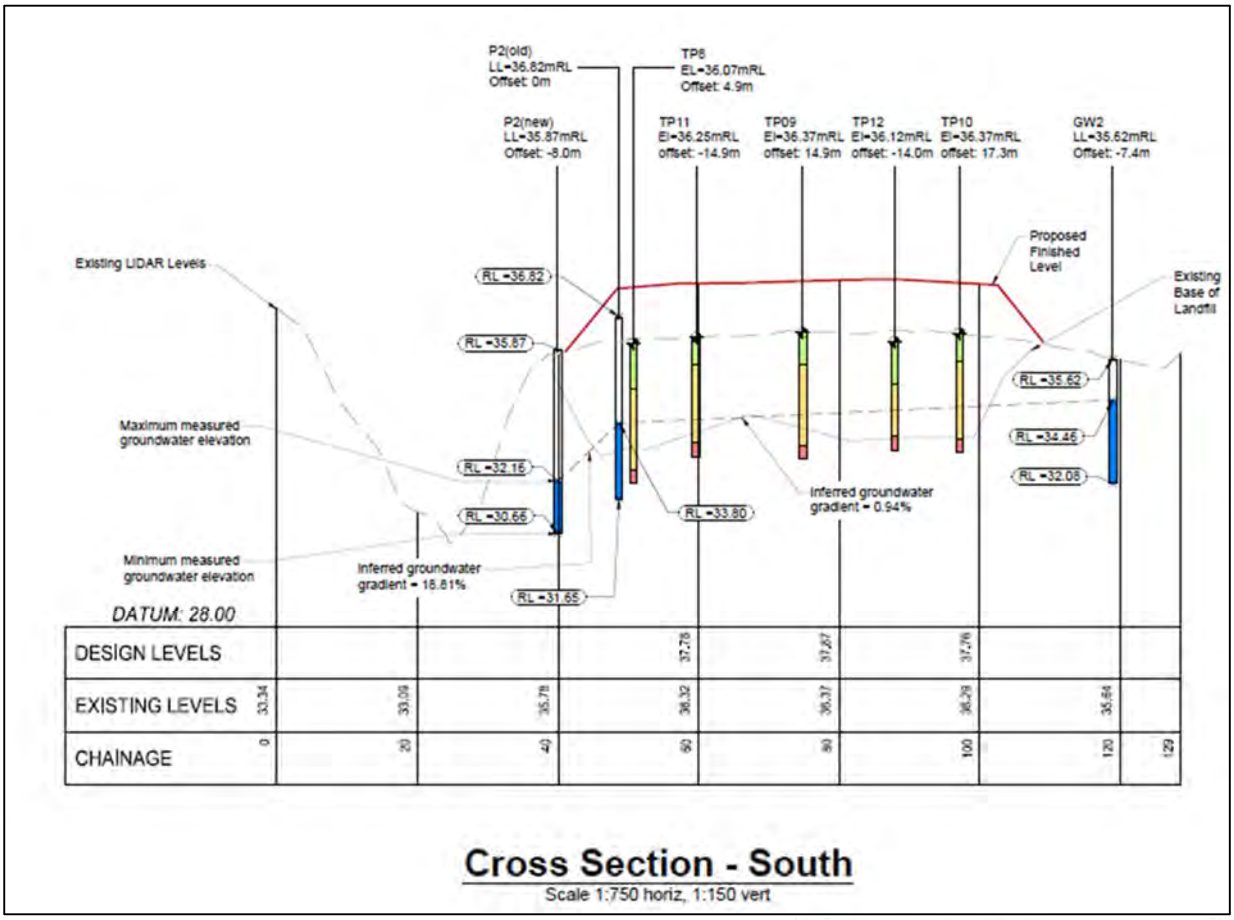


Figure 6: Cross-section – South showing refuse (yellow) and groundwater (blue) extents

4.0 RESULTS

4.1 Estimated Boron Discharge Reduction

The results are summarised in Table 1, with calculations attached in Appendix A. They show that current leachate discharges to the stream are estimated to be in the range of 5,787-11,260m^3/yr, representing 0.29% of average stream flows. The proposed landfill upgrade and repair works will reduce these to an estimated 468-2,700m^3/yr, equivalent to percentage reductions of 72-92% and equating to 0.02-0.07% of annual average stream flows.

Table 1: Summary of Boron Discharge Reduction Results

Item	Stream Flow Method 1 (from rainfall data)		Stream Flow Method 2 (from river flow data)	
Current Situation				
Average annual Stream Flow (m^3/yr)	1,970,261		3,833,394	
Average annual change in boron concentration in stream due to landfill (g/m^3)	0.0738		0.0738	
Average annual boron load to stream (kg/yr)	145		283	
Average Boron Concentration in GW Well, P2 (g/m^3)	25.1		25.1	
Annual average leachate flow to stream (m^3/yr)	5,787		11,260	
Rainfall infiltration rate through landfill (%)	10	25	10	25
Leachate from rainfall (m^3/yr)	1,709	4,273	1,709	4,273
Leachate from groundwater (m^3/yr)	4,078	1,514	9,551	6,987
Effect of Landfill Remedial Works				
Rainfall infiltration rate through landfill (%)	2-5	2-5	2-5	2-5
Leachate from rainfall (m^3/yr)	316-790	316-790	316-790	316-790
Groundwater diversion from landfill (%)	80-90	80-90	80-90	80-90
Leachate from groundwater (m^3/yr)	408-816	151-303	955-1,910	699- 1,397
Total reduced leachate discharge to stream (m^3/yr)	724-1,606	468-1,093	1,271-2,700	1,015-2,188
Reduction in Leachate Discharge to Stream (%)	**72-88**	**81-92**	**76-89**	**81-91**

4.2 Estimated Revised Boron Concentrations in Stream

Actual and estimated annual average boron concentrations in the stream are summarised below and illustrated in Figure 7:

- Existing average annual upstream concentration = 0.0022g/m^3
- Existing average annual downstream concentration = 0.0957g/m^3
- Average estimated downstream concentration post-upgrade works:
    - Rainfall method = 0.00082-0.0227g/m^3
    - Stream flow method = 0.00089-0.0199g/m^3

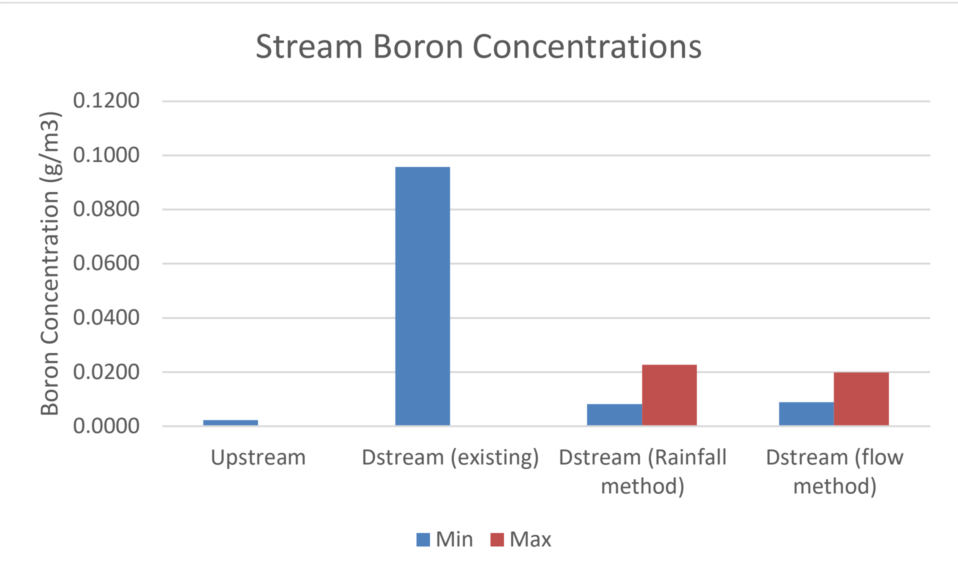


Figure 7: Estimated Downstream Boron Concentrations in Stream Compared with Existing Situation (Upstream and Downstream)

4.3 Estimated Time for Reduced Boron Concentrations to be Achieved

Groundwater travels relatively slowly through the ground, both horizontally and vertically, depending on a range of factors, including the hydraulic gradient and soil permeability. Estimated groundwater travel times have been calculated based on the following:

- A cross-section through the southern landfill, with groundwater having to travel 70m from monitoring well GW2 to the existing P2 well and then another 23m to the stream (refer Figure 6).
- An average hydraulic gradient between GW2 and P2 (old) of 0.94% and from P2 (old) to the stream of 10.4%.
- Variable permeabilities for groundwater to travel through refuse ranging from 0.01-0.001m/s and through natural ground, assuming relatively poor drainage conditions of 0.0001-0.000001m/s.

This gives an estimated groundwater travel time range of from 34 days to 7.2 years. Hence, it may take some months to years for the landfill upgrade and repair works to be reflected in corresponding reductions in boron concentrations reaching the stream.

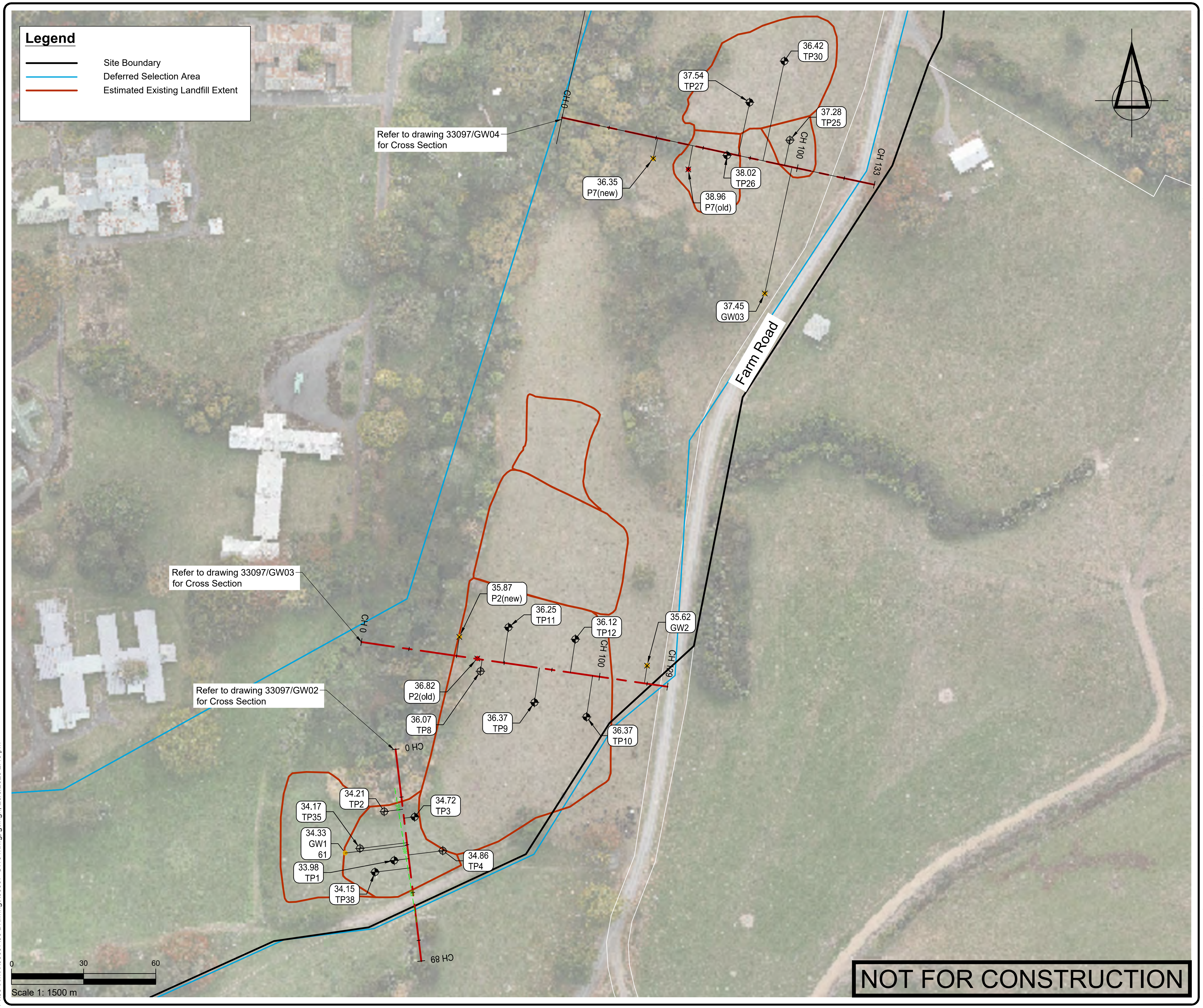
5.0 CONCLUSIONS AND RECOMMENDATIONS

Ongoing long-term consent compliance water quality monitoring has found that there are elevated dissolved boron levels within groundwater that passes through the landfill, leading to increased boron concentrations in the stream, but that the stream boron levels are well within ANZECC 95% freshwater trigger levels.

This assessment has found that boron discharges to the Wharekōrino Stream should significantly reduce by an estimated 72-92% as a result of proposed improved landfill capping and groundwater diversion from the landfill.

This should result in boron concentrations measured at the downstream sampling location in the stream reducing from their current annual average level of 0.0957g/m^3 to in the range of 0.00082-0.0227g/m^3. However, it may take somewhere between just over one month to an estimated 7 years for the landfill upgrade and repair works to be reflected in corresponding reductions in boron concentrations reaching the stream.

Drawings



P:\33 series\33097\03 Drawings\33097-GW01.dwg, gsingh, 20/8/2025 2:40 pm

			APPROVED	DATE
SURVEYED			SF	
DESIGNED	GS	15/08/25	15/08/25	
DRAWN	GS	15/08/25		
CHECKED	SF	15/08/25		

REVISION	CHANGES	CHECKED	DATE

NOTES

1. Landfill base estimated in Civil3D using ground level and test pit log data along cross-section.
2. Groundwater levels for groundwater boreholes P2(old) and P7(old) recorded in 2023, 2024 and 2025 - 7 readings.
3. Groundwater levels for groundwater boreholes GW1, P2(new), GW2, GW3 and P7(new) recorded in 2025 - 3 readings.

PROJECT DATUMS:
LEVEL: New Zealand Vertical Datum 2016
COORDINATE: New Zealand Transverse Mercator

CLIENT
TOITU TE WHENUA LAND INFORMATION NEW ZEALAND

PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
UPDATED GROUNDWATER MONITORING BORE CROSS SECTION PLAN

Over 50 Years
Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS
AUCKLAND 09 278 7078
HAWKE'S BAY 06 211 2766
CHRISTCHURCH 03 358 5936
BLENHEIM 03 428 3292
NELSON 03 222 1132
TAURANGA 07 220 9277
www.fraserthomas.co.nz

STATUS
FOR RESOURCE CONSENT
Construction works shall commence only on receipt of and in accordance with the Council or Council organisation stamped approved drawings, unless otherwise indicated.

SCALE 1:1500 (A3)

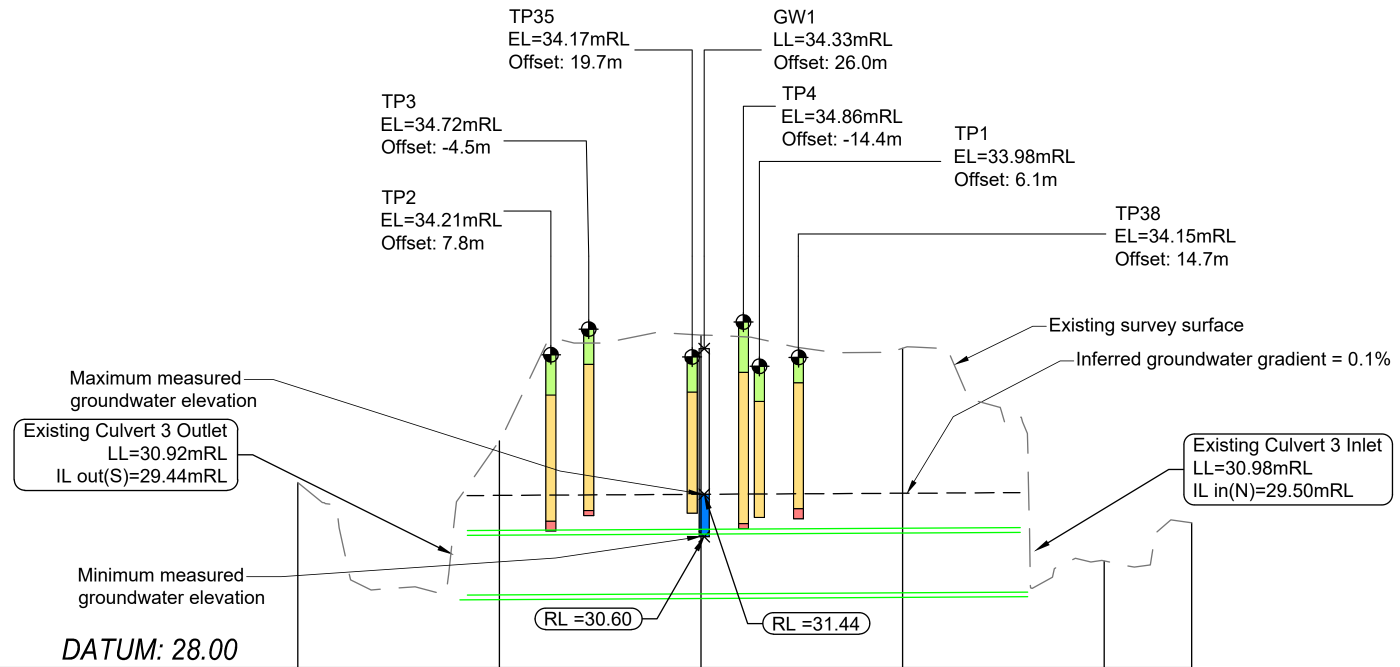
DRAWING No 33097/GW01
REVISION -

Legend

— — — —	Existing Survey level
———	Existing Landfill Base
———	Proposed Finished Level
———	Ground Water Elevation
— — — —	Inferrred Groundwater Table

Testpit - Legend

(green)	Topsoil/Silt/Capping Material
(yellow)	Landfill Material
(red)	Silt/Clay Material (Natural Ground)



EXISTING LEVELS	31.67	32.50	34.60	34.34	30.12	30.88
CHAINAGE	0	20	40	60	80	89

Cross Section - GW01

Scale 1:750 horiz, 1:150 vert

Note:
1. Due to ground stability issues, TP 1 and 35 did not reach natural ground.
2. GW01 monitoring well is offset from the C3 culvert, as shown on drawing 33097/GW01.

0 1.0 2.0 3.0 4.0 5.0 10
Scale 1:150

0 15 30
Scale 1: 750 m

P:\33 series\33097\03 Drawings\33097-GW01.dwg, gsingh, 20/8/2025 2:40 pm

NOT FOR CONSTRUCTION

			APPROVED	DATE
SURVEYED			SF	
DESIGNED	GS	15/08/25	15/08/25	
DRAWN	GS	15/08/25		
CHECKED	SF	15/08/25		

REVISION	CHANGES	CHECKED	DATE

NOTES
1. Landfill base estimated in Civil3D using ground level and test pit log data along cross-section.
2. Groundwater levels for groundwater boreholes P2(old) and P7(old) recorded in 2023, 2024 and 2025 - 7 readings.
3. Groundwater levels for GW1, P2(new), GW2, GW3 and P7(new) recorded in 2025 - 3 readings.

PROJECT DATUMS:
LEVEL: New Zealand Vertical Datum 2016
COORDINATE: New Zealand Transverse Mercator

CLIENT
TOITU TE WHENUA LAND INFORMATION NEW ZEALAND

PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
GROUNDWATER MONITORING CROSS SECTION - GW1

Over 50 Years
Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS
AUCKLAND 09 278 7078
HAWKE'S BAY 06 211 2766
CHRISTCHURCH 03 358 5936
BLENHEIM 03 428 3292
NELSON 03 222 1132
TAURANGA 07 220 9277
www.fraserthomas.co.nz

STATUS
FOR RESOURCE CONSENT
Construction works shall commence only on receipt of and in accordance with the Council or Council organisation stamped approved drawings, unless otherwise indicated.

SCALE AS SHOWN (A3)

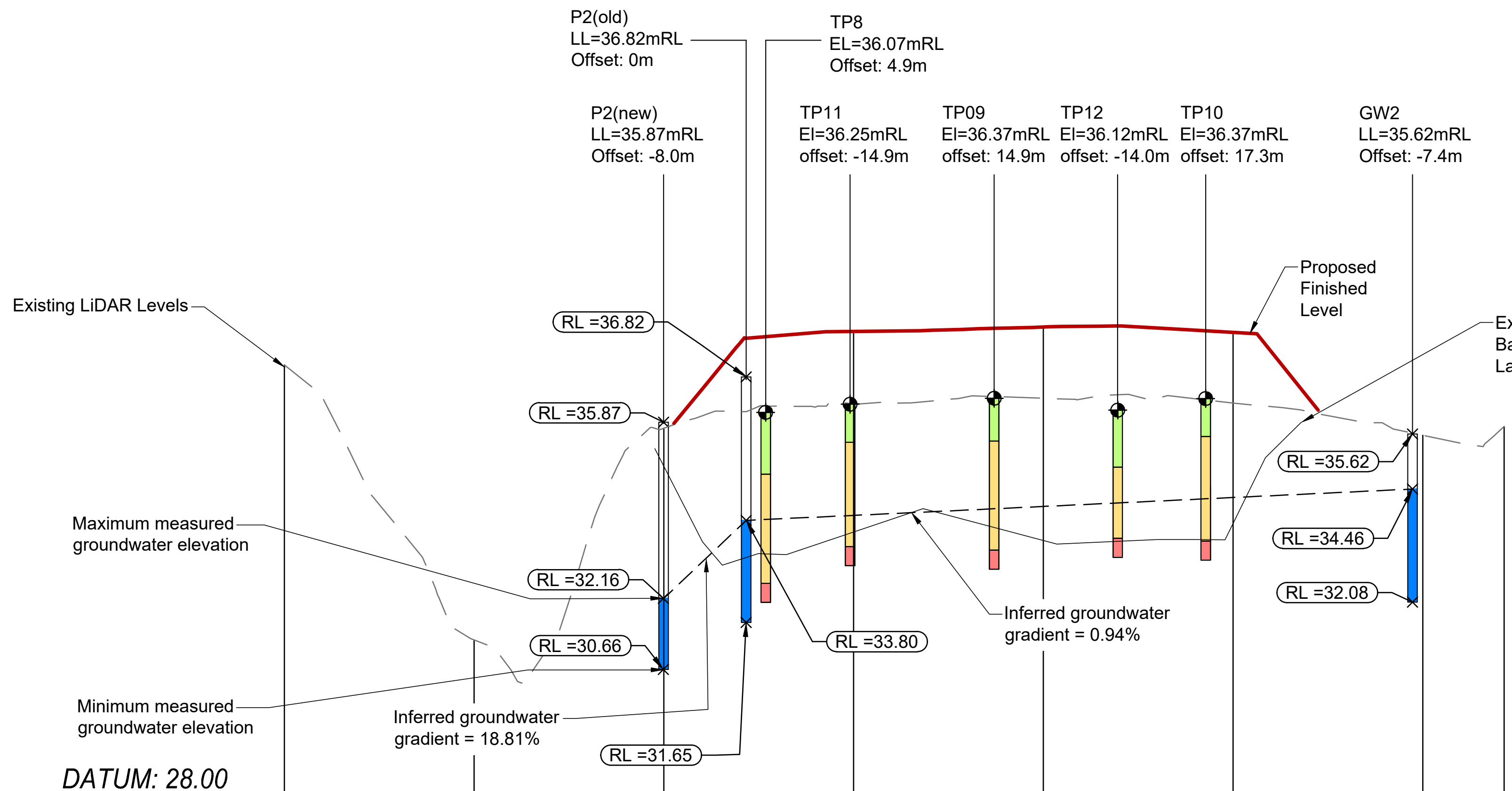
DRAWING No 33097/GW02
REVISION -

Legend

- Existing LiDAR level
- Existing Landfill Base
- Proposed Finished Level
- Ground Water Elevation
- Inferred Groundwater Table

Testpit - Legend

- Topsoil/Silt/Capping Material
- Landfill Material
- Silt/Clay Material (Natural Ground)



DESIGN LEVELS				37.78	37.87	37.76		
EXISTING LEVELS	33.34	33.09	35.78	36.32	36.37	36.29	35.64	
CHAINAGE	0	20	40	60	80	100	120	129

Cross Section - South

Scale 1:750 horiz, 1:150 vert

0 1.0 2.0 3.0 4.0 5.0 10
Scale 1:150

0 15 30
Scale 1: 750 m

P:\33 series\33097\03 Drawings\33097-GW01.dwg, gsingh, 20/8/2025 2:40 pm

NOT FOR CONSTRUCTION

SURVEYED			APPROVED	DATE
DESIGNED	GS	15/08/25	SF	
DRAWN	GS	15/08/25	15/08/25	
CHECKED	SF	15/08/25		

REVISION	CHANGES	CHECKED	DATE

NOTES
1. Landfill base estimated in Civil3D using ground level and test pit log data along cross-section.
2. Groundwater levels for groundwater boreholes P2(old) and P7(old) recorded in 2023, 2024 and 2025 - 7 readings.
3. Groundwater levels for GW1, P2(new), GW2, GW3 and P7(new) recorded in 2025 - 3 readings.

PROJECT DATUMS:
LEVEL: New Zealand Vertical Datum 2016
COORDINATE: New Zealand Transverse Mercator

CLIENT
TOITU TE WHENUA LAND INFORMATION NEW ZEALAND

PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
GROUNDWATER MONITORING CROSS SECTION - SOUTH

Over 50 Years
Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS
AUCKLAND 09 278 7078
HAWKE'S BAY 06 211 2766
CHRISTCHURCH 03 358 5936
BLENHEIM 03 428 3292
NELSON 03 222 1132
TAURANGA 07 220 9277
www.fraserthomas.co.nz

STATUS
FOR RESOURCE CONSENT
Construction works shall commence only on receipt of and in accordance with the Council or Council organisation stamped approved drawings, unless otherwise indicated.

SCALE AS SHOWN (A3)

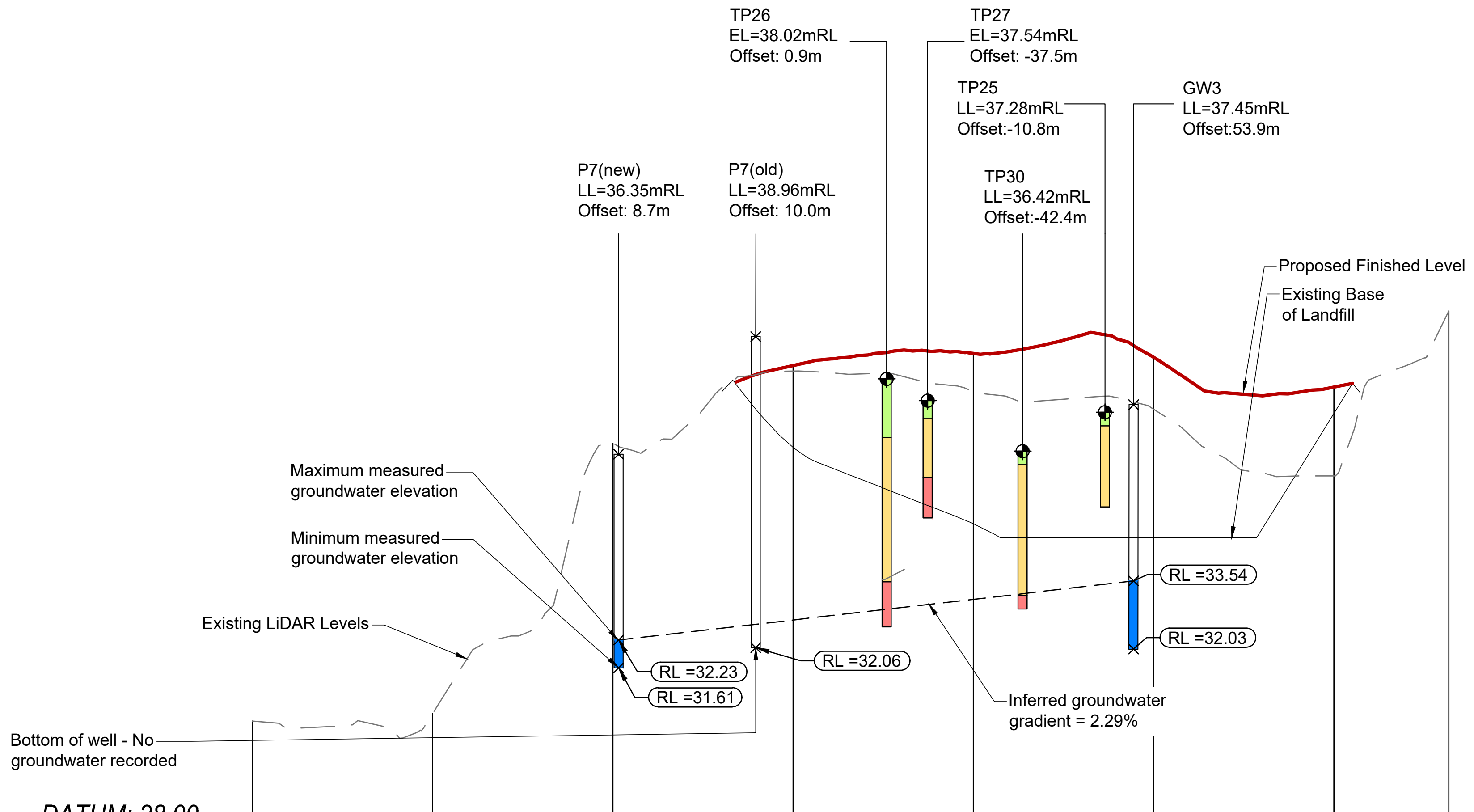
DRAWING No 33097/GW03 REVISION -

Legend

- Existing LiDAR level
- Existing Landfill Base
- Proposed Finished Level
- Ground Water Elevation
- Inferred Groundwater Table

Testpit - Legend

- Topsoil/Silt/Capping Material
- Landfill Material
- Silt/Clay Material (Natural Ground)



DESIGN LEVELS				38.32	38.59	38.50	37.84	
EXISTING LEVELS	30.43	30.60	36.59	38.20	37.75	37.35	35.87	39.53
CHAINAGE	0	20	40	60	80	100	120	133

Cross Section - North

Scale 1:750 horiz, 1:150 vert

0 1.0 2.0 3.0 4.0 5.0 10
Scale 1:150

0 15 30
Scale 1: 750 m

P:\33 series\33097\03 Drawings\33097-GW01.dwg, gsingh, 20/8/2025 2:40 pm

NOT FOR CONSTRUCTION

SURVEYED			APPROVED	DATE
DESIGNED	GS	15/08/25	SF	
DRAWN	GS	15/08/25	15/08/25	
CHECKED	SF	15/08/25		

REVISION	CHANGES	CHECKED	DATE

NOTES

1. Landfill base estimated in Civil3D using ground level and test pit log data along cross-section.
2. Groundwater levels for groundwater boreholes P2(old) and P7(old) recorded in 2023, 2024 and 2025 - 7 readings.
3. Groundwater levels for GW1, P2(new), GW2, GW3 and P7(new) recorded in 2025 - 3 readings.

PROJECT DATUMS:
LEVEL: New Zealand Vertical Datum 2016
COORDINATE: New Zealand Transverse Mercator

CLIENT
TOITU TE WHENUA LAND INFORMATION NEW ZEALAND

PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
GROUNDWATER MONITORING CROSS SECTION - NORTH

Over 50 Years
Fraser Thomas
ENGINEERS • RESOURCE MANAGERS • SURVEYORS

AUCKLAND	09 278 7078
HAWKE'S BAY	06 211 2766
CHRISTCHURCH	03 358 5936
BLENHEIM	03 428 3292
NELSON	03 222 1132
TAURANGA	07 220 9277

www.fraserthomas.co.nz

STATUS
FOR RESOURCE CONSENT
Construction works shall commence only on receipt of and in accordance with the Council or Council organisation stamped approved drawings, unless otherwise indicated.

SCALE AS SHOWN (A3)

DRAWING No 33097/GW04 REVISION -

Appendix A

Calculations

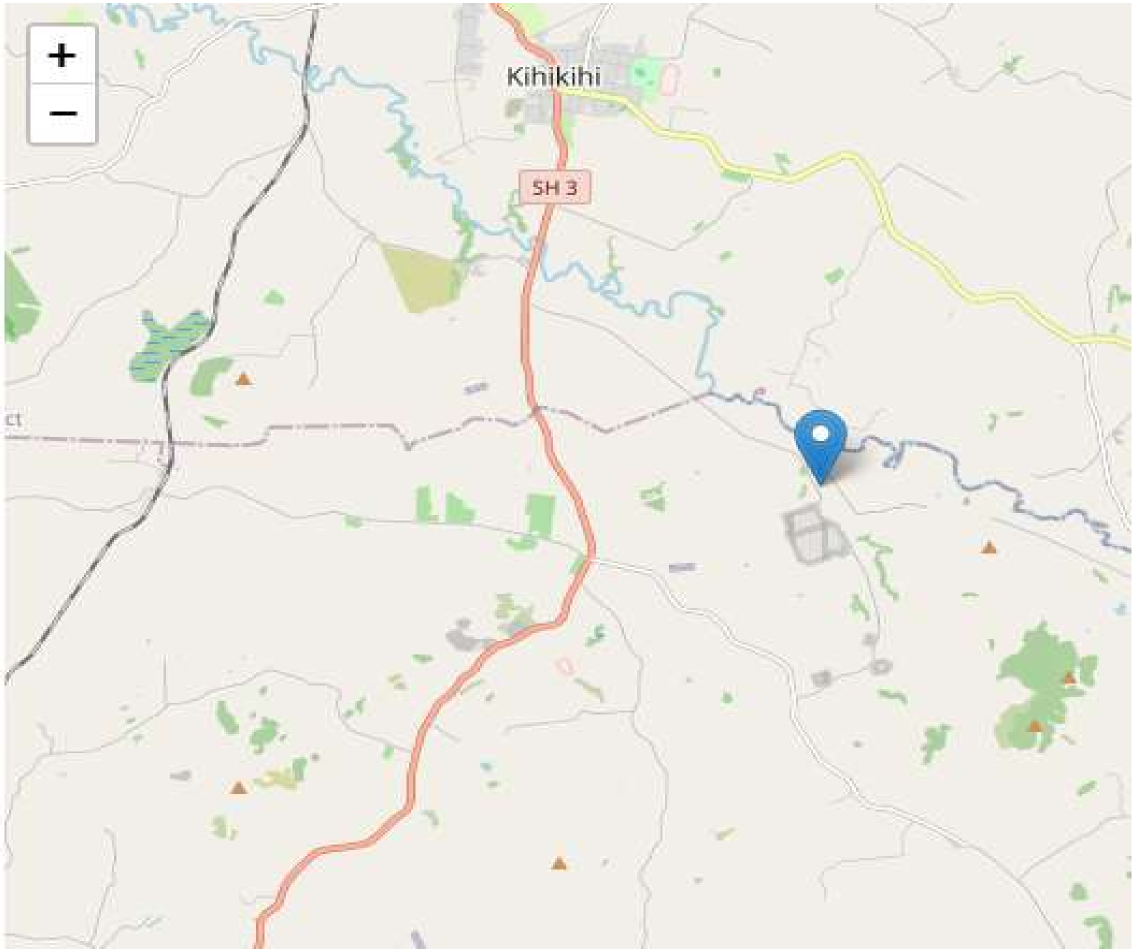
CLIMATE STATION NORMALS

Station: WAIKERIA EWS, parameter: Total rainfall [mm], Climate station normals

Version 0.1 (Updated 16 Dec 2024)

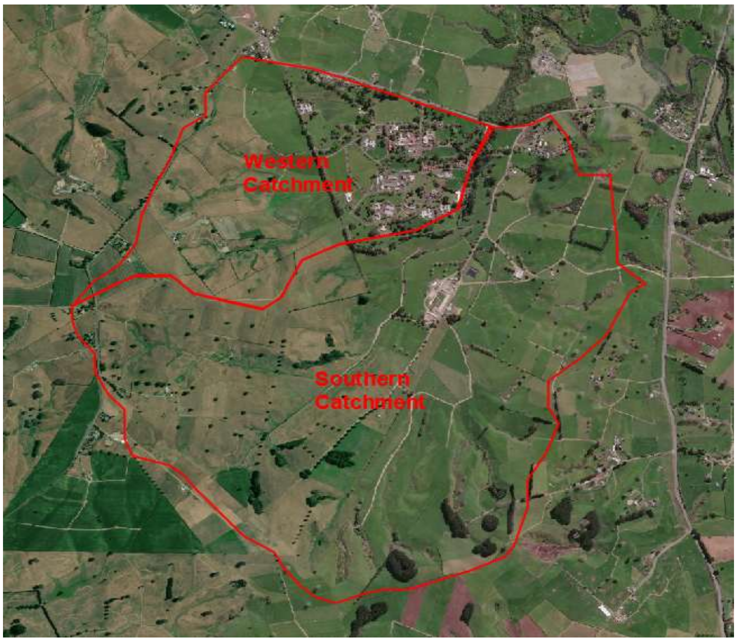
Data period: 1 Jan 1991 — 1 Jan 2021

PERIOD	mm
Annual	1118.7
January	69.8
February	70.9
March	72.2
April	87.5
May	106.4
June	112.3
July	122.4
August	110.1
September	101.2
October	92.9
November	79.7
December	93.3

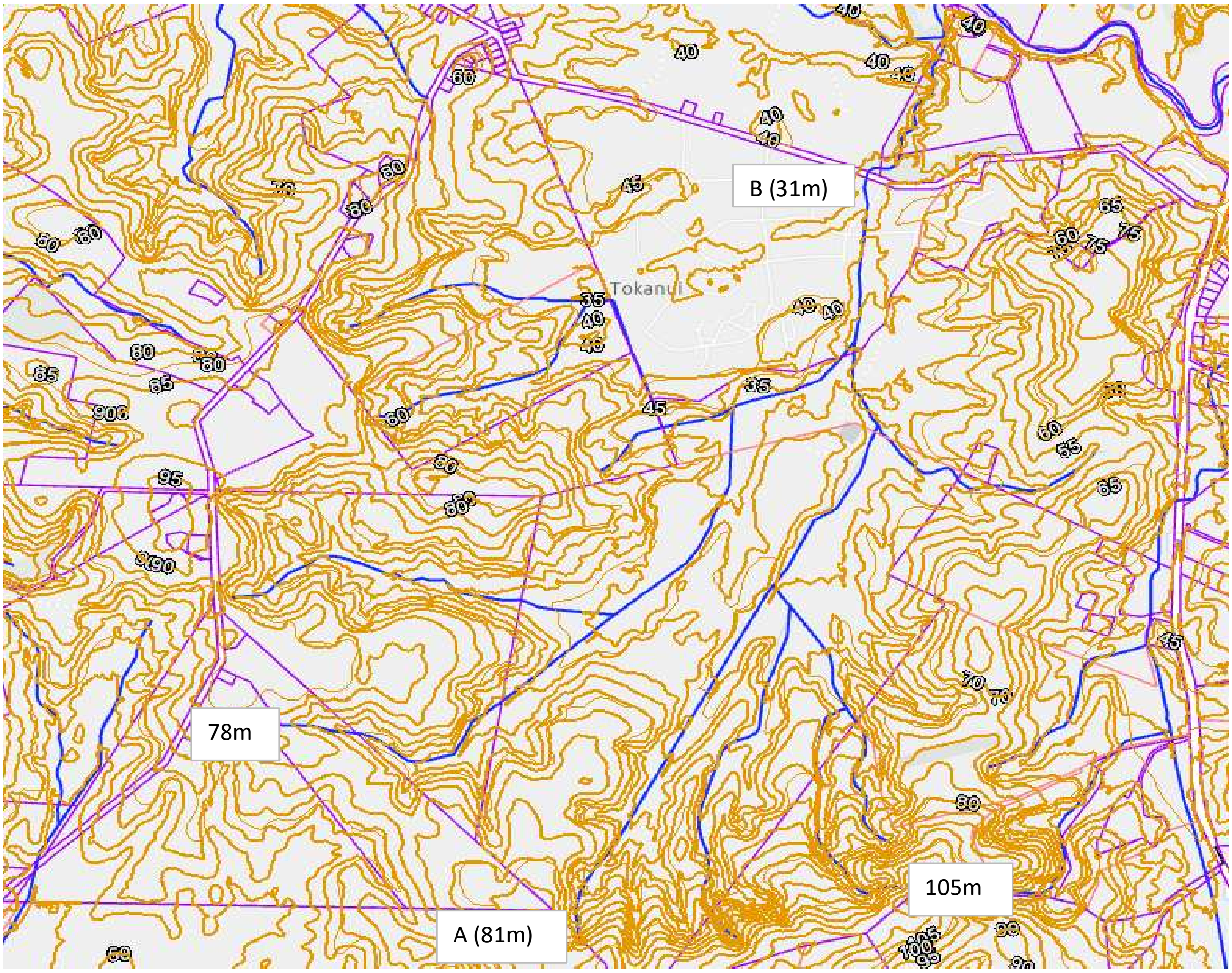


Stream Flow Assessment
Method 1 (Catchment Runoff Basis)

	Landfill	Bartons Br	
Catchment area	440	51870	ha
Catchment slope	Moderate		
Land use	Mainly pasture		
Runoff coefficient	0.4	0.4	heavy clay soil type, 5-10% gradient (measured off contour plans)
Annual rainfall	1118.7	1118.7	mm
Average annual runoff	1968912	2.32E+08	m3/yr
Average flow per day	5394	635912	m3/d
Average flow per day	62.4	7360	L/s



https://waikatomaps.waikatoregion.govt.nz/Viewer/?map=8d6d6fda779b4e59951953ae97d0ec4a



Distance AB = 2860m Gradient = 1.7% (along stream)

Measured overland flow gradients going anticlockwise: Generally in range 5-10%

Line	1	2	3	4	5	6
%	5.6	5.6	7.5	5.6	9.3	9.5

Method 2 (from comparison with WRC flow gauges)

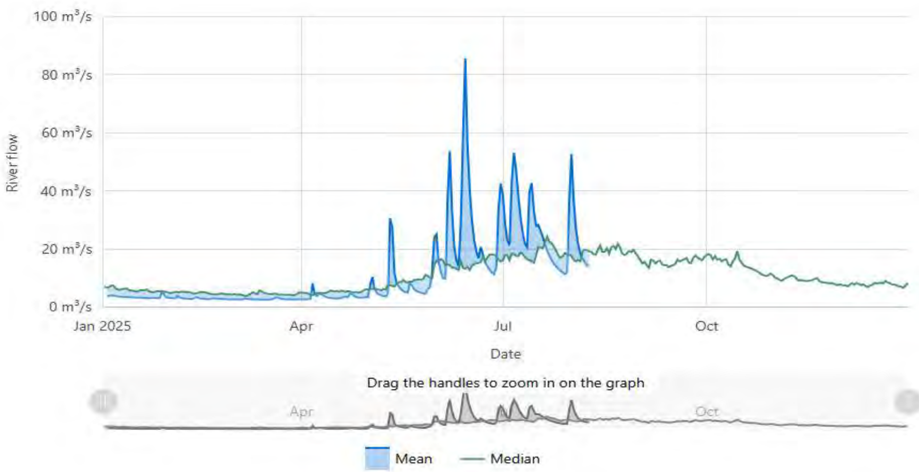
Location	Catch Area (km2)	Mean Q (m3/s)	Spec Q (m3/s/ km2)
Puniu (at Bartons Bridge)	518.7	14.32	0.028
Mangatutu Stream	122	3.79	0.031
Pro rata basis			
Wharekorino at Te Mawhai Rd	6	0.166	
Wharekorino at Landfill	4.4	0.121	

Site information

Site name:	Puniu River - Bartons Corner Rd Br
Site number	818
Station number	2

Additional Information

Mean flow (m^3/s)	14.32
Continuous data since	06/05/1985
Highest recorded flow (m^3/s)	322.19 on 16/10/1989
Lowest recorded flow (m^3/s)	2.14 on 15/02/1992
Data download restriction	No
Altitude (m) above mean sea level (amsl)	30.95
Catchment size (km^2)	518.70
Map reference	NZTM:1801295 - 5788365



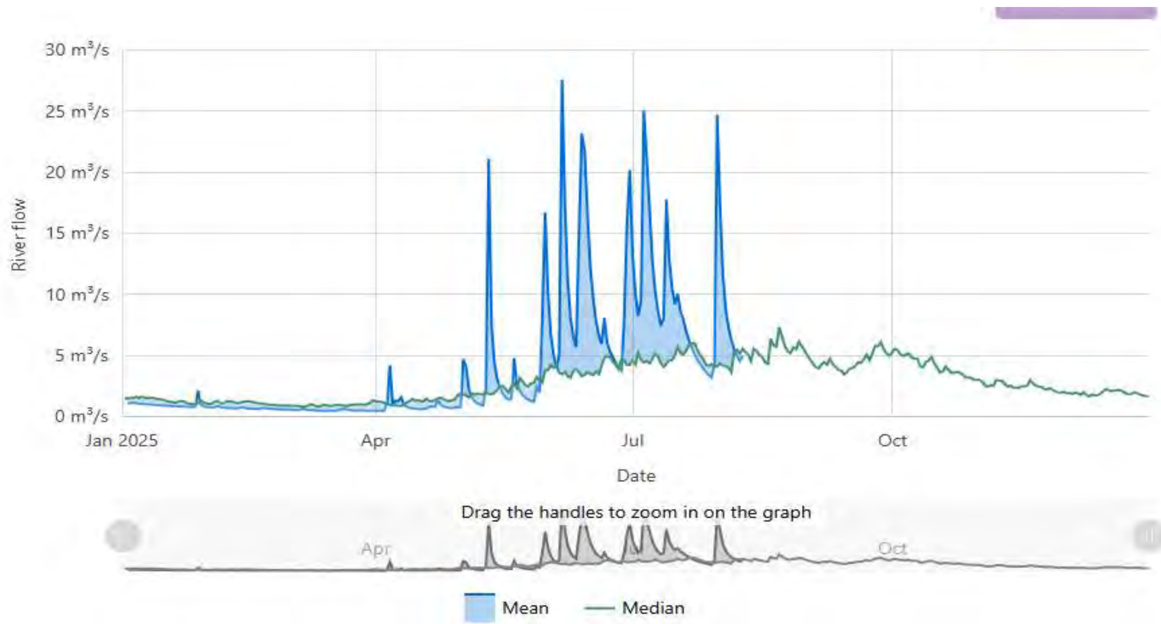
Second smaller stream comparison - Mangatutu Stm

Site information

Site name:	Mangatutu Stm (Waikeria) - Walker Rd Br
Site number	476
Station number	7

Additional Information

Mean flow (m^3/s)	3.79
Continuous data since	08/06/2004
Highest recorded flow (m^3/s)	38.19 on 01/01/2024
Lowest recorded flow (m^3/s)	0.48 on 27/03/2008
Data download restriction	No
Altitude (m) above mean sea level (amsl)	40
Catchment size (km^2)	122.00
Map reference	NZTM:1810109 - 5780575



Comparison

Method	Mean Q (L/s)
Catchment	62.4
WRC flow gauges	121.5

Fraser Thomas

- CONSULTING ENGINEERS
- RESOURCE MANAGERS
- ENVIRONMENTAL CONSULTANTS
- SURVEYORS & PLANNERS

CLIENT ......

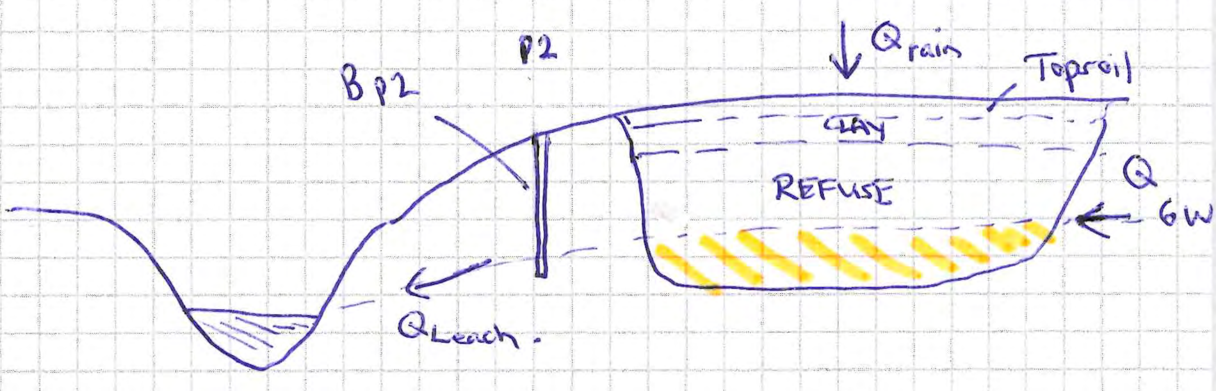
JOB ......

CLIENT REF. NO: ......

BY ...... CHECKED......

JOB No/PAGE ......

DATE ......



Q_{stream}

B_{US}

B_{DS}.

Boron Load from Landfill $= Q_{stream} \times ([B_{US}] - [B_{DS}])$

$$Q_{Leach} = \frac{\text{Boron Load}}{[B_{P2}]} = Q_{rain} + Q_{GW}.$$

Q_{rain} = IR(%) x rainfall x landfill area.

Q_{GW} = kiA (Darcy's Law)

= permeability x GW gradient x Area of GW in contact with refuse

FRASER THOMAS LTD. Office of origin: 152 KOLMAR RD, PAPATOETOE P.O.BOX 23-273 PHONE 0-9 278 7078, FAX 0-9 278 3697
WILLIAMS ROAD, PAIHIA P.O.BOX 154 PHONE & FAX 0-9 402 7838

Results Summary

							Effect of Landfill Improvement Works						
	Q(stm (m3/yr)	QL (m3/yr)	% stm flow	Rainfall IR (%)	QL (rain)	QL (gw)	Rainfall IR (%)	Redn in GW thru refuse (%)	QL (rain)	QL (gw)	Total	% redn	% stream flows
B1	1970261	5787	0.29	10	1709	4078	2	90	316	408	724	87.5	0.037
B2	1970261	5787	0.29	10	1709	4078	5	90	790	408	1198	79.3	0.061
B3	1970261	5787	0.29	25	4273	1514	2	90	316	151	468	91.9	0.024
B4	1970261	5787	0.29	25	4273	1514	5	90	790	151	942	83.7	0.048
B5	1970261	5787	0.29	10	1709	4078	2	80	316	816	1132	80.4	0.057
B6	1970261	5787	0.29	10	1709	4078	5	80	790	816	1606	72.3	0.082
B7	1970261	5787	0.29	25	4273	1514	2	80	316	303	619	89.3	0.031
B8	1970261	5787	0.29	25	4273	1514	5	80	790	303	1093	81.1	0.055
B9	3833394	11260	0.29	10	1709	9551	2	90	316	955	1271	88.7	0.033
B10	3833394	11260	0.29	10	1709	9551	5	90	790	955	1745	84.5	0.046
B11	3833394	11260	0.29	25	4273	6987	2	90	316	699	1015	91.0	0.026
B12	3833394	11260	0.29	25	4273	6987	5	90	790	699	1489	86.8	0.039
B13	3833394	11260	0.29	10	1709	9551	2	80	316	1910	2226	80.2	0.058
B14	3833394	11260	0.29	10	1709	9551	5	80	790	1910	2700	76.0	0.070
B15	3833394	11260	0.29	25	4273	6987	2	80	316	1397	1714	84.8	0.045
B16	3833394	11260	0.29	25	4273	6987	5	80	790	1397	2188	80.6	0.057

Boron Discharge Calcs **Stream Flows - Lower Estimate + 90% Groundwater reduction**

	B1	B2	B3	B4	Units	Comments
Mean Stream Flow	62.4	62.4	62.4	62.4	L/s	
Mean Stream Flow	1970261	1970261	1970261	1970261	m3/yr	
Avg Change in B Concentration	0.0738	0.0738	0.0738	0.0738	g/m3	In stream between US & DS sampling locations, as total B; from long term lab results
Avg Boron Load from Landfill	145	145	145	145	kg/yr	
Avg [B] in gw at P2	25.125	25.125	25.125	25.125	g/m3	At P2, as dissolved B (assumed dissolved B similar to total B)
Leachate flow to stream	5787	5787	5787	5787	m3/yr	
	0.183	0.183	0.183	0.183	L/s	
	0.29	0.29	0.29	0.29	% stm flow	
Leachate contribution from rainfall						
Annual rainfall	1118.7	1118.7	1118.7	1118.7	mm	From Waikeria rain gauge, 30yr average (1991-2020)
Landfill surface areas	15278	15278	15278	15278	m2	From Civil 3D
Infiltration rate	10	10	25	25	%	Estimated infiltration rates (low to high)
Leachate from rainfall	1709	1709	4273	4273	m3/yr	
Leachate from groundwater	4078	4078	1514	1514	m3/yr	By difference
Effect of Proposed Upgrade Works						
Leachate from rainfall						
Adjusted landfill areas	14128	14128	14128	14128	m2	Assumes soils transferred from hospital into area EF contain natural levels of B
Modified infiltration rate	2	5	2	5	%	Estimate based on GCL liner
Leachate (rainfall)	316	790	316	790	m3/yr	
Leachate (groundwater)	408	408	151	151	m3/yr	Assumed 90 % eliminated
Total	724	1198	468	942	m3/yr	
Boron concentration in leach	25.125	25.125	25.125	25.125	g/m3	Assumed unchanged
Boron load into stream	18.2	30.1	11.7	23.7	kg/yr	
Reduction in boron Load	87.5	79.3	91.9	83.7	%	
Avg change in boron conc'n	0.0092	0.0153	0.0060	0.0120	g/m3	
Avg upstream concn	0.0022	0.0022	0.0022	0.0022	g/m3	From lab results
Estimated new DS concn	0.0115	0.0175	0.0082	0.0143	g/m3	
Vs Existing DS concn	0.0957	0.0957	0.0957	0.0957	g/m3	From lab results

Notes:

1. Landfill areas:

	Existing	Post-works	
D (North)	2200	2200	
ABC	10300		A1+B+C (including Agresearch)
A2	1275		
H	1503		
South		11928	Area ABC + A2 + H - 1150, measured from CAD
Total	15278	14128	

GW Flow Check using Darcy's Law

Use Darcy's equation, Q = k.i.A

k, coeff of permeability	0.001	0.01	0.02	0.05	m/s	Note: typical k value for refuse (lower range): 0.001 m/s (low end)
I, hydraulic pressure gradient	0.01	0.01	0.01	0.01	m/m	Estimate I from Civil3D GW table measurements of water level in US & DS wells
A, area of flow	253	253	253	253	m2	Estimate Area from Civil3D cross-sections of gw depths vs refuse
Q	0.00253	0.0253	0.0506	0.1265	m3/s	
	80	798	1597	3992	m3/yr	

Groundwater travel times **Cross-section - south**

Section	Distance	Permeability (m/s)		Hydraulic gradient	v (m/s)		Travel time (days)		
	(m)	Low	High	(m/m)	Low	High	Low	High	
GW2 to P2 (old)	70	0.001	0.01	0.0094	0.0000094	0.000094	86.2	8.6	
P2 (old) to stream	23	0.000001	0.0001	0.1043	1.043E-07	1.04E-05	2552.3	25.5	
Combined							2638.5	34.1	
							7.2	0.09	yrs

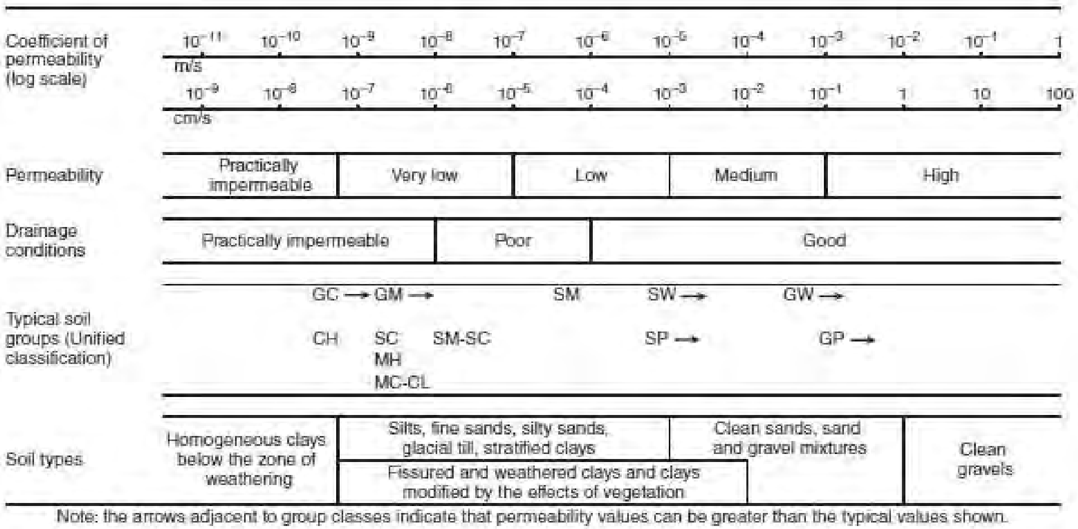


Figure 4.1 Typical permeability values for soils. Adapted from Casagrande and Fadum (1940).

Boron Discharge Calcs **Stream Flows - Lower Estimate + 80% Groundwater reduction**

	B5	B6	B7	B8	Units	Comments
Mean Stream Flow	62.4	62.4	62.4	62.4	L/s	
Mean Stream Flow	1970261	1970261	1970261	1970261	m3/yr	
Avg Change in B Concentration	0.0738	0.0738	0.0738	0.0738	g/m3	In stream between US & DS sampling locations, as total B; from long term lab results
Avg Boron Load from Landfill	145	145	145	145	kg/yr	
Avg [B] in gw at P2	25.125	25.125	25.125	25.125	g/m3	At P2, as dissolved B (assumed dissolved B similar to total B)
Leachate flow to stream	5787	5787	5787	5787	m3/yr	
	0.183	0.183	0.183	0.183	L/s	
	0.29	0.29	0.29	0.29	% stm flow	
Leachate contribution from rainfall						
Annual rainfall	1118.7	1118.7	1118.7	1118.7	mm	From Waikeria rain gauge, 30yr average (1991-2020)
Landfill surface areas	15278	15278	15278	15278	m2	From Civil 3D
Infiltration rate	10	10	25	25	%	Estimated infiltration rates (low to high)
Leachate from rainfall	1709	1709	4273	4273	m3/yr	
Leachate from groundwater	4078	4078	1514	1514	m3/yr	By difference
Effect of Proposed Upgrade Works						
Leachate from rainfall						
Adjusted landfill areas	14128	14128	14128	14128	m2	Assumes soils transferred from hospital into area EF contain natural levels of B
Modified infiltration rate	2	5	2	5	%	Estimate based on GCL liner
Leachate (rainfall)	316	790	316	790	m3/yr	
Leachate (groundwater)	816	816	303	303	m3/yr	Assumed 80 % eliminated
Total	1132	1606	619	1093	m3/yr	
Boron concentration in leach	25.125	25.125	25.125	25.125	g/m3	Assumed unchanged
Boron load into stream	28.4	40.3	15.6	27.5	kg/yr	
Reduction in boron Load	80.4	72.3	89.3	81.1	%	
Avg change in boron conc'n	0.0144	0.0205	0.0079	0.0139	g/m3	
Avg upstream concn	0.0022	0.0022	0.0022	0.0022	g/m3	From lab results
Estimated new DS concn	0.0167	0.0227	0.0101	0.0162	g/m3	
Vs Existing DS concn	0.0957	0.0957	0.0957	0.0957	g/m3	From lab results

Boron Discharge Calcs **Stream Flows - Upper Estimate + 90% Groundwater reduction**

	B9	B10	B11	B12	Units	Comments
Mean Stream Flow	121.5	121.5	121.5	121.5	L/s	
Mean Stream Flow	3833394	3833394	3833394	3833394	m3/yr	
Avg Change in B Concentration	0.0738	0.0738	0.0738	0.0738	g/m3	In stream between US & DS sampling locations, as total B; from long term lab results
Avg Boron Load from Landfill	283	283	283	283	kg/yr	
Avg [B] in gw at P2	25.125	25.125	25.125	25.125	g/m3	At P2, as dissolved B (assumed dissolved B similar to total B)
Leachate flow to stream	11260	11260	11260	11260	m3/yr	
	0.357	0.357	0.357	0.357	L/s	
	0.29	0.29	0.29	0.29	% stm flow	
Leachate contribution from rainfall						
Annual rainfall	1118.7	1118.7	1118.7	1118.7	mm	From Waikeria rain gauge, 30yr average (1991-2020)
Landfill surface areas	15278	15278	15278	15278	m2	From Civil 3D
Infiltration rate	10	10	25	25	%	Estimated infiltration rates (low to high)
Leachate from rainfall	1709	1709	4273	4273	m3/yr	
Leachate from groundwater	9551	9551	6987	6987	m3/yr	By difference
Effect of Proposed Upgrade Works						
Leachate from rainfall						
Adjusted landfill areas	14128	14128	14128	14128	m2	Assumes soils transferred from hospital into area EF contain natural levels of B
Modified infiltration rate	2	5	2	5	%	Estimate based on GCL liner
Leachate (rainfall)	316	790	316	790	m3/yr	
Leachate (groundwater)	955	955	699	699	m3/yr	Assumed 90 % eliminated
Total	1271	1745	1015	1489	m3/yr	
Boron concentration in leach	25.125	25.125	25.125	25.125	g/m3	Assumed unchanged
Boron load into stream	31.9	43.9	25.5	37.4	kg/yr	
Reduction in boron Load	88.7	84.5	91.0	86.8	%	
Avg change in boron conc'n	0.0083	0.0114	0.0067	0.0098	g/m3	
Avg upstream concn	0.0022462	0.0022462	0.0022462	0.0022462	g/m3	From lab results
Estimated new DS concn	0.0106	0.0137	0.0089	0.0120	g/m3	
Vs Existing DS concn	0.0957	0.0957	0.0957	0.0957	g/m3	From lab results

Boron Discharge Calcs **Stream Flows - Upper Estimate + 80% Groundwater reduction**

	B13	B14	B15	B16	Units	Comments
Mean Stream Flow	121.5	121.5	121.5	121.5	L/s	
Mean Stream Flow	3833394	3833394	3833394	3833394	m3/yr	
Avg Change in B Concentration	0.0738	0.0738	0.0738	0.0738	g/m3	In stream between US & DS sampling locations, as total B; from long term lab results
Avg Boron Load from Landfill	283	283	283	283	kg/yr	
Avg [B] in gw at P2	25.125	25.125	25.125	25.125	g/m3	At P2, as dissolved B (assumed dissolved B similar to total B)
Leachate flow to stream	11260	11260	11260	11260	m3/yr	
	0.357	0.357	0.357	0.357	L/s	
	0.29	0.29	0.29	0.29	% stm flow	
Leachate contribution from rainfall						
Annual rainfall	1118.7	1118.7	1118.7	1118.7	mm	From Waikeria rain gauge, 30yr average (1991-2020)
Landfill surface areas	15278	15278	15278	15278	m2	From Civil 3D
Infiltration rate	10	10	25	25	%	Estimated infiltration rates (low to high)
Leachate from rainfall	1709	1709	4273	4273	m3/yr	
Leachate from groundwater	9551	9551	6987	6987	m3/yr	By difference

Effect of Proposed Upgrade Works

Leachate from rainfall						
Adjusted landfill areas	14128	14128	14128	14128	m2	Assumes soils transferred from hospital into area EF contain natural levels of B
Modified infiltration rate	2	5	2	5	%	Estimate based on GCL liner
Leachate (rainfall)	316	790	316	790	m3/yr	
Leachate (groundwater)	1910	1910	1397	1397	m3/yr	Assumed 80 % eliminated
Total	2226	2700	1714	2188	m3/yr	
Boron concentration in leach	25.125	25.125	25.125	25.125	g/m3	Assumed unchanged
Boron load into stream	55.9	67.8	43.1	55.0	kg/yr	
Reduction in boron Load	80.2	76.0	84.8	80.6	%	
Avg change in boron conc'n	0.0146	0.0177	0.0112	0.0143	g/m3	
Avg upstream concn	0.0022462	0.0022462	0.0022462	0.0022462	g/m3	From lab results
Estimated new DS concn	0.0168	0.0199	0.0135	0.0166	g/m3	
Vs Existing DS concn	0.0957	0.0957	0.0957	0.0957	g/m3	From lab results