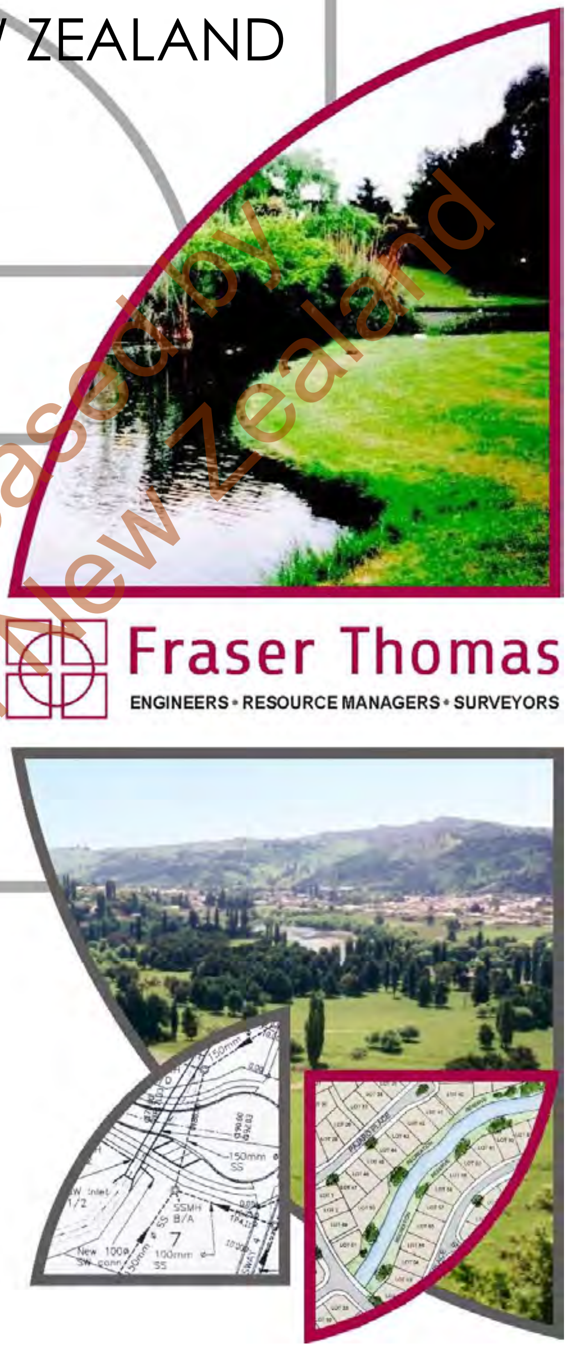
TOITŪ TE WHENUA

LAND INFORMATION NEW ZEALAND



146 TE MAWHAI ROAD, TE AWAMUTU

FORMER TOKANUI HOSPITAL
EXISTING DISPOSAL SITE – FLOOD RISK & MITIGATION ASSESSMENT REPORT

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146 TE MAWHAI ROAD
TE AWAMUTU

FORMER TOKANUI HOSPITAL
EXISTING DISPOSAL SITE – FLOOD RISK & MITIGATION ASSESSMENT REPORT

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TOITŪ TE WHENUA – LAND INFORMATION NEW ZEALAND

FORMER TOKANUI PSYCHIATRIC HOSPITAL DEMOLITION AND REMEDIATION

EXISTING DISPOSAL SITE – FLOOD RISK & MITIGATION ASSESSMENT REPORT

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TOITŪ TE WHENUA – LAND INFORMATION NEW ZEALAND

FORMER TOKANUI PSYCHIATRIC HOSPITAL DEMOLITION AND REMEDIATION

EXISTING DISPOSAL SITE – FLOOD RISK & MITIGATION ASSESSMENT REPORT

1.0 INTRODUCTION

The Tokanui hospital site was part of a land package taken under the Public Works Act in 1910, which included approximately 93ha for health services. The Tokanui Hospital opened in 1912 and closed in 1998. The Site was then transferred into the Treaty Settlements Landbank in 1999 (managed by the Ministry of Justice at the time) to potentially be used as redress to settle historical claims. The site was transferred to Toitū Te Whenua Land Information New Zealand (LINZ) in 2016 with the remainder of Treaty Settlements Landbank property portfolio and is currently managed by LINZ.

The FTPH had its own landfill (disposal site), located on Farm Road (private road), directly east of the FTPH. This comprised a number of different areas that were filled over the lifetime of the hospital with filling being completed in the last area around 1997. The disposal site is located immediately adjacent to the Wharekōrino Stream and is currently in pastoral land use (grazing). A section of the stream has been piped through the landfill.

Previous work by FTL (Existing Disposal Sites - Intrusive Investigation report, June 2024) has identified two key risks associated with the existing disposal site are:

- Potential failure of the culvert (1350dia) that pipes the Wharekōrino Stream through part of the landfill. This culvert is estimated to be 44-65 years old and could be subject to differential settlement from landfill activity, leading to leaking joints and ultimately possible pipe failure. Pipe failure could result in fill/refuse washout down the stream, causing adverse human health and environmental damage, representing a long-term risk.
- Flood modelling of the Wharekōrino Stream has shown that significant landfill areas are currently likely to be inundated to varying extents during a 1% AEP (annual exceedance probability) storm event, particularly if the two downstream culverts on the stream are blocked or become blocked during the storm, with these effects worsening with predicted climate change. Flooding of landfill areas could cause scour/erosion of landfill side slopes and possible exposure of refuse, potentially causing downstream pollution and contamination. This work was reported on in an initial flood modelling memo dated 17 July 2023.

Based on the above background, FTL have completed supplementary flood modelling of the potential effects of a severe flood event on the existing historical landfill areas (disposal sites) at the Tokanui Hospital, based on the FTL 2022-23 intrusive investigation, and possible mitigation measures to mitigate any such effects, including one or more of the following:

- Removal of a redundant road crossing and associated culvert (Culvert 2) across the Wharekōrino Stream, reinstating the stream through this area.

- Removal, repair or replacement of an existing culvert that runs through landfilled areas at the southern end of the site (culvert 3). The stream would be reinstated partially or in full through this area if this culvert is removed, which would involve the removal of associated landfill material in this area.
- Installation of a second culvert under Te Mawhai Road to supplement the existing culvert.

This report presents:

(a) the results of this flood modelling and an associated assessment of environmental effects for the various mitigation options considered;

(b) considers both a "local storm" (flooding of Wharekōrino Stream alone with no tailwater effects) and a "regional storm" (flooding of the Wharekōrino Stream, Pūniu River with possible tailwater effects from both this river and from flooding of the Waipā River further downstream);

(c) considers flooding of Te Mawhai Road from more regular storm events for the existing and preferred scenarios, following discussions with Waipā District Council.

It should be read in conjunction with our earlier flood modelling memo of 17 July 2023 that is included as an appendix in the June 2024 Existing Disposal Sites - Intrusive Investigation Report.

2.0 STORMWATER FLOW ESTIMATION

Stormwater catchments were delineated from the LINZ LiDAR survey for the immediate area, and 2007-2008 Waikato LiDAR data for the catchment area outside of the site. Two main catchments were delineated, referred to as the southern and western catchments in this report. The southern catchment (440ha) drains to the main stream, which flows through the site in a south to north direction. The western catchment (166ha) drains through the hospital site's stormwater pipe reticulation system and associated detention storage areas and enters the main stream near Te Mawhai Road. Refer Figure 1 for catchment locations.

Stormwater flows were calculated using the Waikato Stormwater Runoff Modelling Guideline TR20/06 methodology. The catchment is primarily composed of alluvium and colluvium gravel sand and mud. A curve number of 74 was assumed for the entire area corresponding to good condition, open space with group C soils. The catchment flow hydrograph was modelled in HEC-HMS for the 1% Annual Exceedance Probability (AEP) rainfall event, as well as the 1% AEP (annual exceedance probability) event including an allowance for climate change. Climate change was accounted for by using the HIRDS RCP8.5 "business as usual" rainfall scenario for the years 2081-2100 (refer Figure 2), equivalent to a rainfall increase of approximately 22.5% over existing rainfall. This is considered more conservative than allowing for a 2.1 degree increase in temperature as specified by the Waikato Stormwater Runoff Modelling Guideline. Refer Appendix A for associated calculations.

Stormwater culverts were modelled in four locations as shown on Figure 3. Culvert 1 under Te Mawhai Road was assumed to be 1500mm in diameter as it could not be located. Culvert 2 under the smaller former hospital access road was assumed to be 1500mm in diameter as it also could not be located. Culvert 3 was surveyed and is 1350mm in diameter. Culvert 4 is 1000mm in diameter, based on historic plans provided by LINZ. The assumed culvert diameters were based on the expectation that culverts 1 and 2 would be at least as large as culvert 3 and engineering judgement.

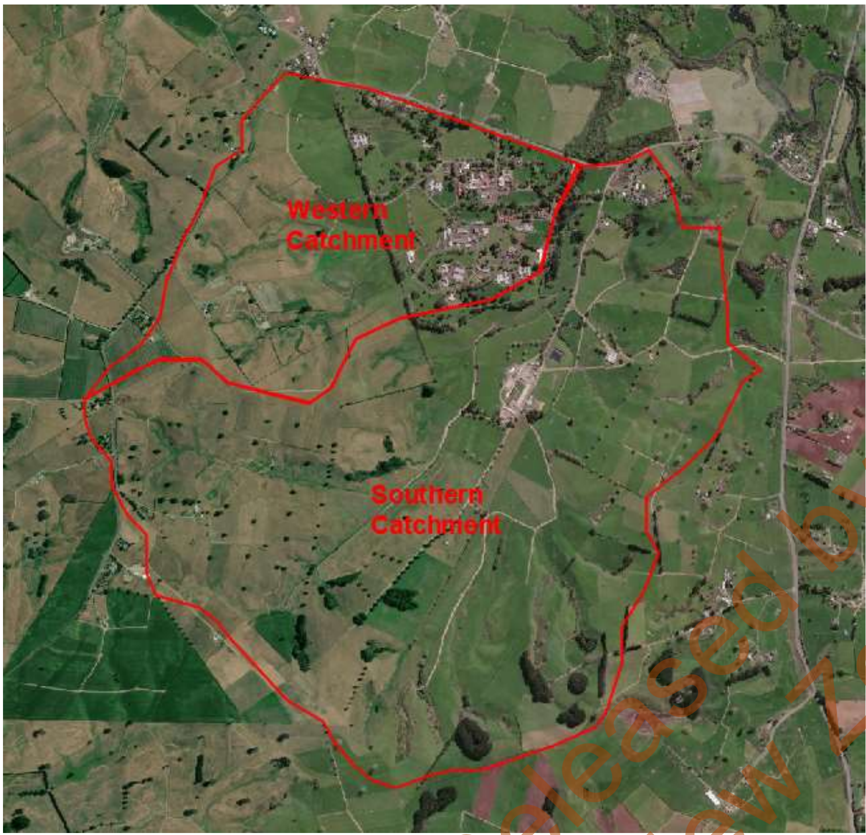


Figure 1: Catchment Locations

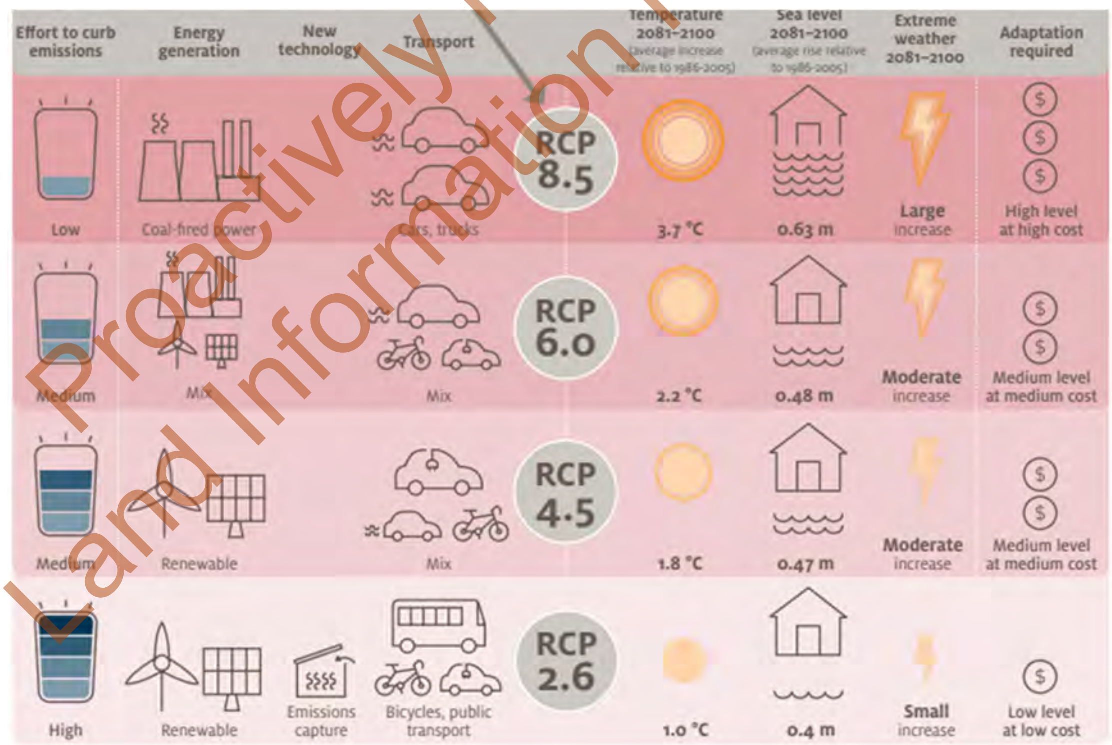


Figure 2: Representative Concentration Pathways (RCP) Schematic: Current emissions are tracking close to RCP8.5 (coastadapt.com.au)

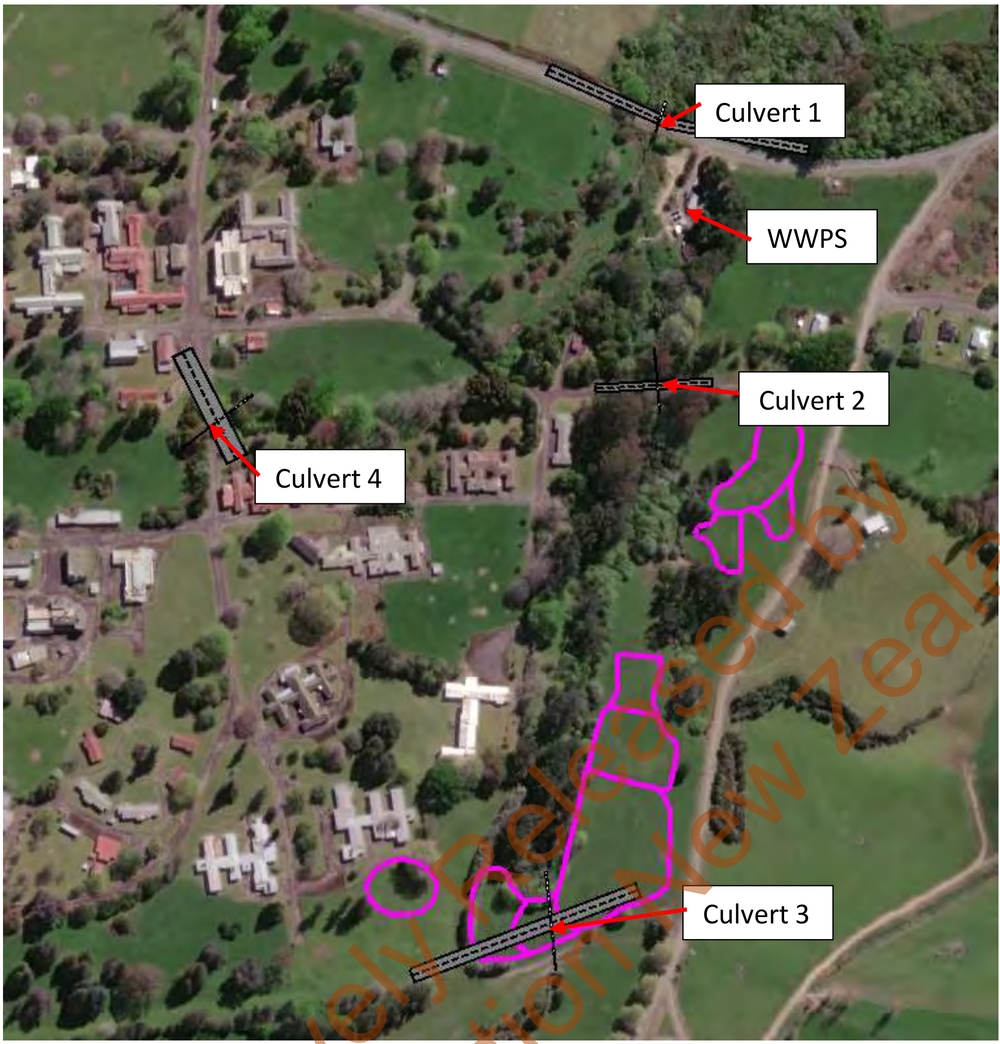


Figure 3: Culvert and Wastewater Pump Station (WWPS) Locations; existing disposal site extent shown in purple (as of June 2024)

3.0 STORMWATER MODELLING

3.1 METHODOLOGY

The flood extent was modelled using HEC-RAS 2D software. A TIN surface was formed from the LINZ LiDAR and 2007-2008 Waikato LiDAR. A uniform Mannings roughness of 0.06 was assumed for the entire area. This Mannings roughness value represents a clay channel bed with light brush and trees. In the earlier flood modelling memo of 17 July 2023, the surveyed stream and LiDAR were validated to be reasonably accurate within the area. This initial modelling was for a "local storm" and assumed no tailwater effects from the downstream Pūniu and Waipā Rivers.

The model did not include the stormwater trunk reticulation pipe system within the hospital area which is to remain post-demolition works and hence flood model results in this area are overly conservative and are not included in this report.

3.2 BACKGROUND

The embankments associated with the three culverts along the main stream are at significantly different elevations - the Te Mawhai Rd embankment (over Culvert 1) is at approximately 33m RL, while the redundant road embankment (over Culvert 2) is some 3-4m higher at around 36-37m RL and the southern embankment (over Culvert 3) is lower by at least 1.6m than culvert 2 embankment at around 34.4m RL.

Several scenarios investigated raising the southern embankment to different extents, namely 35.20m RL in scenarios 9-12, 34.6mRL in Scenario 13 and 35.30m RL in Scenario 14.

Preliminary flood modelling showed flood levels through the site and downstream are primarily controlled by the Culvert 2 and 3 embankments, particularly the Culvert 2 embankment. Removal of culvert 2 was essential to reduce landfill flooding significantly, but its removal caused significant increases in peak flows and flood levels, below it. This meant multiple mitigation scenarios were run testing different options in order to try and balance the benefits of decreasing the landfill flood risk, compared with potentially worsening off-site effects, both upstream and downstream.

3.3 MODELLING SCENARIOS

The scenarios modelled are listed below. The model scenarios were numbered consecutively, but only the key scenarios are included in this report for discussion.

All scenarios were modelled under 1% AEP rainfall with climate change RCP8.5 for the period 2081-2100, except scenario 1E, 9E and 14E were modelled under existing rainfall.

Table 1: Model Scenarios

<table>
<tr><th>Scenario</th><th>Culvert 1</th><th>Culvert 2</th><th>Culvert 3</th><th>Comments</th></tr>
<tr><td>1</td><td>Present</td><td>Present</td><td>Present</td><td>Existing (baseline) situation</td></tr>
<tr><td>2</td><td>Present</td><td rowspan="5">Removed</td><td>Present</td><td>Minimum culvert removal option</td></tr>
<tr><td>3</td><td>Present</td><td>Removed</td><td>Results in maximum increase in flood levels and peak flows downstream of culvert 2</td></tr>
<tr><td>9</td><td>Present</td><td rowspan="3">Existing culvert replaced with new minimum length short culvert + raised southern embankment (35.2m RL)</td><td>Testing effect of having short new culvert and removing rubbish at A2 landfill to extend channel connecting to new culvert 3</td></tr>
<tr><td>10</td><td>Present + 2nd 1.5Ø culvert</td><td>Testing effects of adding 2nd culvert under Te Mawhai Rd</td></tr>
<tr><td>12</td><td>Present + 2nd 2.5Ø culvert</td><td>Testing optimum size for second culvert under Te Mawhai Rd</td></tr>
</table>

13			As for 9-12 but lowering height of embankment (34.6m RL)	Testing optimum height of embankment over new short culvert 3
14			As for 9-12 but elevating height of raised embankment (35.3m RL)	
1E	Same as scenario 1 except modelled under existing rainfall with no climate change.			
9E	Same as scenario 9 except modelled under existing rainfall with no climate change.			
14E	Same as scenario 14 except modelled under existing rainfall with no climate change.			

3.4 POTENTIAL EFFECTS CONSIDERED

Based on this background, the effects assessment considered the following factors (refer Table 2):

(a) Effect on upstream neighbouring land flood extent (i.e. flood area (ha) and corresponding % change in flooded area).

(b) Effect on raised embankment over Culvert 3 (near inlet). All scenarios after scenario 3 retain or reinstate a raised southern embankment over culvert 3, and scenario 3 is not preferred.

(c) Effect on landfill area flood extent (i.e. reduction in area flooded, ha).

(d) Effect on potential scour/erosion along the Wharekōrino Stream adjacent to the landfill. This is commented on qualitatively in section 3.6.

(e) Effect on overtopping of flood waters on Te Mawhai Road. This is considered to be the most critical potential effect. This was evaluated in terms of the modelled flow depth and velocity across the road and corresponding flood hazard, which is a function of both the depth and velocity and expressed as a hazard rating increasing in severity from category H1 to H6, as shown in the following diagram.

(f) Effect on Tokanui wastewater pump station (WWPS). This is located on the true right bank of the stream, a short distance upstream of Te Mawhai Road, as shown in Figure 5. Its location has been taken from asbuilt drawings of the pump station, with drawing PS-003 referring to the pump station chamber having a lid level of 32.93m RL (survey datum not stated but assumed to be same as the datum used in flood modelling and a check on ground levels at the WWPS location showed this is likely correct).

(g) Effect on flood extent and flows downstream of Te Mawhai Road. Below Culvert 1, the stream flows approximately 700m before entering the considerably larger Pūniu River. Mangatoatoa Marae is located on the eastern side of the stream before the confluence with the Pūniu River. There are no other buildings along this section of the stream. However, the Pūniu River Care organisation have a surface water take pump located on a small wooden jetty (refer photo in Appendix D), that takes water from the stream for nursery irrigation purposes under resource consent AUTH144702.01.01. Hence, potential effects below Te Mawhai Rd were assessed in terms of the peak flow below Te Mawhai Rd, the flood extent area (and % change) and the flood level opposite the Marae. It is important to note that the Marae is approximately 9m above the level of the stream at this location, while the pump is approximately 3.5m above the normal stream water level (as measured in October 2024).

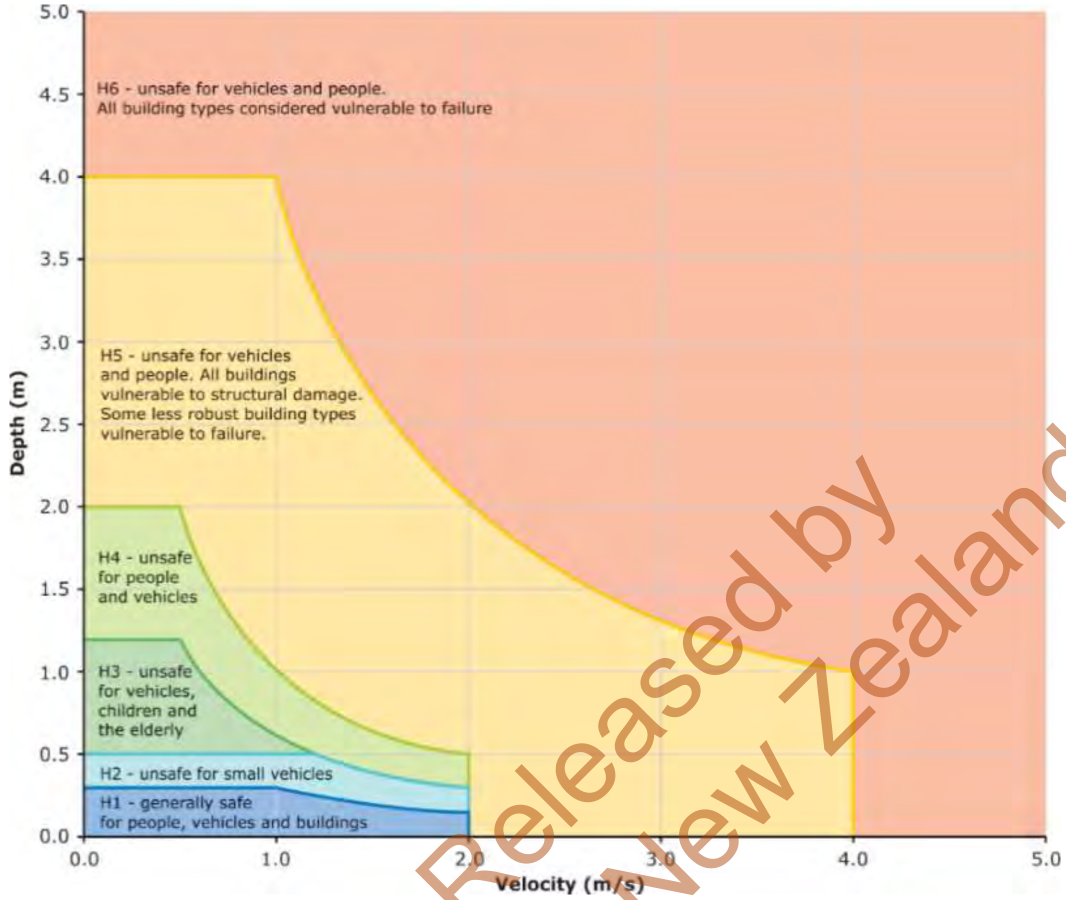


Figure 4: Depth/Velocity Envelopes (from Smith et al., 2014 – from Australian Rainfall and Runoff – Book 6: Flood Hydraulics, Chapter 7 Safety Design Criteria).

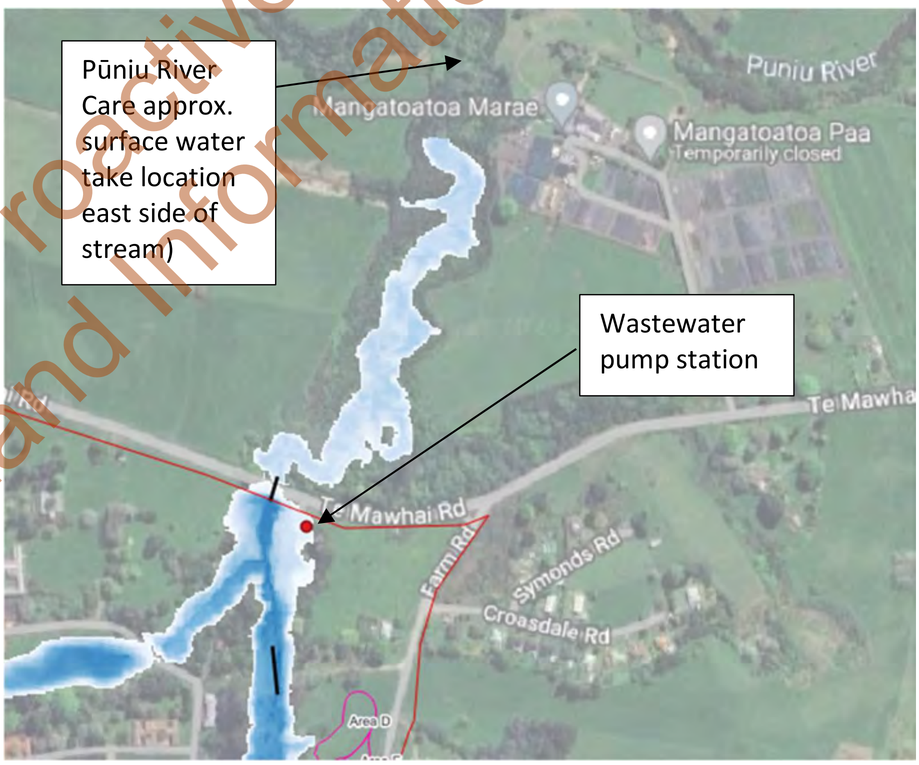


Figure 5: Location of wastewater pump station and Pūniu River Care surface water take location

3.5 MODEL RESULTS AND EFFECTS ASSESSMENT

The model results are presented in drawing 33097/M01 for selected model scenarios for the 1% AEP storm + RCP 8.5 (2081-2100)climate change with their corresponding effects assessment in Table 2. These are the key model runs used to identify the best practical option (BPO) for flood mitigation works. Drawing 33097/M02 shows results for Scenarios 1, 9 and 14 floods without climate change. Drawing 33097/M03 compares the best model scenario, 14 with the existing condition, 1 while drawing 33097/M04 shows the long section of the maximum water surface elevation for model scenarios 1, 2, 3, 9 and 14.

Scenario 1 (existing situation) shows that there is currently a high risk of some of the historic landfilling areas being inundated by the 1% AEP storm event, with and without climate change, as summarised in the following table. The main areas at risk of flooding are in order of decreasing severity: Area A2 and H > Area C > Area B > Area A1. Areas D, E and F are all outside the modelled flood extent with and without climate change.

Culvert 2 has to be removed to significantly reduce flood effects on the landfill areas. Removing this culvert reduces the landfill area flooded from 0.70 ha to 0.39 ha (-44%), but increases peak flows and water levels downstream of this culvert, increasing the flood hazard at Te Mawhai Rd from H3 (unsafe for vehicles, children and elderly) to H5 (unsafe for vehicles, people and buildings).

Removing culvert 3 as well as culvert 2 in scenario 3 and reinstating the stream through both areas has similar effects on the flood hazard at Te Mawhai Road. For scenarios 2 and 3, the duration of flow across the road is predicted to be 13h and 11.8h respectively, compared with 15.7h for the existing situation. Whilst these scenarios do increase peak flows and water levels below Te Mawhai Road, this has no impact on the Marae, due to its elevation relative to the stream.

For scenario 9, adding a new culvert 3 and associated embankment for a farm track crossing achieves the following:

- Minor (5%) reduction in upstream flooded area extent on neighbouring land.
- Increased peak flows and water levels at Te Mawhai Rd compared with the existing situation but less than for Scenarios 2 and 3. The duration of flow across the road is predicted to be 14.3h. The flood hazard increased to H5, the same as in scenario 2 and 3.
- Increase in peak flows and water levels downstream of Te Mawhai Road (but reduced effect compared with scenarios 2 and 3) and with no impact on the Marae.

This option, with some minor further amendments to optimise the new culvert 3 embankment height is considered the minimum potentially acceptable Best Practical Option (BPO) for flood mitigation. The stated flood hazard is for a 100 year storm, with climate change impacted rainfall (~22% increase on existing rainfall) for the RCP8.5 scenario to 2081-2100, which is the current emissions trajectory the world is following. The 100 year storm means there is a 1% probability of such a flood happening in any one year, but also a 63% probability of such a flood occurring within any 100 year period.

Modelling of other options has shown that going from Scenario 10 onwards would mean installing a second culvert in parallel with the existing culvert 1 under Te Mawhai Road as the best additional measure to mitigate the flood risk at the road. Scenario 14 with a second culvert of 2.5m diameter beside culvert 1 has given the best result, as it raises the new embankment over the new culvert 3 slightly to hold back more flood waters above it but without worsening the flood extent on the upstream land, resulting in a small further improvement in the flood hazard reduction at Te Mawhai Road. This option achieves the following:

- Minor (2%) reduction in upstream flooded area extent on neighbouring land, representing an improvement on the existing situation.
- Reduced water levels at Te Mawhai Rd (190mm reduction) due to more flow going through the second culvert and reducing the flood hazard from H3 (unsafe for vehicles, children and the elderly) for the existing situation to H2 (unsafe for small vehicles). The duration of flow across the road is predicted to be 1.5h, representing a reduction of over 14 hours of flow across the road.
- Increase in peak flows and water levels below Te Mawhai Road, with a predicted 8% increase in the flood area extent, but with no impact on the Marae.

Overall, this scenario gives the best outcome in terms of flood mitigation for a "local storm", that effectively results in less than minor effects compared with the existing situation, but for considerable extra cost to install a second large culvert under Te Mawhai Road, while the constructability of a second culvert also needs checking. These modelling results need to be considered in conjunction with those for a wider scale, regional storm – see section 4 of this report.

Another set of models using existing rainfall instead of the 1% AEP rainfall with climate change RCP8.5 (for the period 2081-2100) were generated for scenario 1, 9 and 14 as scenario 1E, 9E and 14E in Table 3 to check estimated flooding as of 2024 for these three key scenarios. Scenario 9E reduced flooding at the landfill but increased flooding at both upstream and downstream with unchanged flood hazard at Te Mawhai Road. Although scenario 14E also resulted in an increase in flood extent upstream, there is no flooding/overtopping over Te Mawhai Road, thereby eliminating flood hazard at the road.

Table 2: Effects Assessment for Scenarios Modelled Under 1% AEP Rainfall with Climate Change RCP8.5 (for period 2081-2100)

Scenario	Flood extent (ha) [% change] of upstream neighbouring land	Flood level above Culvert 3 (m RL)	Flood extent (ha) [% change] of Landfill Area	Flood level at Culvert 1, Te Mawhai Rd (m RL)	Overland flows over Te Mawhai Rd (depth, velocity, hazard)			Effect on flood extents and flows downstream of Te Mawhai Road		
					Velocity (m/s)	Depth (m)	Hazard	Q (m^3/s) below road	Flood Level by Marae (m RL)	Flood Extent (ha) [% change]
1 – Existing	12.64	35.56	0.70	33.44	0.73	0.54	H3	10.83	30.20	1.86
2 – Culvert 2 removed	10.37 [-18%]	35.15	0.39 [-44%]	33.81	1.83	0.91	H5	32.60	30.99	2.24 [+20%]
3 – Culverts 2 and 3 removed	6.00 [-52%]	34.60	0.18 [-74%]	33.91	1.79	1.01	H5	44.41	31.32	2.39 [+28%]
9 – Culvert 2 removed + New short Culvert 3 + raised southern embankment + 1x culvert 1@1.5m	12.06 [-5%]	35.46	0.34 [-51%]	33.74	1.59	0.84	H5	25.43	30.78	2.15 [+16%]
10 – Scenario 9 + 2x Culvert 1 (2@1.5m)	12.02 [-5%]	35.46	0.33 [-53%]	33.59	1.11	0.69	H3	22.09	30.66	2.07 [+11%]
12 – Scenario 9 + 2x Culvert 1 (1@1.5m, 1@2.5m)	12.02 [-5%]	35.45	0.31 [-56%]	33.34	0.35	0.44	H2	21.62	30.64	2.04 [+10%]
13 – Scenario 12 + lower southern embankment	10.05 [-20%]	35.10	0.31 [-56%]	33.58	1.05	0.68	H4	30.08	30.92	2.18 [+17%]
14 – Scenario 12 + elevated southern embankment	12.37 [-2%]	35.52	0.30 [-57%]	33.25	0.23	0.35	H2	20.08	30.59	2.00 [+8%]

Table 3: Effects Assessment for Scenarios Modelled Under Existing Rainfall without Climate Change

Scenario	Flood extent (ha) [% change] of upstream neighbouring land	Flood level above Culvert 3 (m RL)	Flood extent (ha) [% change] of Landfill Area	Flood level at Culvert 1, Te Mawhai Rd (m RL)	Overland flows over Te Mawhai Rd (depth, velocity, hazard)			Effect on flood extents and flows downstream of Te Mawhai Road		
					Velocity (m/s)	Depth (m)	Hazard	Q (m^3/s) below road	Flood Level by Marae (m RL)	Flood Extent (ha) [% change]
1E – Scenario 1 + existing rainfall event	9.68	35.06	0.49	33.42	0.68	0.52	H3	9.48	30.13	1.84
9E – Scenario 9 + existing rainfall event	11.25 [+16%]	35.31	0.27 [-45%]	33.51	0.86	0.61	H3	11.69	30.24	1.89 [+3%]
14E – Scenario 14 + existing rainfall event	11.52 [+19%]	35.36	0.18 [-63%]	32.38	0.00	0.00	N/A	11.53	30.23	1.80 [-2%]

3.6 SCOUR/EROSION EFFECTS

Stream channels evolve over time to convey a certain level of flow commonly referred to as the "channel forming flow" or "bankfull discharge" which generally ranges from recurrence intervals of 1 to 2.5 years. Streams will adjust and further evolve when flows are altered as a result of land use changes, development in the catchment, damming, or other mechanisms. Higher discharge rates can result in erosive processes leading to channel widening and increases in channel cross-section area.

Shear stress is often used to predict whether streams are stable or not. Shear stress increases with increasing flow depth and increasing water surface gradient.

Culvert 2 is located below all landfill areas. During a storm event, stream flows and velocities will gradually increase, until the culvert starts to throttle these flows/velocities, resulting in water ponding upstream of the culvert, increasing the flow depth but decreasing the water surface gradient. For simplicity here, flow velocity has been adopted as a proxy for shear stress effects, as velocity is affected both by flow depth and water surface gradient.

If Culvert 2 was removed, Culvert 1 would still provide a throttle effect, but the associated ponding does not extend as far upstream as previously, and hence some of the areas abutting the landfill may experience higher stream velocities than currently and hence be subject to greater scour/erosion than the current situation. Similarly, if a storm were to hit with a peak rainfall very soon after the beginning of the storm, velocities within the channel may be greater as the stream may not have begun backing up (i.e. more of a flash flood situation).

These situations have been covered under the modelled scenarios, and the maximum velocity within the stream channel was found to be relatively low during the peak of an extreme storm event, due to backing up of water over the crossing at culvert 1. The narrowest portion of the stream channel was found to be around XS4, near to landfill area, A1.

The velocity in scenario 1, 9 and 14 are 0.75 m/s, 0.88 m/s and 1.08 m/s respectively. Under the NZ Transport Agency Stormwater Treatment for State Highway Infrastructure, the maximum permissible velocity to control stream erosion for stiff clays is 1.14m/s. Velocities in these scenarios are within the maximum permissible velocity and therefore considered that stream erosion is unlikely to be an issue, based on the limited modelling undertaken to date. This can be monitored as part of ongoing disposal site maintenance works, with appropriate armouring or other scour/erosion measures put in place if found to be an issue.

Furthermore, historical plans show this stretch of the stream and further downstream to the Pūniu River were historically a swamp (see Figure 6), which is consistent with observations of water ponding in this area and the stream bed being relatively flat, with a measured gradient of 0.5% from LiDAR data, as analysed in the previous memo. The flat nature of the stream supports the relatively low velocities modelled and indicates this is not a highly erosive environment.

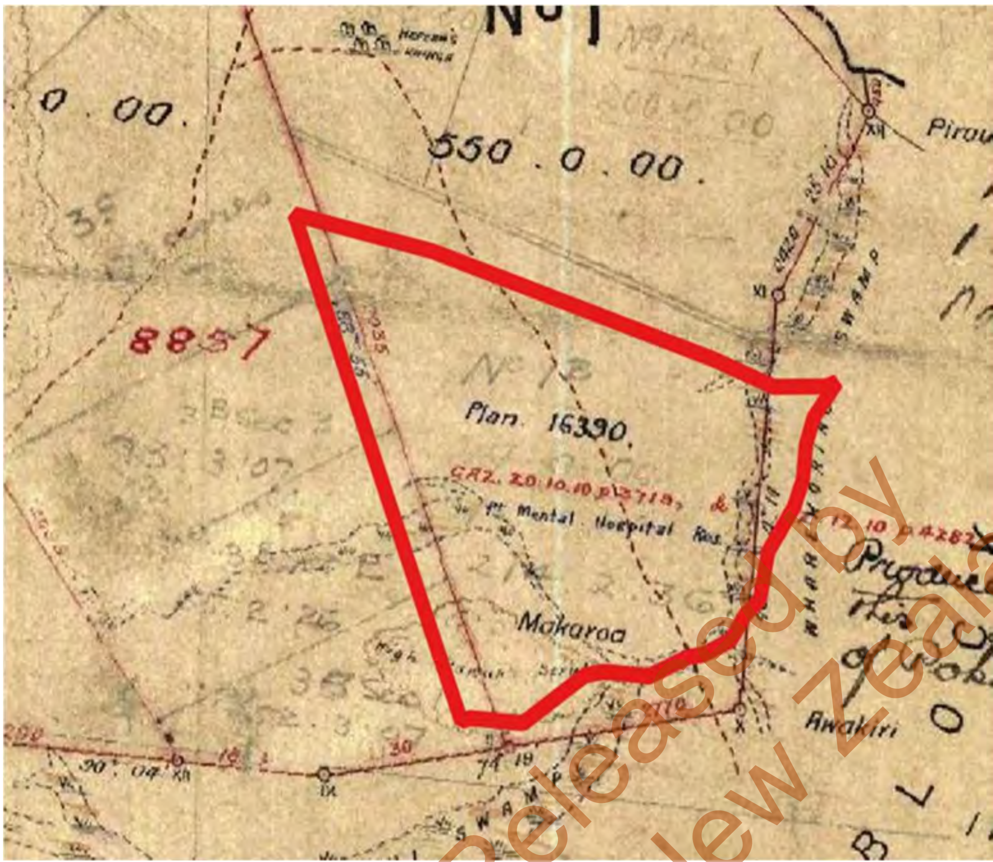


Figure 6: Tokanui Hospital Site – Historical Plan showing former swamps (from CFG, 2023)

Landfill area A2 effectively dams the stream, with culvert 3 passing under it. Modelling has shown this area to be inundated during a 1% AEP event, with the culvert being overtopped and flood waters flowing overland through Area A2. Velocities over the fill area through which the culvert passes may be moderate-high. This could result in localised scour/erosion along this overland flow path, potentially exposing the underlying landfill materials, and in the worst case, uplifting some of these materials and carrying them into the stream. This effect has not been quantified as part of the modelling done.

3.7 WASTEWATER PUMP STATION EFFECTS

The predicted flood level at the pump station (32.93m LL) for the existing situation (but with RCP8.5 climate change adjustment to 2081-2100) is 33.45m RL, meaning it will be under 0.52m depth of water. None of the scenarios modelled under the RCP8.5 climate change scenario are able to stop it from being flooded. The best outcome is scenario 14 which reduces the flood level at the pump station location to 33.25m RL (0.32m flood depth).

Scenario 14E (scenario 14 under existing rainfall) reduced the flood extent and water level at Te Mawhai Rd to 32.38m RL, where the pump station is 0.55m above water and therefore not affected by flooding. For scenario 1E (existing rainfall and current situation), the flood level at the pump station is 33.42m (i.e. 0.49m under water), while for scenario 9E, it is 33.51m RL (0.58m under water).

4.0 POTENTIAL PŪNIU RIVER IMPACTS

4.1 INTRODUCTION

The Wharekōrino Stream flows into the Pūniu River, approximately 700m below the Te Mawhai Road culvert. This is a considerably larger watercourse, with an estimated catchment at the confluence of 499km^2 (49,900ha). The Pūniu River joins into the much larger Waipā River approximately 12km further downstream near Pirongia. The preceding modelling has not considered any potential tailwater effects from the Pūniu River itself, possibly compounded by tailwater effects from the Waipā River, with this scenario representing a "regional scale" storm. This section covers a desktop review of available flooding information for the Pūniu River, followed by additional modelling to test the effect of variable tailwater levels on the mitigation options considered from a possible regional storm.

4.2 WAIKATO REGIONAL HAZARDS PORTAL

As shown on the Waikato Regional Hazards Portal (Figure 7), the subject site (red circle) is shown as being partially affected by the Regional Scale Flood Hazard layer, which means that Waikato Regional Council (WRC) does hold information to suggest that part of the site will be affected by regionwide flooding. This flood hazard layer is formed from a compilation of flood hazard information sourced from a combination of previous event information (photos, anecdotes, surveys), flood modelling (if available), flood protection and drainage scheme information, and elevation data.

The description associated with the Regional Scale Flood Hazard Layer (WP82) for the area is below:

During a 100-year flood the river will breach its channel inundating low-lying land. Most land surrounding this river is pastoral farmland. The Waipā River will likely cause backflow up the Pūniu River. This will compound any inundation of land due to the river breaching banks or ponding from local runoff, which will also collect in low-lying pockets. Tokanui sewage treatment plant has been inundated in past floods and would again be inundated in a 100-year event.

This layer the property is in has been derived from historical flood events in 1958, 1979, and 1998, and unfortunately WRC has not undertaken any flood modelling in this area.

FTL have superimposed LiDAR ground levels from OpenTopography and adjusted to AUK1946 vertical datum (for consistency with previous reports) on the regional flood extent in Figure 8 to check whether they make sense. This has found that the flood levels do not show a consistent increase in water level going upstream along the main reach of the Pūniu River, while levels on opposite sides of the river also show reasonable variability. For example, the Wharekōrino Stream branch shows flood levels associated with the Pūniu River on it of 38.78m on the true left (going downstream) bank and 35.69m on the true right bank, approximately 3m lower, just below Te Mawhai Road, while the most upstream flood level on the Wharekōrino Stream is 32.47m, which does not make sense. For these reasons, we have low confidence in WRC's flood extent.

The flood hazard data presented in Figure 8 does however suggest that severe flood levels in the Pūniu River can overtop the river banks and associated flood levels could potentially range from 35.7-40.5m, which is significantly higher than modelled flood levels in the Wharekōrino Stream up to and above Culvert 3.

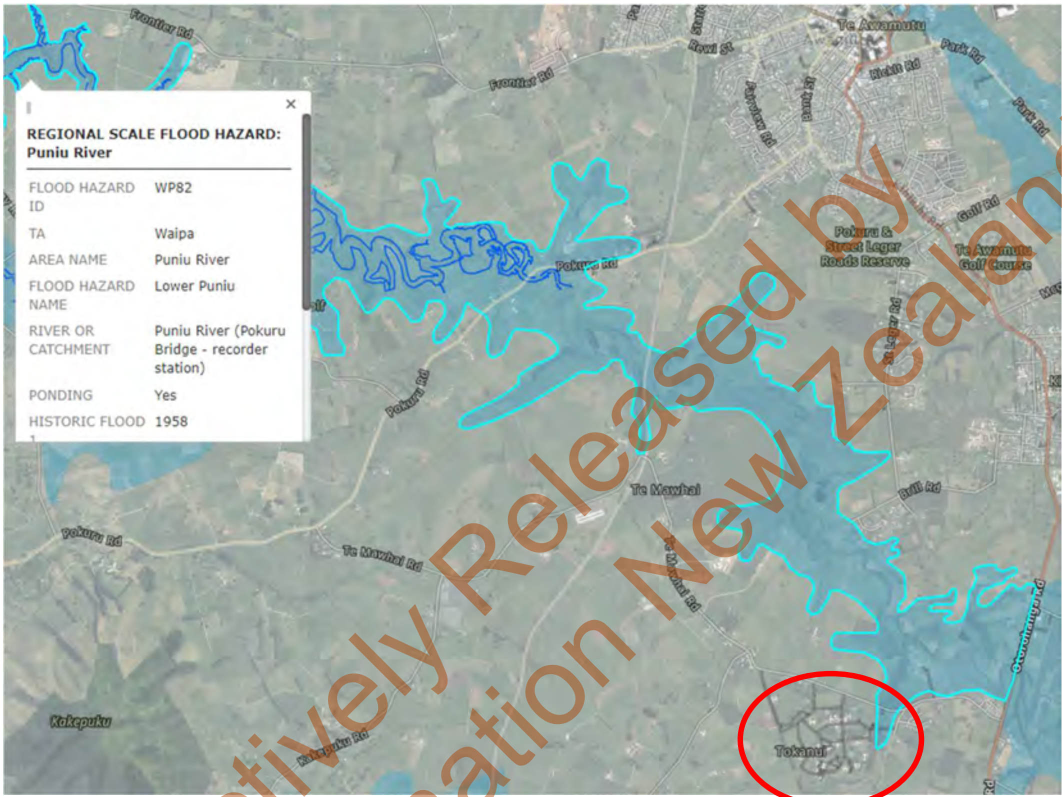


Figure 7: Regional Scale Flood Hazard – Pūniu River in Waikato Regional Hazards Portal

Figure 8: Flood extent elevation for Regional Scale Flood Hazard – Pūniu River

4.3 MODELLING APPROACH

It was not considered realistic for this project to do a flood model for the Pūniu River that would take into account Waipā River tailwater effects, as this would be a major task. Instead a modelling approach based on extending the model downstream and doing tailwater sensitivity testing was undertaken for scenarios 1, 1E, 9E, 14 and 14E. This is explained further below.

The nearest WRC flow gauge to the Pūniu/Wharekōrino confluence is on the Pūniu River further downstream near Pokuru Road as shown in Figure 9. The station is known as Pūniu at Bartons Corner Rd Br and Table 4 shows the relevant readings collected from that station: catchment area 527m^2 with 1% AEP peak flow of 324m^3/s.

Table 4: Readings collected at station at Bartons Corner Rd Br station.

Siteno	Name	NZTM_E	NZTM_N	Area_km^2	Data_100y
43431	Pūniu at Bartons Corner Rd Br	1801295	5788365	527	323.7

Figure 9: Location of Pūniu at Bartons Corner Rd Br station.

The catchment area downstream of the confluence (yellow arrow in Figure 10), where the Wharekōrino Stream joins the Pūniu River is based on NIWA's Flood Statistics 2018 REC1: Pūniu River shown in Table 5. The peak flow downstream of the confluence has been estimated taking a simple approach, based on pro rata calculation of flow from respective catchment areas, based on data recorded at the Pūniu at Bartons Corner Rd Bridge station and the catchment area stated in NIWA. The calculated 1% AEP peak flow is 306m^3/s for existing rainfall and 375m^3/s for rainfall with climate change (increased by 22.5% as stated in section 2).

Table 5: Catchment area at downstream of confluence from NIWA River

NZREACH	River name	Area (km²)
3023753	Pūniu River	498.3

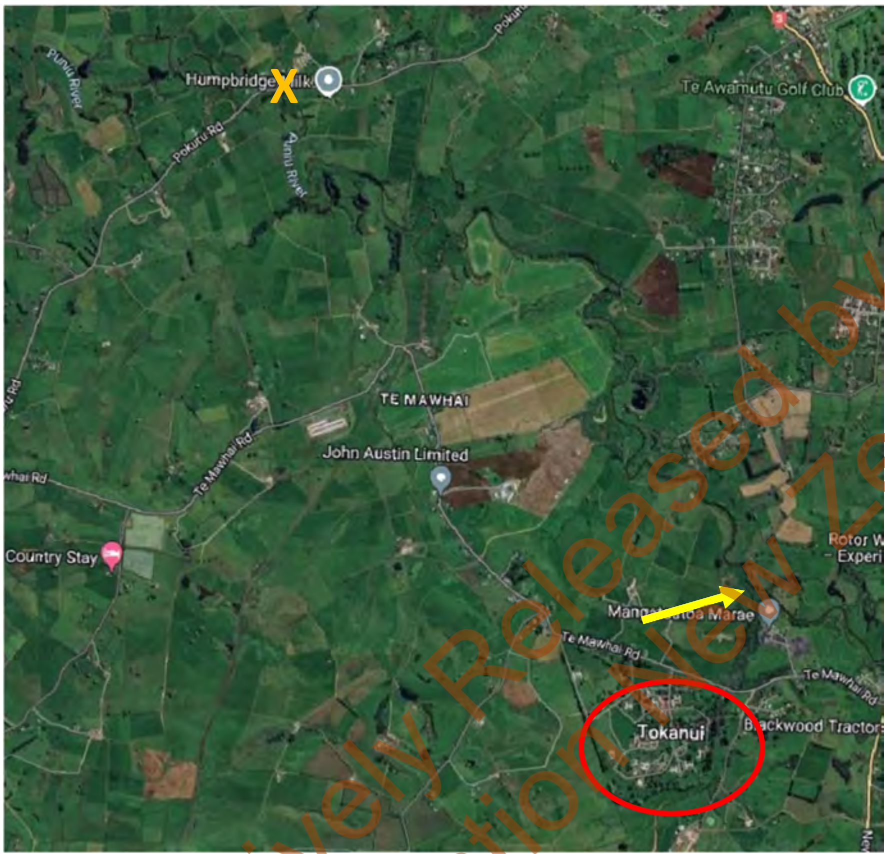


Figure 10: Location of subject site (red circle), downstream of confluence (yellow arrow) and location of Pūniu at Bartons Corner Rd Br station (orange X).

Flood levels for these flows were then assessed using Hydraflow software (refer appendix) based on Pūniu River cross-section data just below the confluence point and an estimated stream bed gradient of 0.044% from interpolation of LIDAR data. The flood level in the 1% AEP and 1% AEP + CC was calculated to be 31.51mRL and 31.90mRL respectively. The 1% AEP flood level is approximately 5.3m lower than the corresponding lowest WRC Hazard Portal data.

The above model scenarios were then run for both these flood levels, which represent the "tailwater" level in the Pūniu River for these two storm events. The sensitivity check involved increasing the tailwater further by 1m and 2m in both rainfall events to check at what point do flood levels become controlled by tailwater.

4.4 MODELLING RESULTS

Table 6 shows the tailwater effects on flood levels at Te Mawhai Rd and the WWPS.

Table 6: Tailwater effects on Flood Levels at Te Mawhai Rd and WWPS

	Without Pūniu River Tailwater					With Pūniu River Tailwater (E = 31.51mRL, CC = 31.90mRL)				
Scenario	1	1E	9E	14	14E	1	1E	9E	14	14E
Te Mawhai Rd water level (XS 7)	33.44	33.42	33.51	33.25	32.38 (within culvert)	33.40	33.35	33.52	33.32	32.40 (within culvert)
Overtopping Te Mawhai Rd	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
WWPS affected (LL at 32.93mRL)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No

Sensitivity Check

	With Pūniu River Tailwater +1m (E = 32.51mRL, CC = 32.90mRL)					With Pūniu River Tailwater +2m (E = 33.51mRL, CC = 33.90mRL)				
Scenario	1	1E	9E	14	14E	1	1E	9E	14	14E
Te Mawhai Rd water level (XS 7)	33.44	33.38	33.61	33.56	32.90 (within culvert)	33.91	33.56	33.65	33.99	33.57
Overtopping Te Mawhai Rd	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
WWPS affected (LL at 32.93mRL)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes

Drawings 33097-M05 to M07 illustrate the long sections depicting the tailwater effects on the water level of the site for different model scenarios. With the 1% AEP tailwater (31.51mRL) applied at Pūniu River, the change in water levels at Te Mawhai Road when compared to the no tailwater scenarios appears to be marginal.

When another 2m is added to the tailwater level (to 33.51mRL), water levels at Te Mawhai Road in the existing scenario begin to increase higher than the no tailwater existing scenario (1E) water levels, hence showing that the tailwater is starting to have an effect on the water level at Te Mawhai Rd (refer Figure 11 and drawing M05).

In scenario 9 with a single culvert at Te Mawhai Road (9E), the water level remains consistently higher than in scenario 1E, both before and after the tailwater is applied (Figure 12). Therefore, this single culvert option is not as effective as scenario 14E in managing downstream water and tailwater effects.

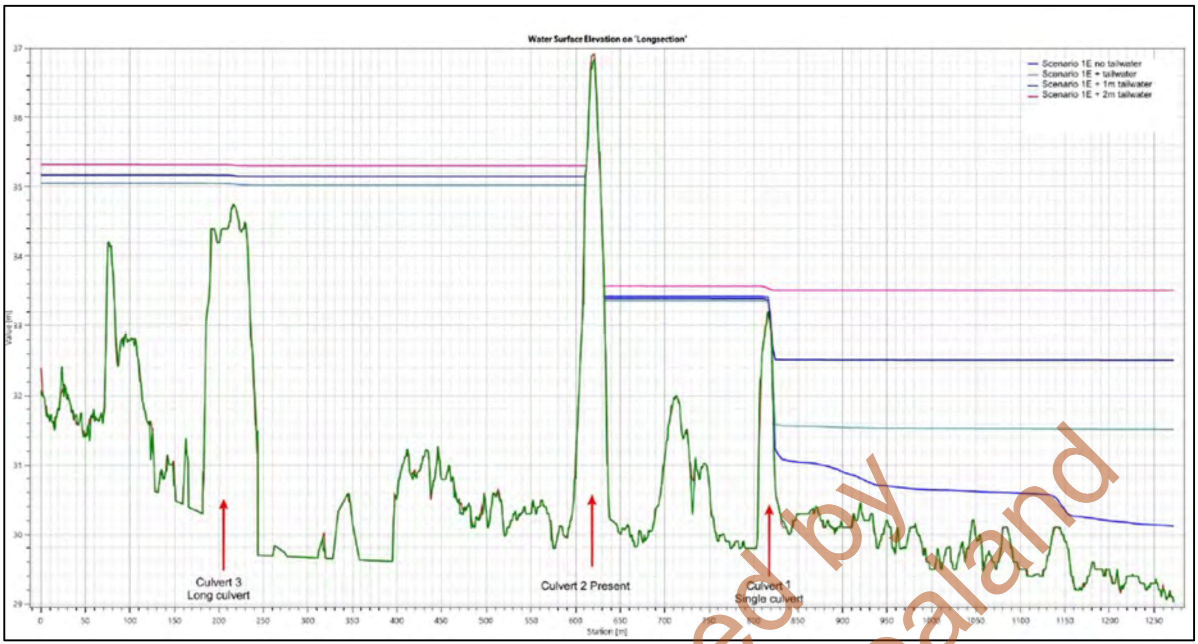


Figure 11: Model Results – Scenario 1E

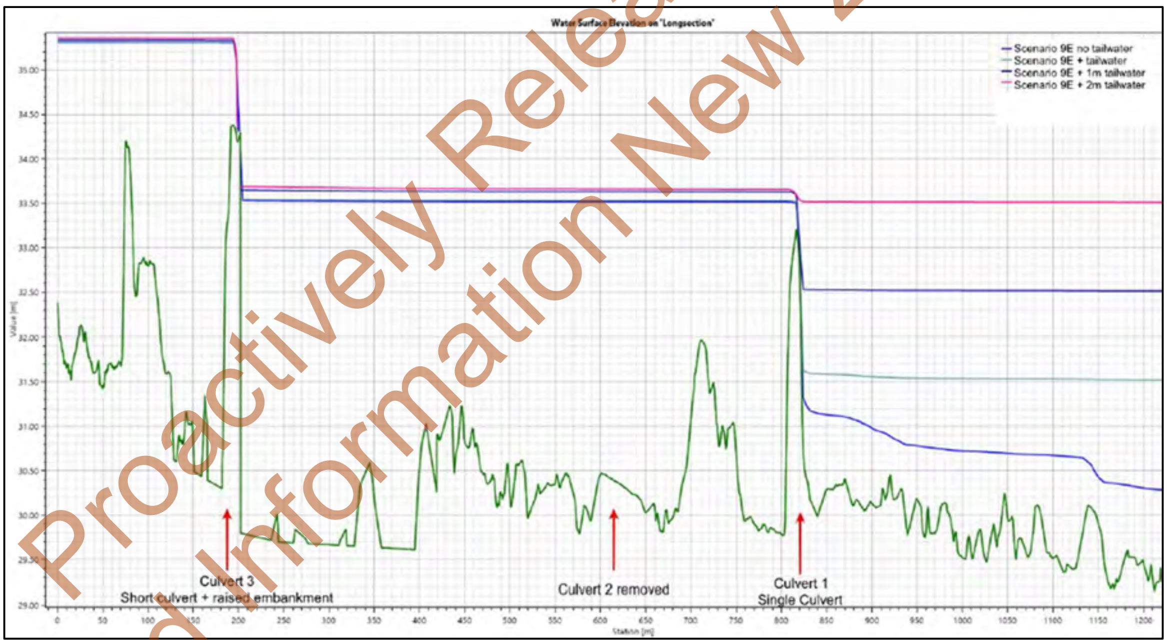


Figure 12: Model Results – Scenario 9E

In scenario 14 with 2 culverts at Te Mawhai Rd (14E), there is no overtopping over Te Mawhai Road until when another 2m is added to the tailwater (refer Figure 13 and drawing M07). Water level at Te Mawhai Rd in 14E is similar to that of 1E, where both levels are close to the increased tailwater level. It is observed that when overtopping occurs at Te Mawhai Road, the WWPS would also be inundated. This highlights that this scenario does not worsen tailwater effects but actually prevents inundation of WWPS and overtopping at Te Mawhai Road until tailwater increases by over 1m.

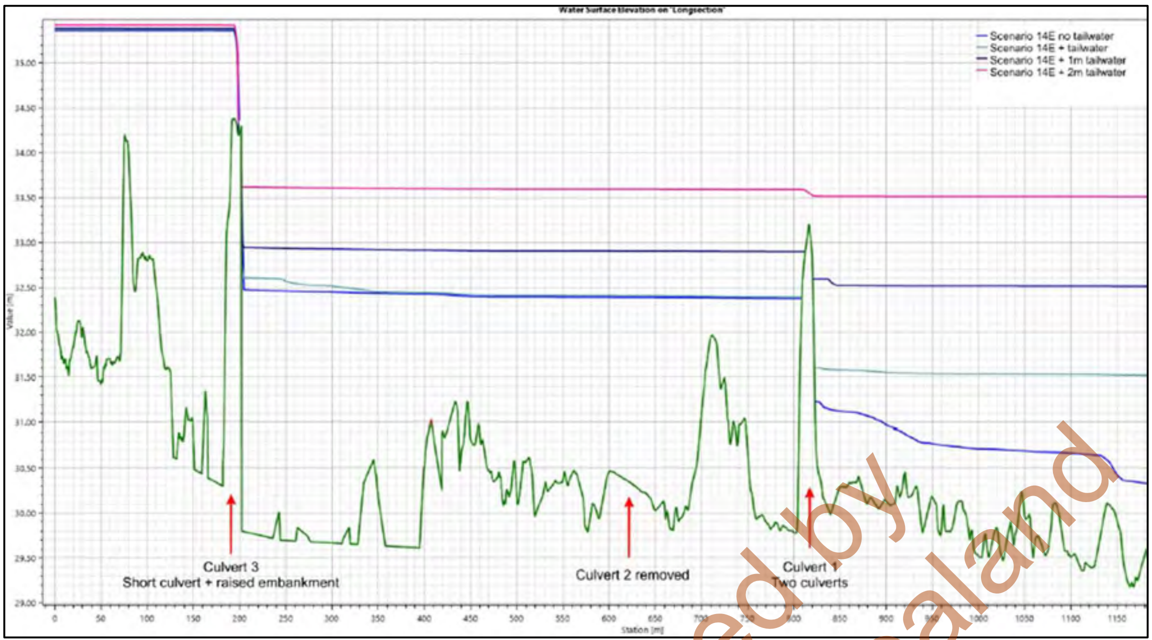


Figure 13: Model Results – Scenario 14E

In the 1% AEP + CC tailwater scenario (31.90mRL), the water level at Te Mawhai Road in Scenario 14 is lower than in Scenario 1, with overtopping and inundation of the WWPS occurring in both scenarios. However, when tailwater increases by 1m, water level in scenario 14 becomes higher than in scenario 1 and when the tailwater level is raised by 2m (to 33.90mRL), water levels in both scenarios become similar and are close to the increased tailwater level. The 2 culvert option provides a slight advantage before the tailwater rises by 1m; however, beyond this point, its performance aligns with that of the existing scenario 1.

This modelling shows that 2 culverts at Te Mawhai Rd are beneficial in low tailwater conditions, i.e. when tailwater is below 33.51mRL. However, once the tailwater increases above this, water levels are controlled more by tailwater levels rather than whether there are one or two culverts under Te Mawhai Road. The WRC flood layer for this area suggests tailwater levels over 33.51m will occur in a 1% AEP storm and hence a second culvert under Te Mawhai Rd will have no measurable additional flood mitigation benefit over a single culvert in this situation (i.e. a "regional" storm event).

4.5 FLOOD EMERGENCY ACCESS/EGRESS

WRC have advised that the measured maximum flood level at the "Pūniu at Bartons Corner Rd Br" gauging station was 15.421m in October 1989, with this being within the range of the gauge. They have advised that a provisional add of 13.216m is required to convert this level to NZVD2016. This gives a flood level of 28.64m RL in NZVD2016 and 28.94m RL in AUK1946 (+0.297m). The levels used in this report are in AUK1946 for consistency purposes.

Checking contour data against the WRC flood extent gives higher flood levels of 32.2mRL to 36mRL in this area, as shown in Figure 14, again noting that these levels are not consistent (i.e. flood levels upstream are lower than downstream and flood levels vary on opposite sides).

It is however possible that flood levels may have exceeded gauge readings back in earlier years, before the “Pūniu at Bartons Corner Rd Br” station started measuring water levels i.e. before year 1985, noting WRC refer to their flood extent maps taking into account historical floods from 1958, 1979 and 1998, only one of which would be captured by this gauge.

Figure 14: Flood levels at Pokuru Rd bridge based on WRC Flood Hazard Extent.

The LiDAR data indicates that the road levels on either side of the bridge are approximately 32.2m RL (refer to Figure 12). As Figure 13 shows that the bridge and road levels are similar, it is assumed that the bridge level is also around 32.2m RL. Given the historical maximum flood level of 28.94m RL (1% AEP event), the bridge at Pokuru Road is elevated by about 3.3m above the flood level, suggesting it would not have been inundated and could serve as a viable access/egress route.

In the event of flooding on Te Mawhai Road northeast of the subject site, the emergency access and egress route to the nearest town, Te Awamutu, would be via the northwest side of the subject site. From there, the route follows Te Mawhai Road westward, then turns northeast towards Pokuru Road, and finally continues to Te Awamutu, as indicated by the red dashed lines in Figure 15.

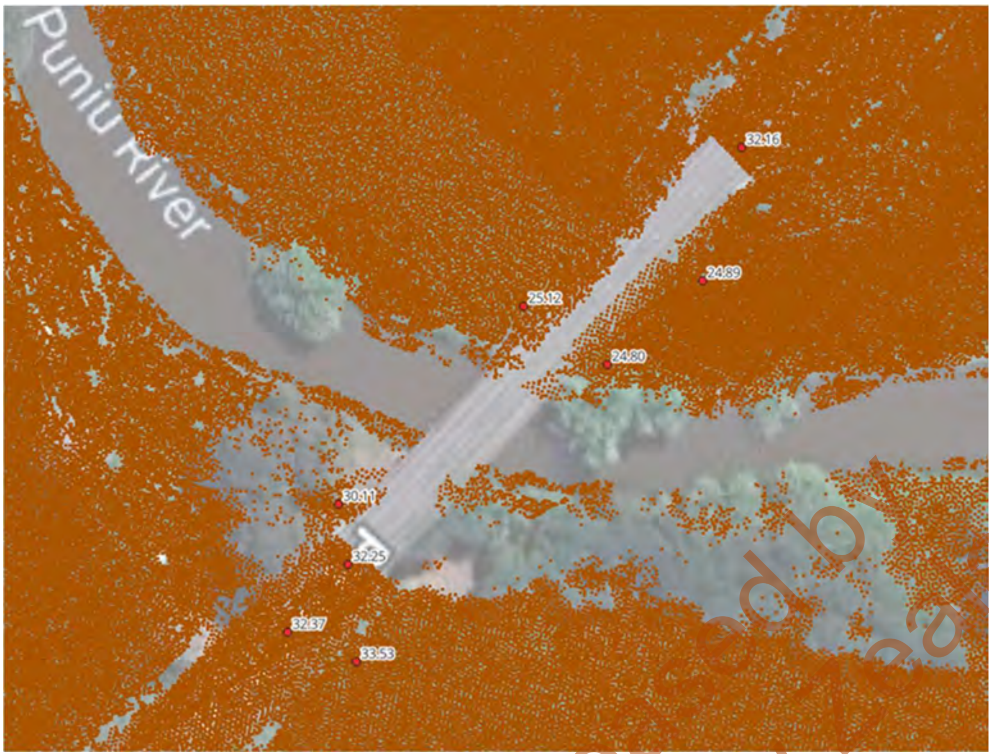


Figure 15: LiDAR point cloud extent at Pokuru Rd bridge.

Figure 16: Old photo of Pokuru Rd bridge provided by WRC.

Figure 17: Access/egress route from subject site to nearest town, Te Awamutu. Location of subject site (red circle) and Pūniu at Bartons Corner Rd Br station (orange X).

5.0 ADDITIONAL WORK IN RESPONSE TO DISCUSSIONS WITH WAIPĀ DISTRICT COUNCIL

5.1 WAIPĀ DISTRICT COUNCIL LIAISON

An earlier version of this report was provided to Johan Rossouw (Asset Manager, Waipā District Council, WDC) on 14 August 2024 along with supporting photos of the Te Mawhai Road culvert 1 crossing, followed by an online meeting with Mr Rossouw on 21 August 2024 to discuss matters relating to Te Mawhai Road flooding and the WWPS. At this meeting, WDC were advised that FTL were seeking regional flooding information from Waikato Regional Council (WRC) and would then update the flood risk assessment report to incorporate this information followed by a further meeting with WDC.

This was done with the updated report provided to WDC, followed by a second online meeting with Mr Rossouw and Bryan Hudson, Transport Manager, WDC, on 16 October 2024. Key points from this second meeting are summarised below:

(a) Mr Hudson grew up in the Waipā area and has seen the Pūniu River flood on several occasions, with flooding extending over a relatively large area. However, both the bridges on SH3 and Pokuru Road were well above the flood waters, indicating that emergency egress to Te Awamutu should be possible via these roads for people living either side of the Te Mawhai Road culvert 1 crossing, if this was flooded.

(b) It was explained that several attempts had already been made to locate Culvert 1 but without success, due to it being submerged. Photos were shared showing some signs of subsidence in the road embankment on the inlet side of this culvert. Mr Hudson also advised that fallen trees and willows is relatively common in the district on small streams similar to this one and these can cause culverts upgradient of them to be submerged. He advised that if the culvert was found to be blocked or collapsed, or downstream trees need removing, then their road maintenance crew can assist with this.

(c) Any second culvert under Te Mawhai Road would need to be constructable and affordable.

(d) It was agreed that further modelling be undertaken of more frequent storm events (50%, 20% and 5% AEP storms) with and without climate change to check if the proposed Culvert 2/3 works result in more regular flooding of Te Mawhai Rd. If not, WDC might accept not installing a second culvert.

(e) LINZ own the WWPS but have a maintenance agreement for it with WDC. To minimise flood damage to the WWPS, consideration may be given to raising the electrical control cabinet, noting that the WWPS access lids are all sealed. However, Mr Hodson advised that WDC likes the control cabinets to be close to the WWPS for ease of maintenance.

5.2 ADDITIONAL FIELD WORK

Further investigation of Culvert 1 was undertaken on 18 October 2024 by FTL staff. This involved 3D-GPR Scanning of Culvert 1 through the road above (unsuccessful), attempted inspection of Culvert 1 in waders (unsuccessful) and inspection of the Pūniu River Care surface water take pump station. With the GPR, the signal was lost between 3-3.5m below the road surface (32.80m ground level), but with no culvert being found above this depth.

A Compulevel was used to check water levels either side of Te Mawhai Road. This found:

- Water Level 2.67m below top of surveyed manhole lid (estimated 32.70m IL from watermain asbuilt) – southern side of culvert 1. This gives a water level of 30.03m RL.
- Water level 2.53m below top of surveyed manhole lid – northern side of culvert 1

Hence, there is a 140mm water level difference between culvert inlet and outlet.

Using a survey staff, it was not possible to find the stream bottom. This was made difficult by debris in the stream, giving false bottom readings. The estimated water depth at this location is over 2m.

Asbuilt information for Tokanui village watermain and wastewater reticulation upgrades shows that the 75dia wastewater line would cross Culvert 1 at an invert level of 31.45m RL, while the 180dia watermain would cross Culvert 1 at an invert level of approximately 31.60-31.74m RL. No sign of the culvert was found during these works. WSP, who designed these works, refer to Culvert 1 as being 1.2m diameter (but were not able to advise the source of this information), which differs from the 1.6m diameter recorded in WDC's RAMM records.

Based on the GPR findings, it is inferred that the top of the culvert may be at 29.80m maximum, and more likely below 29.30m RL, which would give an invert level of around 27.70m assuming the 1.6m culvert diameter is correct.

Based on the water level readings, and not being able to reach the stream bottom, this gives a culvert invert level of 28.03m RL or lower.

Similar measurements were taken further downstream on the Wharekōrino Stream at the Pūniu Rivercare Surface Water Take Pumpstation (approx. 500m below Te Mawhai Road):

- Water level @ Pump Station: 0.57m
- Channel Depth @ Pump Station: 0.8m
- Vertical height from water level to base of pump: 3.525m
- Base of pump station supports (ground level) to pump: 2.37m

Relevant photos from this and some earlier investigations are included in Appendix D.

5.3 ADDITIONAL MODELLING RESULTS

Additional modelling was undertaken for the 50%, 20% and 5% AEP storm events with and without climate change, as discussed with WDC. Model results are summarised in Table 7 with key points highlighted below:

(a) 50% AEP Storm (2yr event) – no flooding occurs of Te Mawhai Rd or the WWPS for the existing situation (Option 1) and preferred option (Option 9) with existing and climate change rainfall.

(b) 20% AEP Storm (5yr event) – no flooding of Te Mawhai Rd or the WWPS occurs for the existing and preferred option for existing rainfall and for the existing situation with climate change rainfall. Some flooding of Te Mawhai Rd and WWPS (32.93m LL) will occur for the preferred option with climate change rainfall. The WWPS will be under 170mm of water and the flood depth across Te Mawhai Rd will be 0.2m and velocity 0.29m/s – this corresponds to flood hazard category H1: generally safe for people, vehicles and buildings.

(c) 5% AEP Storm (20yr event) – flooding of the WWPS occurs for all scenarios. For the preferred option and existing rainfall, the flood depth at the WWPS will increase from 270mm to 320mm, while the flood depth across Te Mawhai Rd will increase from 300 to 350mm. The flood hazard will increase marginally from H1 to H2 (unsafe for small vehicles). For the preferred option and climate change rainfall, the flood depth at the WWPS will decrease from 470mm to 460mm, while the flood depth across Te Mawhai Rd will decrease from 500 to 490mm. The flood hazard will remain the same at H2.

Table 7: Modelling Results – 50%, 20% and 5% AEP Storms

Scenario	Flood extent (ha) [% change] of upstream neighbouring land	Flood level above Culvert 3 (m RL)	Flood extent (ha) [% change] of Landfill Area	Flood level at Culvert 1, Te Mawhai Rd (m RL)	Overland flows over Te Mawhai Rd (depth, velocity, hazard)			Effect on flood extents and flows downstream of Te Mawhai Road		
					Velocity (m/s)	Depth (m)	Hazard	Q (m^3/s) below road	Flood Level by Marae (m RL)	Flood Extent (ha) [% change]
50% AEP										
1	3.31	34.36	0.07	32.23	0	0	N/A	3.99	29.79	1.61
9	2.77 [16% reduced]	34.30	0.04 [43% reduced]	32.26	0	0	N/A	4.05	29.79	1.61
50% AEP with Climate Change										
1	4.71	34.54	0.22	32.48	0	0	N/A	4.82	29.85	1.64
9	4.53 [4% reduced]	34.53	0.06 [73% reduced]	32.53	0	0	N/A	4.95	29.86	1.65 [1% increase]
20% AEP										
1	5.70	34.59	0.22	32.55	0	0	N/A	4.99	29.86	1.66
9	5.81 [2% increase]	34.60	0.07 [68% reduced]	32.64	0	0	N/A	5.19	29.88	1.65 [1% reduced]
20% AEP with Climate Change										
1	7.27	34.69	0.28	32.90	0	0	N/A	5.78	29.92	1.72
9	7.21 [1% reduced]	34.72	0.10 [64% reduced]	33.10	0.29	0.2	H1	6.21	29.95	1.69 [2% reduced]
5% AEP										
1	7.63	34.73	0.31	33.20	0.27	0.30	H1	6.62	29.97	1.75
9	8.22 [8% increase]	34.79	0.11 [65% reduced]	33.25	0.22	0.35	H2	6.87	29.98	1.75
5% AEP with Climate Change										
1	8.55	34.89	0.42	33.40	0.61	0.50	H2	8.97	30.10	1.82
9	10.90 [27% increase]	35.24	0.20 [52% reduced]	33.39	0.42	0.49	H2	8.44	30.08	1.81 [1% reduced]

Notes: WWPS LL = 32.93m (red colour indicates if flooded)

In our opinion, these results show that the preferred option will have a minor effect on Te Mawhai Road in more frequent storms, causing slightly more "nuisance" flooding but no significant increased adverse effects in terms of flood hazard compared with the existing situation. On this basis, it is considered that installing a second culvert under Te Mawhai Road is not required.

Instead, it is recommended that WWPS flood risks be mitigated by raising the pump station electrical control cabinet by at least 1000mm up to possibly 1310mm as explained below:

- Raising the WWPS control cabinet a minimum of 500mm would protect it from inundation in storm events up to and including 5% AEP storm, with significant allowance for climate change.
- Raising the WWPS control cabinet by 810mm would protect it from being flooded in a 1% AEP storm for the preferred option with climate change.
- Normally, a "freeboard" or safety factor allowance of 500mm would be added on top of this, if practical, to allow for modelling accuracy and unexpected events such as a tree blocking culvert, etc. This would increase the above height raises to 1000-1310mm.

LINZ are currently investigating whether the control cabinet can be raised and by what extent.

Photos provided by Pūniu River Care of their surface water pump intake during a flood event show that the pump was just above the flood level. Flood levels by the marae are estimated to only increase by 1-3cm for the more regular storm events modelled, which is unlikely to affect this pump.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Overall, Culvert 2 has to be removed to have any significant effect on reducing flooding effects on the landfill from the Wharekōrino Stream ("local storm" with no tailwater effects). The existing culvert 3 should also be removed and replaced with a shorter new culvert and associated raised southern embankment over it, with the stream reinstated over the rest of the length of the original culvert, involving the transfer of deposited landfill material within this area to other landfill areas. These works (Scenario 9) do however result in increased flood flows and water levels at Te Mawhai Rd, resulting in an increase in the flood risk at this road, albeit for a rare event, with a conservative allowance for climate change.

The main benefit of Scenario 14 (Scenario 9 + 2nd 2.5m dia culvert under Te Mawhai Rd) over Scenario 9 is decreased flood levels at Te Mawhai Road and an associated reduction in flooding of the WWPS just above the road. The flood levels by the WWPS are similar for Scenario 1E and slightly reduced for Scenario 9E (compared with Scenarios 1 and 9), assuming no tailwater effects from the Pūniu River.

In a regional storm situation, it is expected that peak flows would occur in the Wharekōrino Stream in advance of peak flows in the Pūniu River, based on the relative catchments and the Wharekōrino Stream having a much shorter time of concentration than the Pūniu River. Modelling shows that the option with a single culvert under Te Mawhai Road is not as effective as the double culvert option in managing downstream tailwater effects for tailwater levels from the Pūniu River up to around 33.5m RL. The double culvert option model results show that under these tailwater conditions and for existing rainfall, it should prevent inundation of the WWPS and overtopping at Te Mawhai Road compared with other options. The WRC flood layer for this area suggests tailwater levels over 33.51m will occur in a 1% AEP regional storm. Once the tailwater increases above this, there is no additional benefit from having a second culvert compared with the one existing culvert.

Modelling of more regular flood events (50%-5% AEP storm events) shows that Scenario 9 will have a minor effect on Te Mawhai Road in more frequent storms, causing slightly more "nuisance" flooding but no significant increased adverse effects in terms of flood hazard compared with the existing situation. On this basis, it is considered that installing a second culvert under Te Mawhai Road is not required.

Given the historical maximum flood level of 28.94m RL for a 1% AEP event, the bridge at Pokuru Road is elevated by about 3.3m above the flood level, suggesting it would not have been inundated in that event and hence could serve as a viable emergency access/egress route for people living on the western side of the Wharekōrino Stream. In the event of flooding, the access and egress route to the nearest town, Te Awamutu would be via the northwest of the site and towards the bridge at Pokuru Rd. Similarly, anecdotal comments provided by WDC indicate that emergency egress to Te Awamutu via SH3 would be maintained in an extreme storm event for residents living on the eastern side of the Wharekōrino Stream.

Overall, the best practicable option is considered to be Scenario 9. This scenario has no significant increased adverse effects for more regular storms (50%-5% AEP events) but does increase flood levels and flood hazard across Te Mawhai Road for a 1% AEP storm event with and without climate change. However, emergency access/egress is maintained for all residents living either side of the road from Te Awamutu.

Whilst Scenario 14 does have more benefits than Scenario 9, the constructability and affordability of this option are questionable. The recommended size of the second culvert (2.5m dia) under Te Mawhai Rd is based on preliminary modelling set out in this report. Modelling found a second culvert of similar size to the existing one or slightly bigger (1500-1800dia) made little difference to a single culvert, while a 2500dia culvert did show a benefit. Practically, a rectangular box culvert of similar height to match the existing culvert would need to be installed. This would require a 3.0 x 1.6m high box culvert to achieve a similar flow area to a 2.5m diameter culvert. However, there is limited space available to install a culvert of these dimensions. Installation of a second culvert would also be costly, as the inferred depth of water in this area means the works area would need to be isolated from the stream area, likely using trench shields at least 3m high, and maintained dry for the duration of the works. For these reasons, it is not considered to be the best practicable option.

The impacts of these scenarios in terms of the criteria adopted in this report are summarised in Table 8.

Table 8: Summary of Model Results for Existing Scenario and Mitigation Scenarios 9 and 14 (no tailwater)

Scenario	Flood extent (ha) [% change] of upstream neighbouring land	Flood level above Culvert 3 (m RL)	Flood extent (ha) [% change] of Landfill Area	Flood level at Culvert 1, Te Mawhai Rd (m RL)	Overland flows over Te Mawhai Rd (depth, velocity, hazard)			Effect on flood extents and flows downstream of Te Mawhai Road		
					Velocity (m/s)	Depth (m)	Hazard	Q (m^3/s) below road	Flood Level by Marae (m RL)	Flood Extent (ha) [% change]
Existing Rainfall										
1E	9.68	35.06	0.49	33.42	0.68	0.52	H3	9.48	30.13	1.84
9E	11.25 [16% increase]	35.31	0.27 [45% reduction]	33.51	0.86	0.61	H3	11.69	30.24	1.89 [3% increase]
14E	11.52 [19% increase]	35.36	0.18 [63% reduction]	32.38	0.00	0.00	N/A	11.53	30.23	1.80 [2% reduction]
With Climate Change										
1	12.64	35.56	0.70	33.44	0.73	0.54	H3	10.83	30.20	1.86
9	12.06 [5% reduction]	35.46	0.34 [51% reduction]	33.74	1.59	0.84	H5	25.43	30.78	2.15 [16% increase]
14	12.37 [2% reduction]	35.52	0.30 [57% reduction]	33.25	0.23	0.35	H2	20.08	30.59	2.00 [8% increase]

Notes: Scenario 1 = existing; Scenario 9 = Culvert 2 removed + New short Culvert 3 + raised southern embankment; Scenario 14 = Scenario 9 + 2nd 2.5m dia. culvert under Te Mawhai Rd; WWPS LL = 32.93m (red colour indicates if flooded)

7.0 DISCLAIMER

The professional opinion expressed herein has been prepared solely for, and is furnished to our client, Toitū Te Whenua Land Information New Zealand, on the express condition that it will only be used for the purpose for which it is intended.

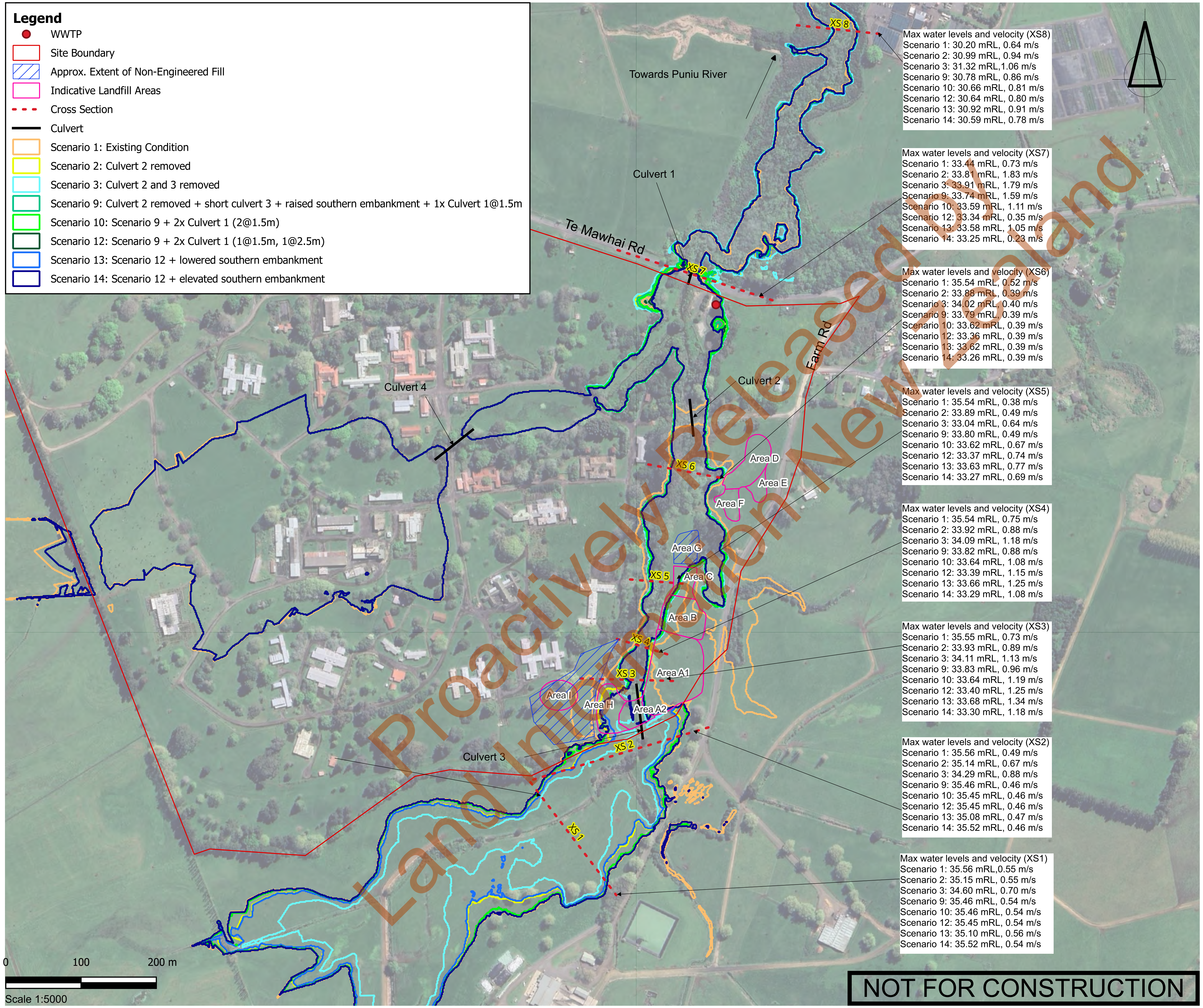
No liability is accepted by this firm or by any Principal, or Director, or any servant or agent of this firm, in respect of its use by any other person, and any other person who relies upon any matter contained in this report does so entirely at its own risk. This disclaimer shall apply notwithstanding that this report may be made available to any person by any person in connection with any application for permission or approval, or pursuant to any requirement of law.

We do not assume any liability for misrepresentation or items not visible, accessible or present at the subject site during the time of the site inspection; or for the validity or accuracy of any information provided by our client or third parties that have been utilised in the preparation of this report.

In particular, the accuracy of this modelling is subject to the following main limitations:

- Use of estimated diameters for culvert 2. However, this only affects the existing scenario, as this culvert is removed in all other scenarios.
- Use of estimated diameters of 1500mm for culvert 1 although Waipā District Council have advised that this culvert is a 1600mm diameter concrete pipe (according to their RAMM records) installed in the early 1970s. The modelling has not been revised for this minor change, as it is not expected to have a significant effect on the results.
- The surveyed stream cross-sections agreed reasonably well with LiDAR survey data at cross-sections, but were consistently higher than LiDAR survey data around landfill area A to C, as analysed in the 17 July 2023 memo. LiDAR data was used in the model to avoid surface discontinuities affecting running of the model, but the ground surface could potentially be higher by 0.3-0.8m, resulting in some increases in flood level in these areas. This is not anticipated to have a significant effect on the flood extents however, as the cross sections are fairly consistent in shape relative to LiDAR, and as such flooding will still spread out a similar amount. If this were to have an effect, the flood extents on landfill areas A or B might be slightly reduced.
- Use of a uniform Mannings roughness of 0.06. Flooding has been shown to primarily be controlled by water backing up behind Culvert 2 and hence flood levels are not expected to be sensitive to variations in Mannings values. This could be checked through sensitivity testing if required.
- The computation of change in flood extent only accounts for flooding occurring within the flow area of our 2D model, approximately 650m south from the site's southern boundary up to 420m beyond the northern boundary.

Drawings



SURVEYED			APPROVED	DATE
DESIGNED				
DRAWN	YG	08/07/2024		
CHECKED	SF	08/07/2024		

REVISION	CHANGES	CHECKED	DATE

NOTES

CLIENT
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PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
100YR ARI (RCP 8.5 FOR YEARS 2081-2100) - FLOOD EXTENT MODELLING SCENARIO 1,2,3,9,10,12,13,14

Fraser Thomas
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HAWKE'S BAY.....06 211 2766
CHRISTCHURCH.....03 358 5936
BLENHEIM.....03 428 3292
NELSON.....03 222 1132
TAURANGA.....020 4118 9465
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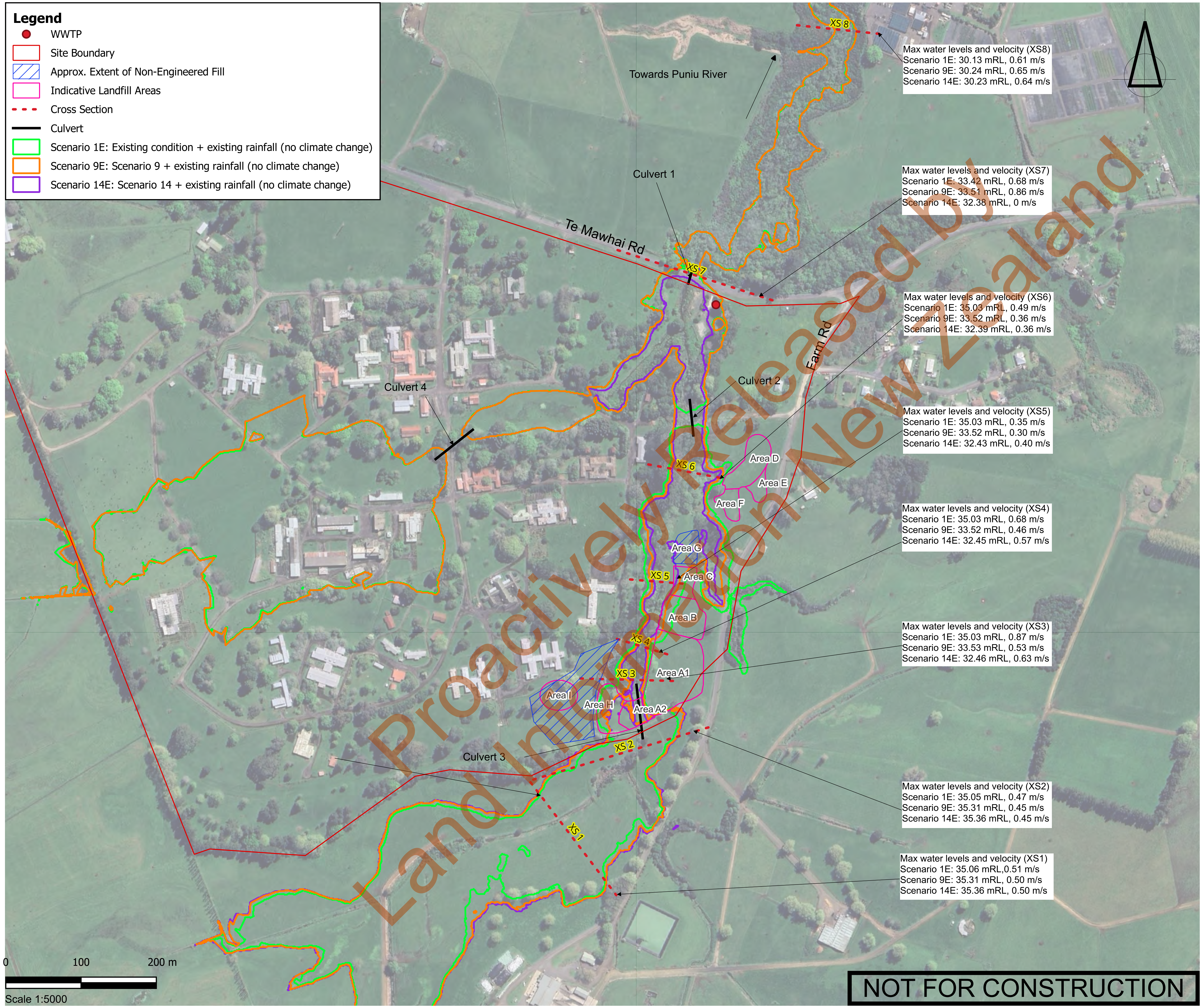
STATUS
Construction works shall commence only on receipt of and in accordance with the Council or Council organisation stamped approved drawings, unless otherwise indicated.

SCALE 1:5000 A3

DRAWING No 33097/M01 REVISION

P:\33 series\33097\03 Drawings\01 QGIS\33097 LINZ Tokanui Hospital.qgz



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SURVEYED			APPROVED	DATE
DESIGNED				
DRAWN	YG	08/07/2024		
CHECKED	SF	08/07/2024		

REVISION	CHANGES	CHECKED	DATE

NOTES

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PROJECT

FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE

100YR ARI (EXISTING RAINFALL) - FLOOD EXTENT MODELLING SCENARIO 1E, 9E, 14E

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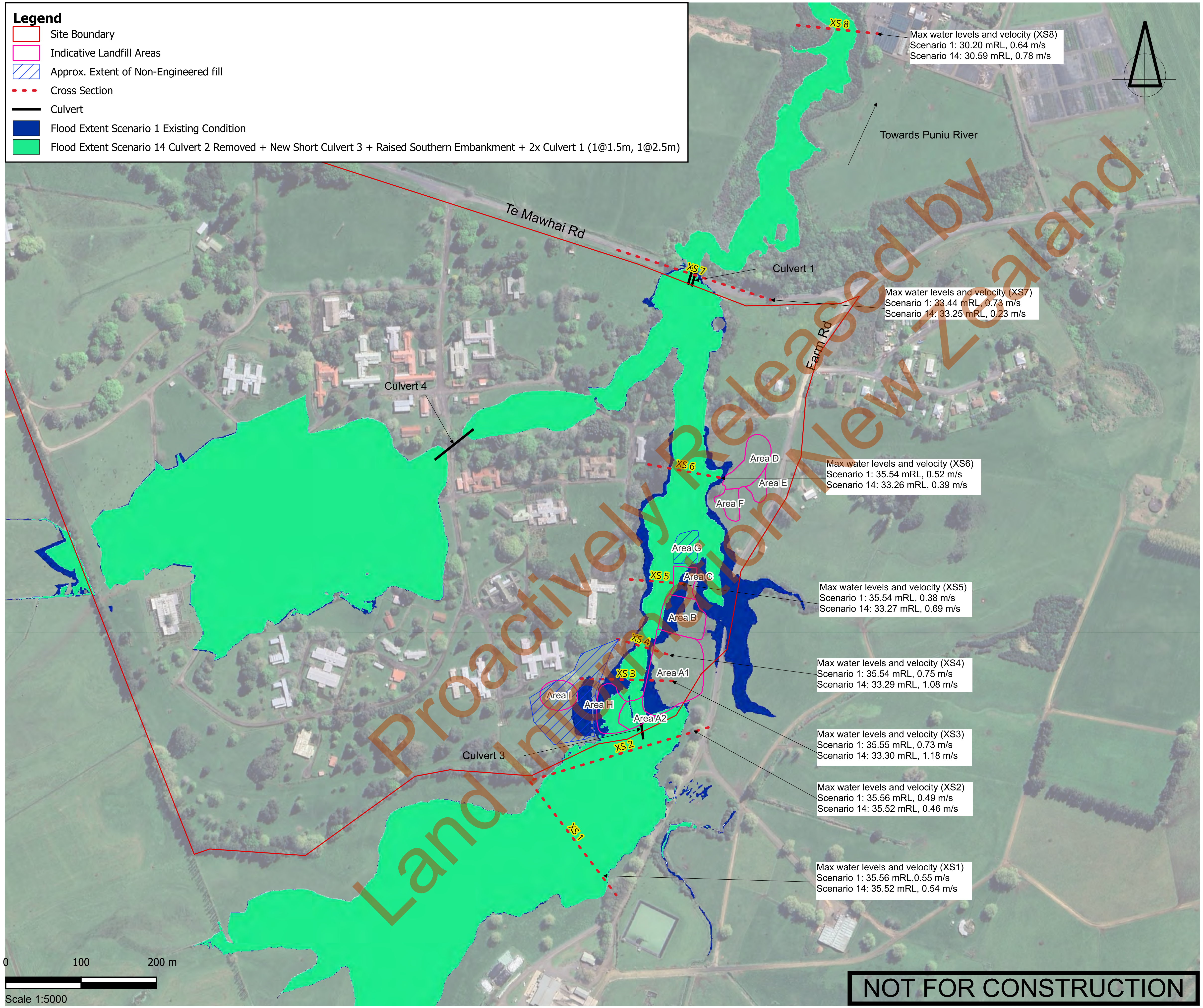
SCALE 1:5000 A3

DRAWING No 33097/M02 REVISION



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SURVEYED			APPROVED	DATE
DESIGNED				
DRAWN	YG	08/07/2024		
CHECKED	SF	08/07/2024		

REVISION	CHANGES	CHECKED	DATE

NOTES

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PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
100YR ARI (RCP 8.5 FOR YEARS 2081-2100) - FLOOD EXTENT OF EXISTING VS SCENARIO 14

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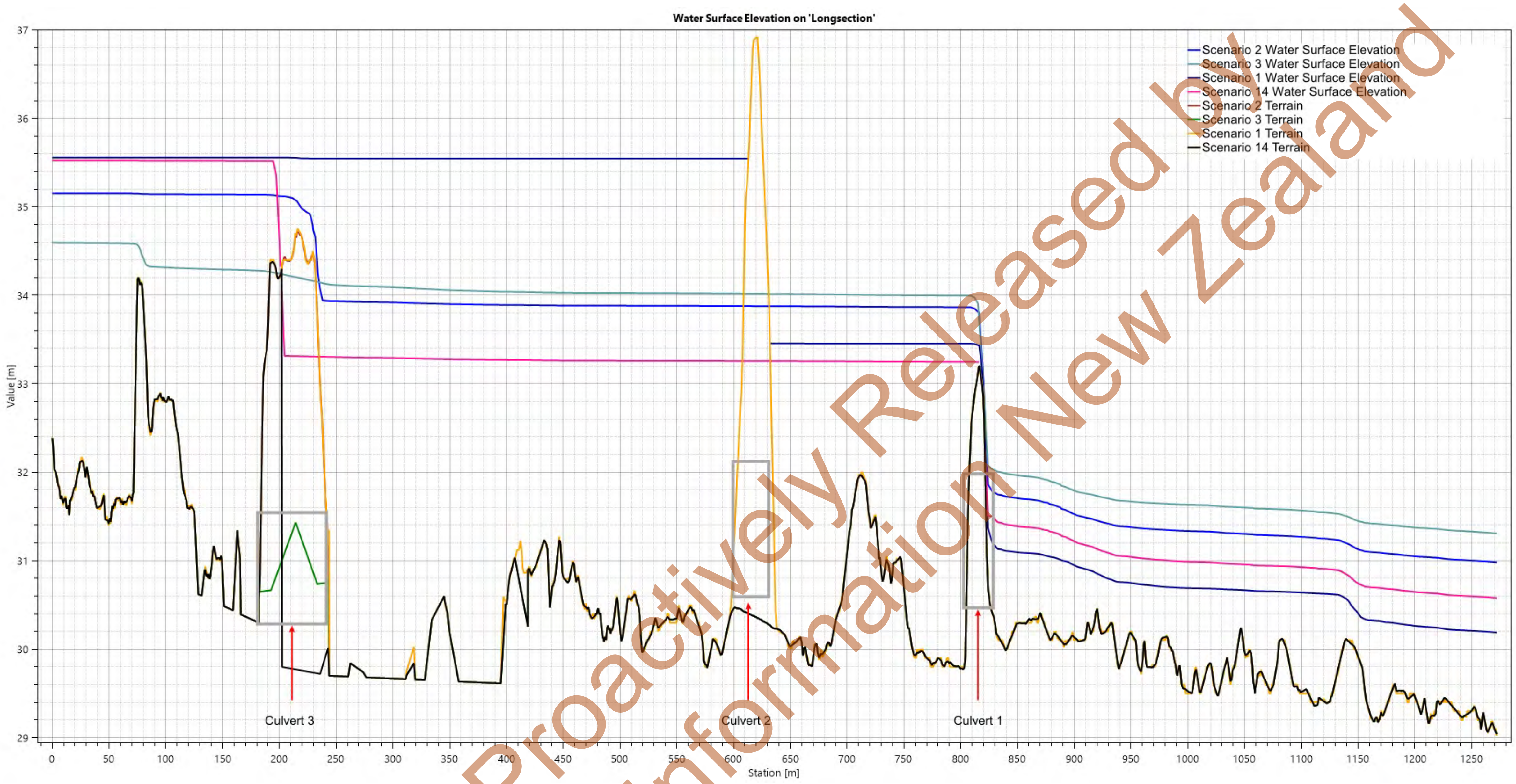
SCALE 1:5000 A3

DRAWING No 33097/M03
REVISION



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SURVEYED			APPROVED	DATE
DESIGNED				
DRAWN	YG	08/07/2024		
CHECKED	SF	08/07/2024		

REVISION	CHANGES	CHECKED	DATE

NOTES

1. Culvert placements and dimensions in this long section are approximate.
2. Data extracted from HEC RAS model.

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PROJECT

FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE

LONG SECTION OF WATER SURFACE ELEVATION IN SCENARIO 1,2,3 AND 14

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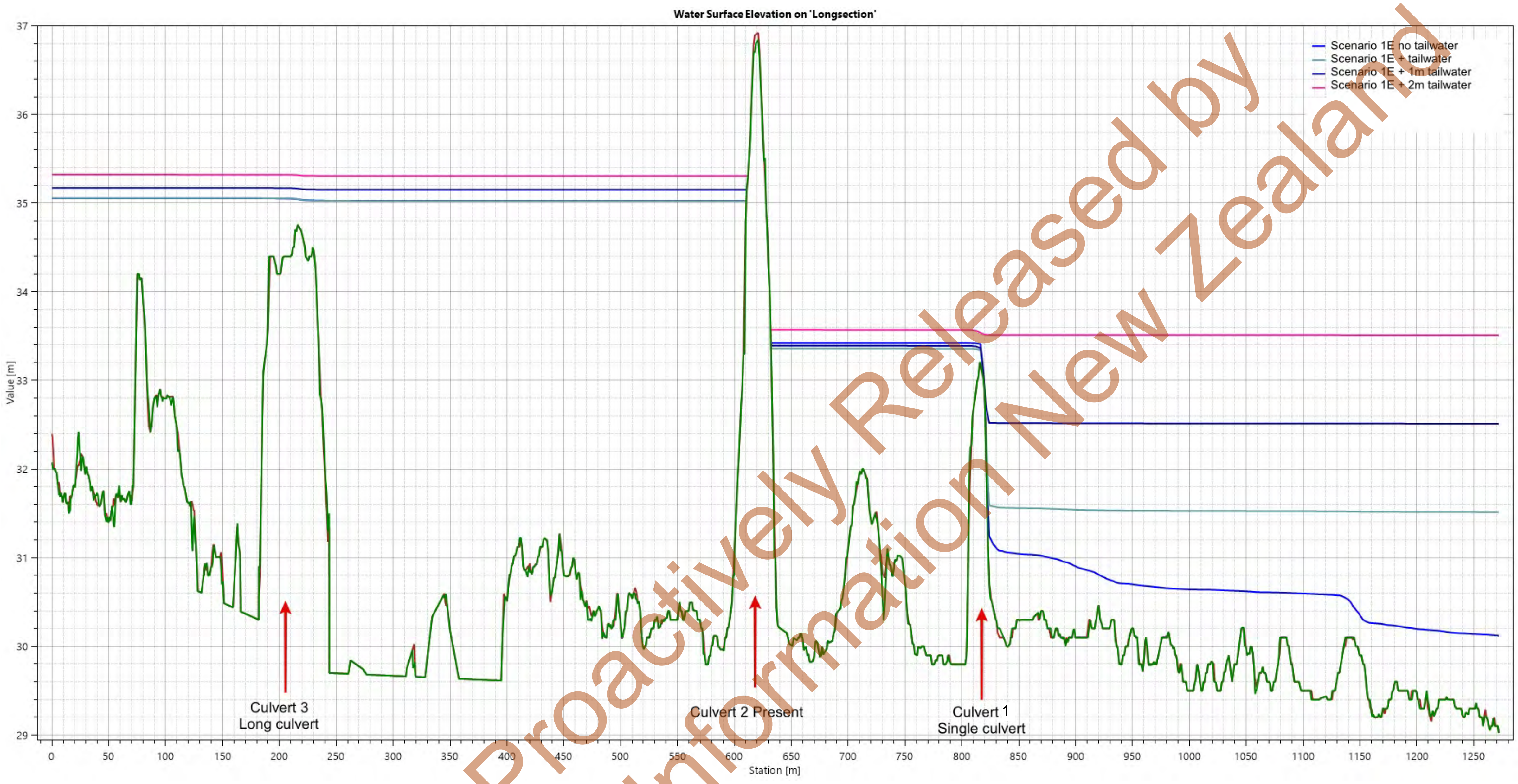
SCALE A3

DRAWING No 33097/M04

REVISION



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SURVEYED			APPROVED	DATE
DESIGNED				
DRAWN	YG	27/09/2024		
CHECKED	SF	27/09/2024		

REVISION	CHANGES	CHECKED	DATE

NOTES

1. Culvert locations in this long section are approximate.
2. Data extracted from HEC RAS model.

CLIENT

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PROJECT

FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE

TAILWATER EFFECTS - LONG SECTION OF WATER SURFACE ELEVATION IN SCENARIO 1E

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HAWKE'S BAY.....06 211 2766
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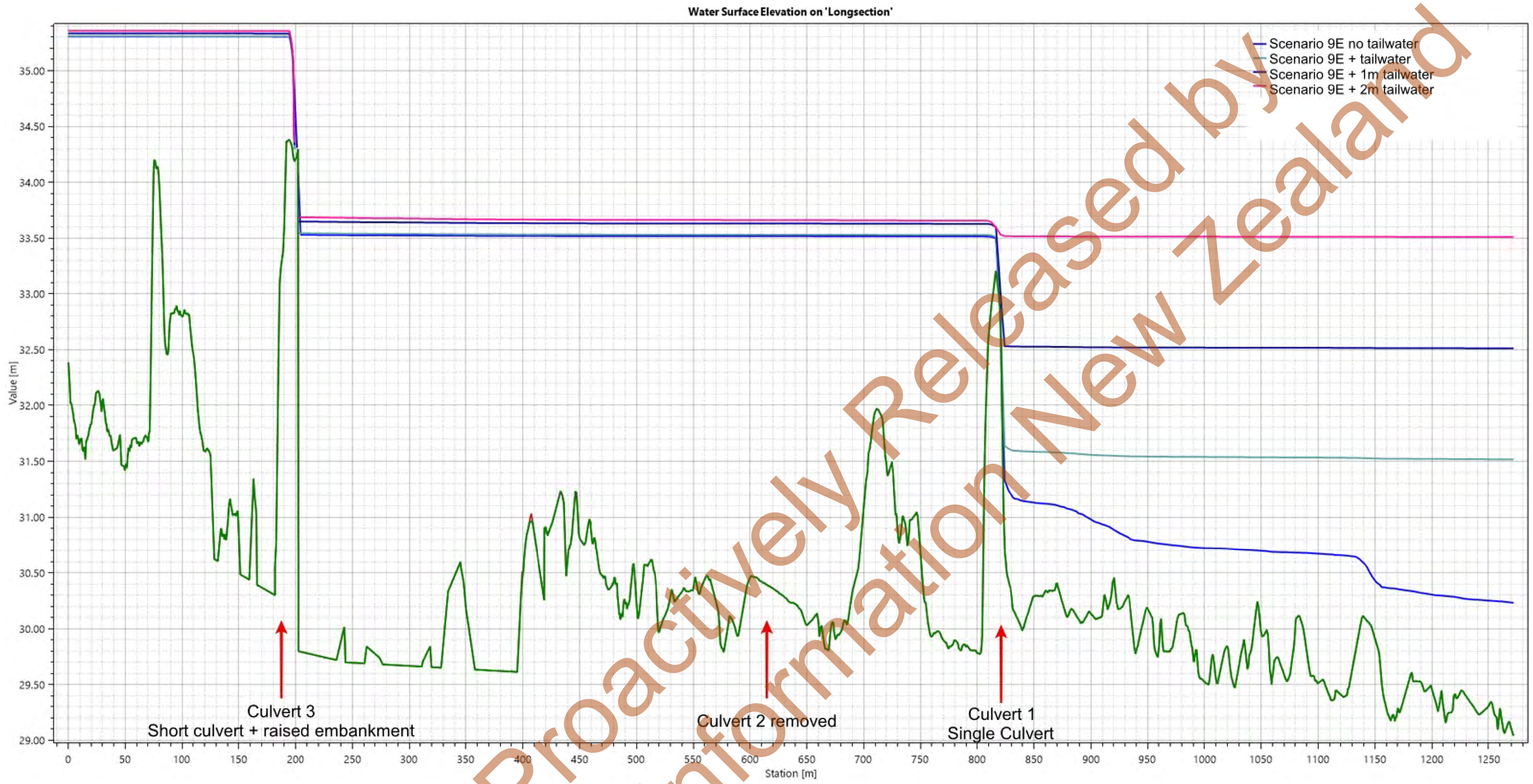
SCALE A3

DRAWING No 33097/M05

REVISION

Water Surface Elevation on 'Longsection'



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DESIGNED				
DRAWN	YG	20/09/2024		
CHECKED	SF	20/09/2024		

REVISION	CHANGES	CHECKED	DATE

NOTES
1. Culvert locations in this long section are approximate.
2. Data extracted from HEC RAS model.

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PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
TAILWATER EFFECTS - LONG SECTION OF WATER SURFACE ELEVATION IN SCENARIO 9E

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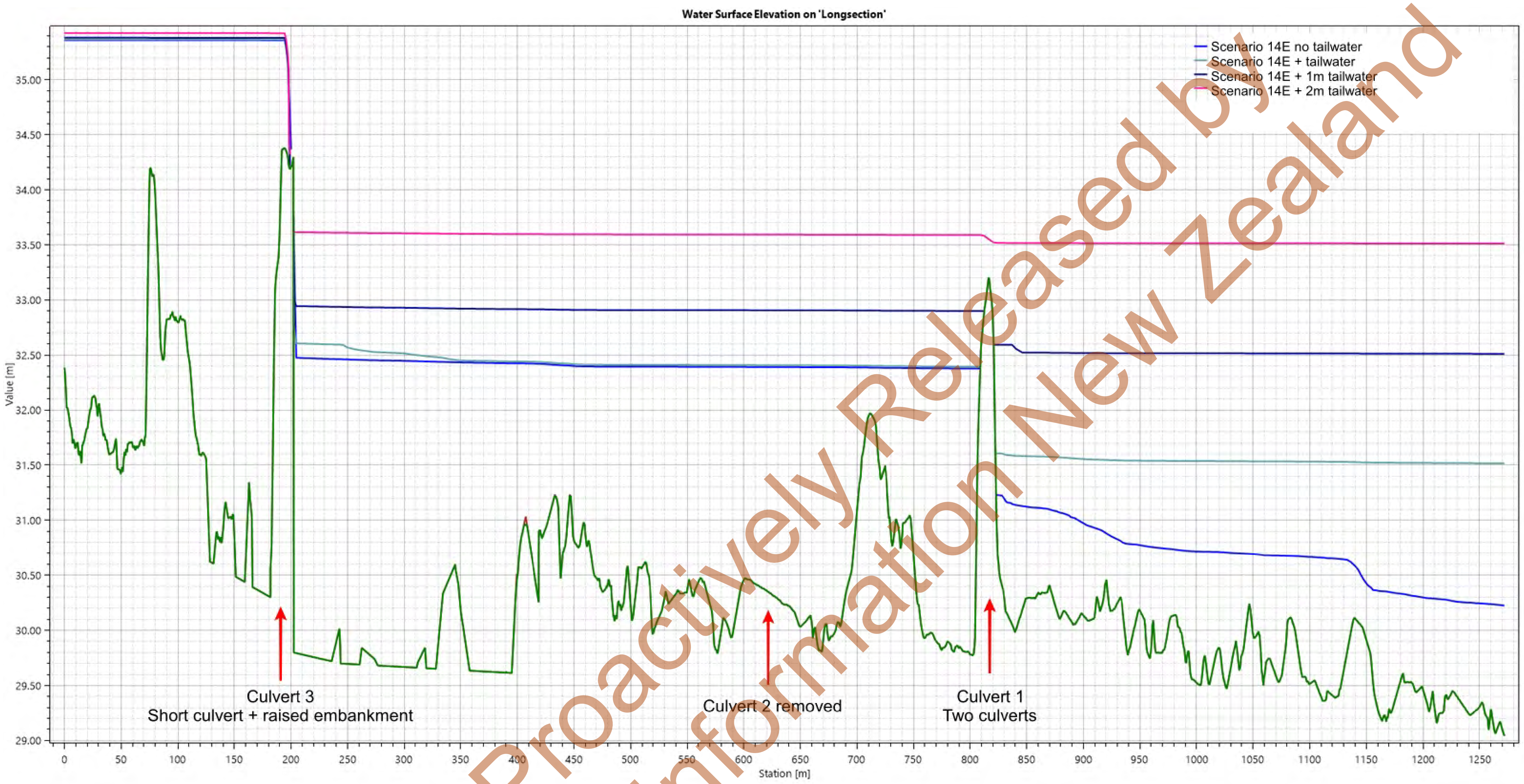
SCALE A3

DRAWING No 33097/M06
REVISION



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SURVEYED			APPROVED	DATE
DESIGNED				
DRAWN	YG	20/09/2024		
CHECKED	SF	20/09/2024		

REVISION	CHANGES	CHECKED	DATE

NOTES
1. Culvert locations in this long section are approximate.
2. Data extracted from HEC RAS model.

CLIENT
TOITŪ TE WHENUA / LINZ

PROJECT
FORMER TOKANUI HOSPITAL DEMOLITION AND REMEDIATION PROJECT

TITLE
TAILWATER EFFECTS - LONG SECTION OF WATER SURFACE ELEVATION IN SCENARIO 14E

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HAWKE'S BAY............06 211 2766
CHRISTCHURCH............03 358 5936
BLENHEIM............03 428 3292
NELSON............03 222 1132
TAURANGA............020 4118 9465
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SCALE A3

DRAWING No 33097/M07
REVISION

Appendix A

Catchment and Flow Calculations

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Catchment West

Catchment characteristics

	Soil Group	CN	Area (ha)	
Undisturbed pasture	C	74	160	(Pasture good condition)
Reinstated pasture	D	80	0	(Pasture good condition)
Capped area	D	89	0	(Pasture poor condition)
Total Area	160			
Weighted CN	74			
S	89.2432432			
Ia	4.46216216			

Time of concentration

Sheet and shallow concentrated flow

Length of flow	200	m		
Slope	10.500	%		
Mannings n	0.045			
Time	16.16	Minutes		

Open channel flow 1

Slope	0.037	m/m		
Mannings n	0.035			
Channel base width	0.5	m		
Channel height	0.5	m		
Channel side slope 1:	3			
Hydraulic radius	0.273			
Velocity	2.30	m/s	Q check	2.300125
Length	820	m		
Time	5.94	Minutes		

Open channel flow 2

Slope	0.0029	m/m		
Mannings n	0.035			
Channel base width	2	m		
Channel height	1.5	m		
Channel side slope	3			
Hydraulic radius	0.849			
Velocity	1.38	m/s	Q check	13.47767
Length	1030	m		
Time	12.42	Minutes		

Pipe flow N/A

Gradient
Diameter
Velocity
Length
Time

Total time of concetration

Time	34.52	Minutes
Lag time	0.38	Hours

Catchment time of concentration check

Length	2500
Height difference	54.5
Time	35.17

Catchment South

Catchment characteristics

	Soil Group	CN	Area (ha)	
Undisturbed pasture	C	74	440	(Pasture good condition)
Reinstated pasture	D	80	0	(Pasture good condition)
Capped area	D	89	0	(Pasture poor condition)
Total Area	440			
Weighted CN	74			
S	89.2432432			
Ia	4.46216216			

Time of concentration

Sheet and shallow concentrated flow

Length of flow	160	m		
Slope	20.000	%		
Mannings n	0.045			
Time	13.19	Minutes		

Open channel flow 1

Slope	0.039	m/m		
Mannings n	0.035			
Channel base width	0.5	m		
Channel height	0.5	m		
Channel side slope 1:	5			
Hydraulic radius	0.268			
Velocity	2.33	m/s	Q check	3.497912
Length	700	m		
Time	5.00	Minutes		

Open channel flow 2

Slope	0.0061	m/m		
Mannings n	0.035			
Channel base width	2	m		
Channel height	1.5	m		
Channel side slope	3			
Hydraulic radius	0.849			
Velocity	2.00	m/s	Q check	19.46425
Length	2140	m		
Time	17.87	Minutes		

Pipe flow	N/A
Gradient	
Diameter	
Velocity	
Length	
Time	

Total time of concetration

Time	36.06	Minutes
Lag time	0.40	Hours

Catchment time of concentration check

Length	3000
Height difference	72
Time	39.00

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Catchment Flow Summary

Western catchment 1% AEP storm

Summary Results for Subbasin "Catchment West"

Project: 33097 catchment flows Simulation Run: 1% AEP
Subbasin: Catchment West

Start of Run:	18Jan2023, 00:00	Basin Model:	Basin 1
End of Run:	20Jan2023, 00:00	Meteorologic Model:	1% AEP
Compute Time:	27Jan2023, 15:15:23	Control Specifications:	Control 1

Volume Units: ◯ MM ◉ 1000 M3

Computed Results

Peak Discharge:	15.98940 (M3/S)	Date/Time of Peak Discharge:	18Jan2023, 12:30
Precipitation Volume:	241.45920 (1000 M3)	Direct Runoff Volume:	145.59947 (1000 M3)
Loss Volume:	95.85974 (1000 M3)	Baseflow Volume:	0.00000 (1000 M3)
Excess Volume:	145.59947 (1000 M3)	Discharge Volume:	145.59947 (1000 M3)

Southern catchment 1% AEP storm

Summary Results for Subbasin "Catchment south"

Project: 33097 catchment flows Simulation Run: 1% AEP
Subbasin: Catchment south

Start of Run:	18Jan2023, 00:00	Basin Model:	Basin 1
End of Run:	20Jan2023, 00:00	Meteorologic Model:	1% AEP
Compute Time:	27Jan2023, 15:15:23	Control Specifications:	Control 1

Volume Units: ◯ MM ◉ 1000 M3

Computed Results

Peak Discharge:	41.83201 (M3/S)	Date/Time of Peak Discharge:	18Jan2023, 12:30
Precipitation Volume:	664.01280 (1000 M3)	Direct Runoff Volume:	400.39853 (1000 M3)
Loss Volume:	263.61427 (1000 M3)	Baseflow Volume:	0.00000 (1000 M3)
Excess Volume:	400.39853 (1000 M3)	Discharge Volume:	400.39853 (1000 M3)

Western catchment 1% AEP + climate change storm

Summary Results for Subbasin "Catchment West"

Project: 33097 catchment flows Simulation Run: 1% AEP cc
Subbasin: Catchment West

Start of Run:	18Jan2023, 00:00	Basin Model:	Basin 1
End of Run:	20Jan2023, 00:00	Meteorologic Model:	Met 1
Compute Time:	27Jan2023, 12:00:55	Control Specifications:	Control 1

Volume Units: ◯ MM ◉ 1000 M3

Computed Results

Peak Discharge:	21.67060 (M3/S)	Date/Time of Peak Discharge:	18Jan2023, 12:30
Precipitation Volume:	295.48160 (1000 M3)	Direct Runoff Volume:	192.84731 (1000 M3)
Loss Volume:	102.63429 (1000 M3)	Baseflow Volume:	0.00000 (1000 M3)
Excess Volume:	192.84731 (1000 M3)	Discharge Volume:	192.84731 (1000 M3)

Southern catchment 1% AEP + climate change storm

Summary Results for Subbasin "Catchment south"

Project: 33097 catchment flows Simulation Run: 1% AEP cc
Subbasin: Catchment south

Start of Run:	18Jan2023, 00:00	Basin Model:	Basin 1
End of Run:	20Jan2023, 00:00	Meteorologic Model:	Met 1
Compute Time:	27Jan2023, 12:00:55	Control Specifications:	Control 1

Volume Units: ◯ MM ◉ 1000 M3

Computed Results

Peak Discharge:	56.74596 (M3/S)	Date/Time of Peak Discharge:	18Jan2023, 12:30
Precipitation Volume:	812.57440 (1000 M3)	Direct Runoff Volume:	530.33011 (1000 M3)
Loss Volume:	282.24429 (1000 M3)	Baseflow Volume:	0.00000 (1000 M3)
Excess Volume:	530.33011 (1000 M3)	Discharge Volume:	530.33011 (1000 M3)

Appendix B
Tailwater Calculations

Channel Report

Downstream Tailwater 1% AEP

User-defined		**Highlighted**	
Invert Elev (m)	= 25.3100	Depth (m)	= 6.2028
Slope (%)	= 0.0440	Q (cms)	= 306
N-Value	= 0.060	Area (sqm)	= 440.9435
		Velocity (m/s)	= 0.6940
Calculations		Wetted Perim (m)	= 158.1449
Compute by:	Known Q	Crit Depth, Yc (m)	= 3.3986
Known Q (cms)	= 306.0000	Top Width (m)	= 156.0695
		EGL (m)	= 6.2274

(Sta, El, n)-(Sta, El, n)...
(0.0000, 38.1810)-(123.1200, 38.5200, 0.060)-(140.1000, 28.3000, 0.060)-(150.7100, 25.8400, 0.060)-(163.4500, 25.3100, 0.060)-(169.8200, 28.2100, 0.060)-(
-(199.5400, 27.8500, 0.060)-(229.2500, 29.7810, 0.060)-(281.2600, 29.6500, 0.060)-(333.2600, 39.7700, 0.060)

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Friday, Sep 20 2024

Downstream Tailwater 1% AEP + CC

User-defined
Invert Elev (m) = 25.3100
Slope (%) = 0.0440
N-Value = 0.060

Calculations
Compute by: Known Q
Known Q (cms) = 375.0000

Highlighted
Depth (m) = 6.5899
Q (cms) = 375
Area (sqm) = 501.8682
Velocity (m/s) = 0.7472
Wetted Perim (m) = 160.9220
Crit Depth, Yc (m) = 3.5906
Top Width (m) = 158.7018
EGL (m) = 6.6184

(Sta, El, n)-(Sta, El, n)...
(0.0000, 38.1810)-(123.1200, 38.5200, 0.060)-(140.1000, 28.3000, 0.060)-(150.7100, 25.8400, 0.060)-(163.4500, 25.3100, 0.060)-(169.8200, 28.2100, 0.060)-(
-(199.5400, 27.8500, 0.060)-(229.2500, 29.7810, 0.060)-(281.2600, 29.6500, 0.060)-(333.2600, 39.7700, 0.060)

Appendix C
WRC Correspondence

sfinnigan@ftl.co.nz

From:	Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Sent:	Friday, 23 August 2024 2:36 pm
To:	sfinnigan@ftl.co.nz
Subject:	RE: REQ212049 Flood hazard information for 149 Te Mawhai Road

Hi Sean,

WRC does not have any records to show whether the roads at those locations have flooded before or not.

No problem - I will work with our environmental data team to pull the relevant info from that gauge. I cannot give you an exact time frame on that unfortunately as it depends on their capacity but will likely be next week.

When is your meeting with Waipa DC? I will let the team know to aim to provide this information before if possible.

Kind regards,
Lauren

Lauren Empson | REGIONAL RESILIENCE ASSISTANT | Regional Resilience, Integrated Catchment Management
WAIKATO REGIONAL COUNCIL | Te Kaunihera ā Rohe o Waikato
P: +6478590779
F: facebook.com/waikatoregion
Private Bag 3038, Waikato Mail Centre, Hamilton, 3240

From: sfinnigan@ftl.co.nz <sfinnigan@ftl.co.nz>
Sent: Friday, August 23, 2024 9:31 AM
To: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Subject: RE: REQ212049 Flood hazard information for 149 Te Mawhai Road

Hi Lauren

Yes – pls if we can have this data for downstream gauge along with any indication of what flows this gauge can measure up to. Our experience with gauges is that they capture the in-channel flows generally reasonably well, but as soon as the channel is overtopped and flow spreads across the floodplain, they are not reliable.

It would also be useful to know if there have been any records of roads overtopping at locations 2 and 3 in my image below

Regards | Ngā mihi

Sean Finnigan - Director, Environmental Engineering

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Auckland: Level 1, 21 El Kobar Drive, East Tamaki, PO Box 204006, Highbrook, Auckland 2161, NZ

Christchurch | Hawkes Bay | Tauranga | Nelson | Blenheim

From: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Sent: Friday, 23 August 2024 8:34 am
To: sfinnigan@ftl.co.nz
Subject: RE: REQ212049 Flood hazard information for 149 Te Mawhai Road

Good morning Sean,

I have done some investigation and unfortunately, WRC does not have much of the specific information requested. I will provide you with the information we do have and hopefully it can assist you.

As shown on the Waikato Regional Hazards Portal, the property is inside of the Regional Scale Flood Hazard layer, which means that WRC does hold information to suggest the area the property is located in is susceptible to flooding. This layer is formed from a compilation of flood hazard information which is soured from a combination of previous event information (photos, anecdotes, surveys), flood modelling (if available), flood protection and drainage scheme information, and elevation data.The description associated with the Regional Scale Flood Hazard Layer for the area is below, please refer to the hazard portal for the location of this layer labelled WP82:

- During a 100-year flood the River will breach its channel inundating low-lying land. Most land surrounding this river is pastoral farmland. The Waipa River will likely cause backflow up the Puniu River. This will compound any inundation of land due to the river breaching banks or ponding from local runoff, which will also collect in low-lying pockets. Tokanui sewage treatment plant has been inundated in past floods and would again be inundated in a 100-year event.

This layer the property is in has been derived from historical flood events in 1958, 1979, and 1998, and unfortunately WRC has not undertaken any flood modelling in this area.

WRC does not have any flow gauges at the specifically requested sites i.e., Puniu/Wharekorino confluence, however we do manage a gauge on the Puniu River that is a bit further downstream of the second requested site. See below for the location of this gauge.

I am liaising with our environmental data team to get the flow information at this location. Just confirming that you would still like this information for the site further downstream?

Kind regards,
Lauren

Lauren Empson | REGIONAL RESILIENCE ASSISTANT | Regional Resilience, Integrated Catchment Management
WAIKATO REGIONAL COUNCIL | Te Kaunihera ā Rohe o Waikato
P: +6478590779
F: facebook.com/waikatoregion

Private Bag 3038, Waikato Mail Centre, Hamilton, 3240

From: sfinnigan@ftl.co.nz <sfinnigan@ftl.co.nz>
Sent: Thursday, August 22, 2024 9:12 AM
To: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Cc: 'Bryan Daly' <bdaly@linz.govt.nz>
Subject: RE: REQ212049 Flood hazard information for 149 Te Mawhai Road

Hi Lauren

Much appreciated thanks

Regards | Ngā mihi

Sean Finnigan - Director, Environmental Engineering

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p 09 2787078 - ext. 7750 – m 021 0223 0510

Auckland: Level 1, 21 El Kobar Drive, East Tamaki, PO Box 204006, Highbrook, Auckland 2161, NZ

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From: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Sent: Thursday, 22 August 2024 8:38 am
To: sfinnigan@ftl.co.nz
Subject: RE: REQ212049 Flood hazard information for 149 Te Mawhai Road

Good morning Sean,

My plan is to work on your request today and hopefully send out the information we have today, and if not then tomorrow.

I appreciate your patience.

Kind regards,
Lauren

Lauren Empson | REGIONAL RESILIENCE ASSISTANT | Regional Resilience, Integrated Catchment Management
WAIKATO REGIONAL COUNCIL | Te Kaunihera ā Rohe o Waikato
P: +6478590779
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Private Bag 3038, Waikato Mail Centre, Hamilton, 3240

From: sfinnigan@ftl.co.nz <sfinnigan@ftl.co.nz>
Sent: Thursday, August 22, 2024 8:20 AM
To: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Cc: 'Bryan Daly' <bdaly@linz.govt.nz>
Subject: RE: REQ212049 Flood hazard information for 149 Te Mawhai Road

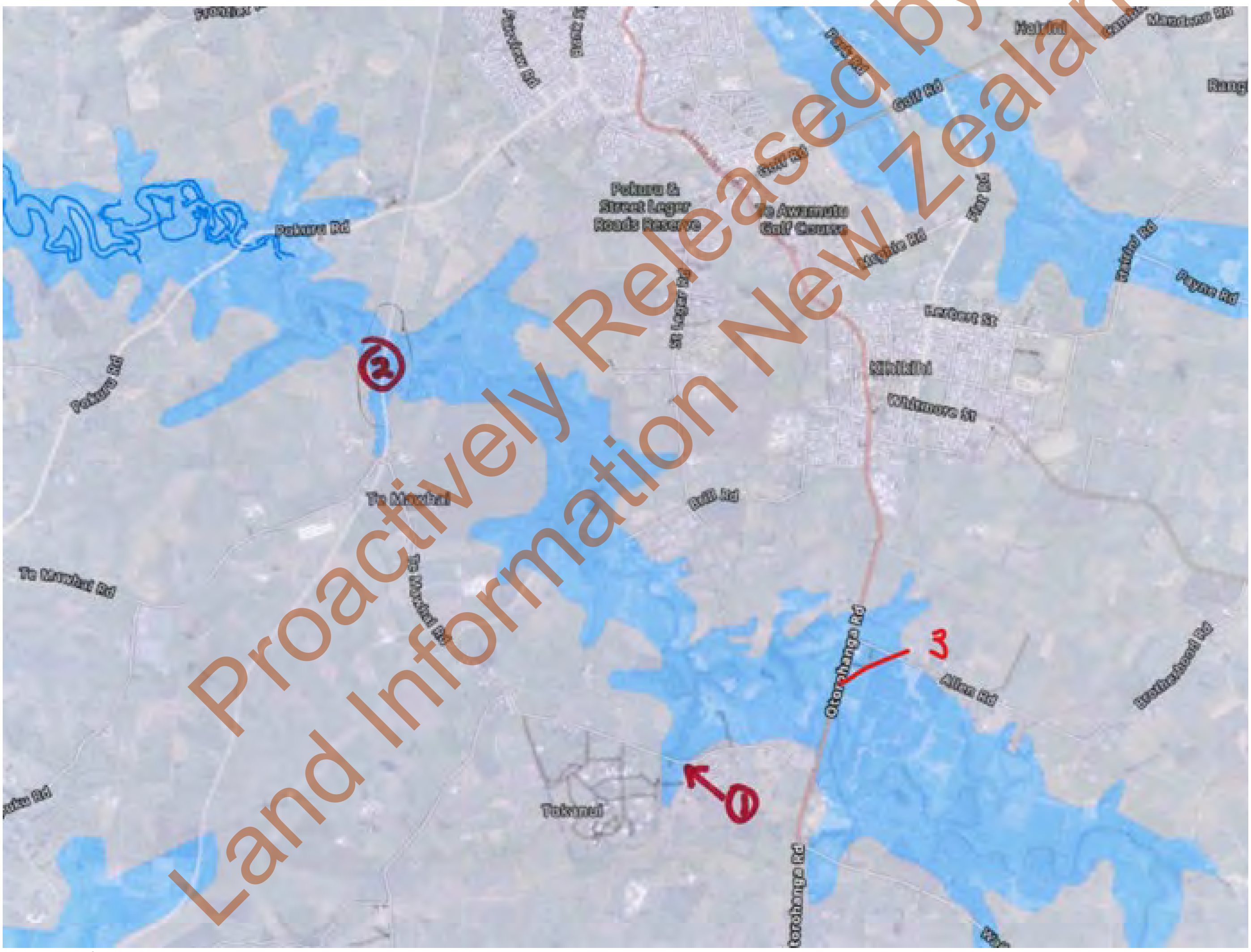
Hi Lauren

REF240828265

We ended up having a preliminary meeting with Waipa DC yesterday on this and they want to have a followup meeting next wk, but for that, we need the WRC modelling results for the Puniu river, as per my online request, including the flood hydrograph at the Puniu/Wharekorino confluence. I appreciate you're busy with lots of requests, but if you can give us an idea of when you can get the results to us that would be greatly appreciated, as we need a bit of time to apply them to our model and it can take some time to arrange meetings with Waipa DC staff.

Can we have all results requested for the 100yr storm with and without climate change(including specifying the climate change allowance made).

In addition to my requests for locations 1 and 2, are you able to advise peak flows and levels at Otorohonga Rd (location 3) just so we can check the depth of flooding over this road, if any.



Regards | Ngā mihi

Sean Finnigan - Director, Environmental Engineering

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From: sfinnigan@ftl.co.nz <sfinnigan@ftl.co.nz>
Sent: Wednesday, 21 August 2024 3:39 pm
To: 'Lauren Empson' <Lauren.Empson@waikatoregion.govt.nz>
Cc: 'Bryan Daly' <bdaly@linz.govt.nz>
Subject: RE: REQ212049 Flood hazard information for 149 Te Mawhai Road

Hi Lauren

Thanks for the advice. Any idea of when we might get a response as we are having a meeting with Waipa DC to discuss this issue in next wk.

Regards | Ngā mihi

Sean Finnigan - Director, Environmental Engineering

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From: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Sent: Friday, 16 August 2024 1:35 pm
To: sfinnigan@ftl.co.nz
Subject: REQ212049 Flood hazard information for 149 Te Mawhai Road

Hi Sean,

Thank you for your request for flood hazard information.

We are currently receiving a high number of requests so just a heads up it may take longer than normal to get the information we have to you.

I will look into your request and get this information to you as soon as I can.

Kind regards,
Lauren

Lauren Empson | REGIONAL RESILIENCE ASSISTANT | Regional Resilience, Integrated Catchment Management

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sfinnigan@ftl.co.nz

From:	Doug Stewart <Doug.Stewart@waikatoregion.govt.nz>
Sent:	Monday, 26 August 2024 3:14 pm
To:	sfinnigan@ftl.co.nz
Cc:	Lauren Empson
Subject:	RE: User Task - Gauge data at Puniu River - Bartons Corner Rd Br
Attachments:	REQ212049 Punui at Bartons Corner Rd.xlsx

Hi Sean,
The attached file has information for Puniu at Bartons Corner Rd Water Level/Flow site
Cheers, Doug

Doug Stewart | SENIOR ENVIRONMENTAL MONITORING SCIENTIST - HYDROLOGY | Hydrology and Air, Science, Policy and Information
WAIKATO REGIONAL COUNCIL | Te Kaunihera ā Rohe o Waikato
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Private Bag 3038, Waikato Mail Centre, Hamilton, 3240

From: IRISMail@wairc.govt.nz <IRISMail@wairc.govt.nz>
Sent: Monday, August 26, 2024 8:23 AM
To: Doug Stewart <Doug.Stewart@waikatoregion.govt.nz>
Subject: User Task - Gauge data at Puniu River - Bartons Corner Rd Br

IRIS task **User Task - Gauge data at Puniu River - Bartons Corner Rd Br** has been assigned to **Doug Stewart**.

Due Date:	**28/08/2024**
Description:	Hello Doug. The requester has asked for peak flow, velocity, and depth information at a couple locations near this address. I have advised WRC does not have gauging equipment at the requested locations, but we do have a river gauge further downstream "Puniu River - Bartons Corner Rd Br". They have confirmed they would like this information for this river gauge. Could you please help them with this query? I have answered the remainder of the request. Cheers.
Notes:	
IRIS Record:	FHI-149 Te Mawhai Road (was Tokanui psychiatric hospital
IRIS ID:	REQ212049
Type:	Request | Flooding and hazards | General

The requester has asked for peak flow, velocity, and depth information at a couple locations near this address. I have advised WRC does not have gauging equipment at the requested locations, but we do have a river gauge further downstream "Puniu River - Bartons Corner Rd Br". They have confirmed they would like this information for this river gauge.

Summary

Puniu at Bartons Cnr Rd			
Maximum Recorded Level	15.421	m	16/10/1989
Maximum Recorded Flow	322.2	m3/s	16/10/1989
Estimated Mean Velocity at Peak	1.2	m/s	
Estimated Maximum Depth at peak	8.5	m	

Puniu at Bartons Corner Rd

Maximum Annual Flow 1985 to 2023

Maximum Flow		322.2	m3/s	16/10/1989
Date	Discharge [	Occurrence timestamp	Valid	
1/01/1985	68.7	3/12/1985 18:30	67%	
1/01/1986	177.4	26/07/1986 18:45	100%	
1/01/1987	73.9	22/03/1987 12:30	100%	
1/01/1988	159.2	7/10/1988 19:45	100%	
1/01/1989	322.2	16/10/1989 2:15	100%	
1/01/1990	143.6	12/03/1990 4:30	100%	
1/01/1991	188.5	10/08/1991 1:00	100%	
1/01/1992	137.5	6/12/1992 13:00	100%	
1/01/1993	75.3	22/11/1993 9:30	100%	
1/01/1994	109.7	4/08/1994 3:45	100%	
1/01/1995	111.8	7/09/1995 19:30	100%	
1/01/1996	157.0	12/09/1996 23:30	100%	
1/01/1997	69.9	14/11/1997 2:35	100%	
1/01/1998	223.0	10/07/1998 13:40	100%	
1/01/1999	82.7	12/11/1999 1:55	100%	
1/01/2000	152.1	3/10/2000 13:55	100%	
1/01/2001	79.1	10/12/2001 3:55	100%	
1/01/2002	176.7	8/07/2002 5:40	100%	
1/01/2003	87.8	27/11/2003 14:15	100%	
1/01/2004	240.3	29/02/2004 20:25	100%	
1/01/2005	67.9	19/09/2005 14:50	100%	
1/01/2006	96.9	7/08/2006 20:15	100%	
1/01/2007	98.3	5/08/2007 13:40	100%	
1/01/2008	118.1	8/10/2008 16:15	100%	
1/01/2009	87.1	6/10/2009 1:55	100%	
1/01/2010	98.8	13/09/2010 6:15	100%	
1/01/2011	116.6	12/07/2011 17:40	100%	

Puniu at Bartons Corner Rd

Maximum Annual Level 1985 to 2023

Maximum Level		15.421	m	16/10/1989
Date	Water Leve	Occurrence timestamp	Valid	
1/01/1985	12.268	3/12/1985 18:30	67%	
1/01/1986	13.653	26/07/1986 18:45	100%	
1/01/1987	12.111	22/03/1987 12:30	100%	
1/01/1988	13.274	7/10/1988 19:45	100%	
1/01/1989	15.421	16/10/1989 2:15	100%	
1/01/1990	13.122	12/03/1990 4:30	100%	
1/01/1991	13.746	10/08/1991 1:00	100%	
1/01/1992	13.425	6/12/1992 13:00	100%	
1/01/1993	12.242	22/11/1993 9:30	100%	
1/01/1994	12.576	4/08/1994 3:45	100%	
1/01/1995	12.606	15/07/1995 19:45	100%	
1/01/1996	13.306	12/09/1996 23:30	100%	
1/01/1997	11.997	14/11/1997 2:35	100%	
1/01/1998	13.981	10/07/1998 13:40	100%	
1/01/1999	12.202	12/11/1999 1:55	100%	
1/01/2000	13.201	3/10/2000 13:55	100%	
1/01/2001	12.125	10/12/2001 3:55	100%	
1/01/2002	13.506	8/07/2002 5:40	100%	
1/01/2003	12.289	27/11/2003 14:15	100%	
1/01/2004	14.231	29/02/2004 20:25	100%	
1/01/2005	11.89	19/09/2005 14:50	100%	
1/01/2006	12.441	7/08/2006 20:15	100%	
1/01/2007	12.467	5/08/2007 13:40	100%	
1/01/2008	12.774	8/10/2008 16:15	100%	
1/01/2009	12.279	6/10/2009 1:55	100%	
1/01/2010	12.487	13/09/2010 6:15	100%	
1/01/2011	12.753	12/07/2011 17:35	100%	

Annual Maximum Flow Level

1/01/2012	183.0	17/07/2012 7:50	100%
1/01/2013	131.0	13/09/2013 7:20	100%
1/01/2014	99.2	13/06/2014 5:20	100%
1/01/2015	122.5	21/09/2015 16:45	100%
1/01/2016	118.2	7/10/2016 6:20	100%
1/01/2017	195.1	6/04/2017 5:30	100%
1/01/2018	52.5	23/08/2018 21:35	100%
1/01/2019	58.8	13/08/2019 21:30	100%
1/01/2020	45.1	26/11/2020 13:50	100%
1/01/2021	95.8	24/09/2021 11:25	100%
1/01/2022	85.2	14/07/2022 4:50	100%
1/01/2023	67.1	31/01/2023 0:45	100%

1/01/2012	13.568	17/07/2012 7:50	100%
1/01/2013	13.011	13/09/2013 7:20	100%
1/01/2014	12.656	13/06/2014 5:20	100%
1/01/2015	12.914	21/09/2015 16:45	100%
1/01/2016	12.865	7/10/2016 6:20	100%
1/01/2017	13.718	6/04/2017 5:30	100%
1/01/2018	11.795	23/08/2018 21:35	100%
1/01/2019	11.998	13/08/2019 21:30	100%
1/01/2020	11.556	26/11/2020 13:50	100%
1/01/2021	12.605	24/09/2021 11:25	100%
1/01/2022	12.476	14/07/2022 4:50	100%
1/01/2023	12.249	31/01/2023 0:45	100%

Area Mean Velocity Max Depth

Puniu at Bartons Corner Flow Gaugings

Date	Time	Water Level [m]	Flow [m³/s]	A [m²]	v [m/s]	
16/10/1989	9:05:00	14.72	268.55	244.506	1.098	7.860
10/07/1998	10:47:30	13.845	220.53	193.18	1.142	6.97
1/03/2004	11:32:30	13.553	103.7	172.75	0.6	
12/03/1990	11:30:00	12.915	104.454	145.826	0.716	
8/10/1988	10:08:00	12.723	117.376	135.185	0.868	5.88
27/07/1986	15:32:00	12.583	101.949	125.605	0.812	
25/08/1988	14:05:00	12.578	108.576	131.441	0.826	6.1
15/07/2011	12:00:00	12.54	91.301	124.621	0.733	
9/06/1988	14:36:00	12.388	88.187	114.88	0.768	
21/06/2013	13:12:00	12.354	78.59025			
4/10/2000	9:20:00	12.306	90.041	114.288	0.788	
17/10/1989	10:32:00	12.305	89.693	110.38	0.813	5.48
7/01/1986	12:45:00	12.298	70.924	121.876	0.582	
3/10/2022	9:08:00	12.286	67.15167			
3/10/2022	9:40:00	12.275	69.82186			
27/11/2003	12:20:00	12.252	85.956	106.804	0.805	
7/09/1995	13:30:00	12.193	100.554	107.145	0.938	
24/07/1991	15:15:00	12.109	73.129	103.557	0.706	
23/07/1996	14:05:00	12.103	81.153	102.68	0.79	
23/07/1992	9:24:00	12.076	66.957	105.07	0.637	
23/06/2004	11:35:00	11.993	78.932	102.465	0.77	
28/07/1986	15:50:00	11.992	69.094	91.235	0.757	
8/08/1990	12:09:00	11.96	71.816	98.636	0.728	
5/04/2017	14:10:00	11.953	55.4			
28/07/1988	9:43:00	11.872	64.56199	92.458	0.698	4.75
8/01/1986	11:47:00	11.868	46.415	95.31	0.487	
5/08/2016	13:41:30	11.851	50.377			
24/07/1995	12:22:00	11.826	65.412	92.927	0.704	
13/06/1989	11:48:00	11.718	55.064	82.674	0.666	
5/01/1986	15:25:00	11.716	46.241	97.593	0.474	
14/11/1997	10:30:00	11.672	56.028	82.013	0.683	
5/01/1986	10:35:00	11.662	43.34	89.867	0.482	
19/02/1991	13:22:00	11.649	51.093	87.781	0.582	
14/06/1993	14:02:00	11.62	55.331	82.623	0.67	
29/07/1986	12:25:00	11.609	54.022	82.11	0.658	
19/07/2012	14:04:00	11.56	43.9			
10/06/1988	11:52:00	11.527	48.191	77.338	0.623	
27/06/1994	10:49:00	11.5	49.86	74.388	0.67	
9/01/1986	9:40:00	11.465	33.964	75.42	0.45	
6/01/1986	15:05:00	11.384	35.958	67.661	0.531	
9/07/1992	10:10:00	11.374	40.224	71.391	0.563	
6/01/1986	13:50:00	11.352	36.15599	68.321	0.529	
6/01/1986	12:13:00	11.313	34.006	70.489	0.482	
6/01/1986	10:23:00	11.303	29.201	65.659	0.445	
22/07/1996	15:35:00	11.279	48.009	67.868	0.707	
14/06/1989	12:32:00	11.207	43.328	65.645	0.66	

Area Mean Velocity Max Depth

14/08/1991	10:50:00	11.202	41.215	65.33	0.631	
10/01/1986	10:00:00	11.158	29.656	63.616	0.466	
27/08/1991	14:40:00	11.148	40.033	62.24	0.643	
17/08/1999	16:00:00	11.138	41.746	65.141	0.641	
11/08/1994	11:00:00	11.006	42.11	58.769	0.717	
29/06/1995	14:22:00	10.932	36.37099	62.17	0.585	
24/09/1997	15:25:00	10.931	37.972	55.762	0.681	
18/01/1979	10:02:00	10.93	1.981	22.08	0.09	
1/10/2003	11:56:30	10.884	36.266	55.406	0.655	
2/02/2023	15:37:00	10.835	29.23144			
29/08/1988	10:05:00	10.804	36.11399	52.362	0.69	3.85
13/10/2011	15:23:30	10.691	34.392	49.7	0.692	
7/05/2013	15:20:00	10.648	29.465			
30/08/1989	14:42:00	10.637	32.136	49.538	0.649	3.75
10/10/1989	13:05:00	10.626	32.86	50	0.657	
1/10/1991	14:46:00	10.617	29.457	50.057	0.588	
4/07/2008	9:37:30	10.613	32.209	54.738	0.588	
22/07/1991	14:56:00	10.599	22.629	53.677	0.422	
4/06/2015	14:33:30	10.597	26.21			
3/09/2009	13:10:00	10.569	33.74	53.73	0.628	
21/07/2017	13:13:00	10.528	32.721			
8/09/2017	13:58:00	10.488	32.155			
14/12/2001	9:27:30	10.457	28.42	48.835	0.582	
6/06/2018	14:00:00	10.409	30.339			
29/08/2008	9:30:00	10.36	28.423	47.043	0.604	
10/04/1996	13:37:00	10.344	21.619	45.765	0.472	
29/08/1996	15:37:00	10.322	28.753	45.638	0.63	
25/05/2017	14:34:00	10.302	27.306			
25/05/1988	10:30:00	10.262	19.603	41.881	0.468	
1/07/2009	12:17:30	10.191	24.504	46.346	0.529	
19/07/1988	12:15:00	10.169	21.825	39.458	0.553	
2/06/1994	14:50:00	10.165	20.968	42.31	0.496	
17/12/1992	13:02:00	10.142	22.876	46.757	0.489	
1/10/2013	11:43:00	10.128	29.768			
1/10/2013	12:39:00	10.098	25.403			
14/09/1992	12:11:00	10.097	20.066	39.023	0.514	
29/09/2010	11:22:30	10.041	27.328	44.259	0.617	
10/07/1990	14:00:00	10.033	20.884	37.426	0.558	
11/12/1985	10:37:00	9.984	12.316	36.628	0.336	
25/07/1989	10:32:00	9.967	20.7	38.491	0.538	
25/05/2001	11:27:30	9.96	13.439	40.866	0.329	
27/06/1995	15:10:00	9.946	16.978	39.335	0.432	
18/02/1992	13:08:00	9.938	11.758	34.514	0.341	
27/08/2015	14:45:00	9.931	18.524			
19/10/1994	8:37:00	9.923	21.272	37.52	0.567	
23/08/2007	12:42:30	9.91	23.295	41.907	0.556	
31/08/2022	12:34:12	9.909	23.8923			
1/11/1990	8:51:00	9.908	21.184	37.893	0.559	

Area Mean Velocity Max Depth

4/04/1995	14:57:00	9.874	13.237	35.305	0.375
16/01/1986	13:47:00	9.867	12.143	31.558	0.385
23/08/1993	12:22:00	9.836	13.904	35.257	0.394
9/12/1988	13:15:00	9.826	18.452	34.37	0.537
12/09/1988	11:22:00	9.823	22.192	38.534	0.576
21/06/2012	11:34:00	9.815	19.301		
12/01/1989	14:57:00	9.784	17.813	33.146	0.537
27/01/2000	14:05:00	9.777	12.592	34.789	0.362
19/06/1996	15:10:00	9.771	17.842	37.84	0.472
7/05/1996	15:25:00	9.73	14.916	34.37	0.434
25/06/1991	9:53:00	9.72	11.937	32.219	0.37
22/06/1987	13:42:00	9.694	14.568	31.488	0.463
15/10/1996	14:25:00	9.679	19.14399	35.774	0.535
16/09/2021	14:50:00	9.666	21.554	37.15	0.58
6/09/2016	12:38:00	9.664	16.081		
7/09/2018	13:30:00	9.664	23.163		
5/09/1995	15:20:00	9.639	16.389	33.1	0.495
3/06/1998	11:47:30	9.63	13.658	34.825	0.392
8/10/2015	12:52:00	9.63	17.202		
15/12/2021	12:40:00	9.63	19.521	35.11	0.556
20/10/2016	12:01:00	9.61	16.524		
11/12/2020	12:40:00	9.584	19.354	32.16	0.602
1/12/1987	14:15:00	9.582	8.759	28.436	0.308
10/09/2019	14:00:00	9.565	20.908	35.8	0.584
11/09/1989	14:02:00	9.564	15.577	30.99	0.503
5/11/1991	12:24:00	9.561	12.281	30.031	0.409
2/12/1999	13:22:30	9.557	13.754	32.65	0.421
28/10/2008	9:00:00	9.544	18.364	33.209	0.553
26/11/2003	10:57:30	9.543	14.867	31.036	0.479
2/08/2000	16:08:00	9.538	14.494	31.79	0.456
4/09/2001	10:15:00	9.532	13.631	31.731	0.43
13/06/1990	13:42:00	9.526	14.784	34.814	0.425
6/12/1993	13:09:00	9.501	10.262	30.146	0.34
16/05/2023	10:51:00	9.5	19.15951		
5/01/1988	10:20:00	9.494	9.558	32.749	0.292
15/03/1988	14:26:00	9.491	7.919	26.522	0.299
20/12/1995	13:00:00	9.48	12.751	30.55	0.417
22/11/1994	12:47:00	9.461	15.644	30.07	0.52
15/06/1999	13:45:00	9.461	11.163	31.817	0.351
16/06/1986	14:46:00	9.452	9.875	27.2	0.363
6/09/2012	15:16:00	9.449	17.3		
15/11/1995	13:30:00	9.438	14.603	29.873	0.489
25/08/1998	15:07:30	9.434	16.775	31.441	0.534
10/01/1994	11:43:00	9.433	7.439	28.725	0.259
6/11/1989	13:40:00	9.429	14.396	28.851	0.499
21/12/2011	12:25:00	9.42	18.495	33.716	0.549
23/01/1986	13:46:00	9.418	17.666	41.141	0.429
7/10/1987	10:15:00	9.416	9.917	27.251	0.364

19/07/1993	13:59:00	9.41	10.643	28.341	0.376	
14/09/1994	14:22:00	9.409	12.657	29.855	0.424	
28/09/2022	10:22:00	9.395	19.09062			
4/11/1987	9:47:00	9.387	8.677	25.601	0.339	
23/12/1986	11:47:00	9.383	4.084	23.785	0.172	
19/12/2005	14:30:00	9.382	17.022	30.562	0.557	
23/07/2014	15:03:00	9.38	15.279			
29/04/1987	15:52:00	9.369	10.389	26.136	0.397	
19/10/1992	11:02:00	9.369	10.734	26.453	0.406	
27/07/2018	12:40:00	9.357	19.088			
16/05/1990	12:16:00	9.355	12.222	33.066	0.37	
1/11/1993	12:53:00	9.339	9.741	26.71	0.365	
9/11/1988	9:53:00	9.337	12.925	26.26	0.492	2.41
24/11/1992	11:16:00	9.322	9.909	25.875	0.383	
25/03/1992	15:00:00	9.304	6.491	24.843	0.261	
24/02/2009	10:00:00	9.297	12.658	29.411	0.43	
14/01/1992	9:20:00	9.294	5.744	24.855	0.231	
6/04/1993	11:37:00	9.267	8.116	25.178	0.322	
30/06/2006	12:47:30	9.265	14.933	31.242	0.478	
27/02/1996	14:00:00	9.258	9.179	26.825	0.342	
23/07/2003	12:32:30	9.24	10.552	30.235	0.349	
5/12/1990	8:48:00	9.234	11.207	26.136	0.429	
2/07/2001	13:25:00	9.223	9.1141	28.689	0.318	
20/05/2011	12:52:30	9.222	11.308	27.706	0.408	
27/06/2005	15:12:30	9.214	12.162	28.444	0.428	
27/10/2005	9:22:30	9.21	15.956	27.783	0.574	
25/06/2007	11:52:30	9.207	11.756	27.551	0.427	
1/03/2001	12:05:00	9.202	8.0395	27.871	0.288	
8/10/1986	9:12:00	9.201	9.289	20.749	0.448	
1/04/1987	14:11:00	9.195	8.234999	20.557	0.401	
2/10/1985	11:57:00	9.193	6.246	20.764	0.301	
12/08/2011	12:30:00	9.187	15.94	30.141	0.529	
28/09/1993	12:50:00	9.186	8.868	25.1	0.353	
6/10/1999	13:54:00	9.186	9.78	25.834	0.379	
24/06/1997	14:27:00	9.184	8.991	26.358	0.341	
1/09/1987	10:04:00	9.179	7.15	21.302	0.336	
28/11/1996	13:47:00	9.172	12.606	26.693	0.472	
3/11/2021	13:03:00	9.153	15.41	2.71	5.686	
12/04/1990	10:50:00	9.147	9.454	23.207	0.407	
16/04/2015	14:10:00	9.144	7.597			
30/11/1989	13:46:00	9.139	8.702	18.82	0.462	
22/05/2006	13:10:00	9.138	10.796	25.939	0.416	
21/07/1987	10:03:00	9.119	8.938	22.163	0.403	
19/12/1997	13:52:30	9.115	7.9274	24.988	0.317	
31/05/2022	14:56:00	9.104	12.37106			
6/05/1994	12:51:00	9.099	7.125	23.139	0.308	
16/06/2016	13:38:00	9.099	9.194			
16/05/1995	14:50:00	9.097	7.715	25.7	0.3	

Area Mean Velocity Max Depth

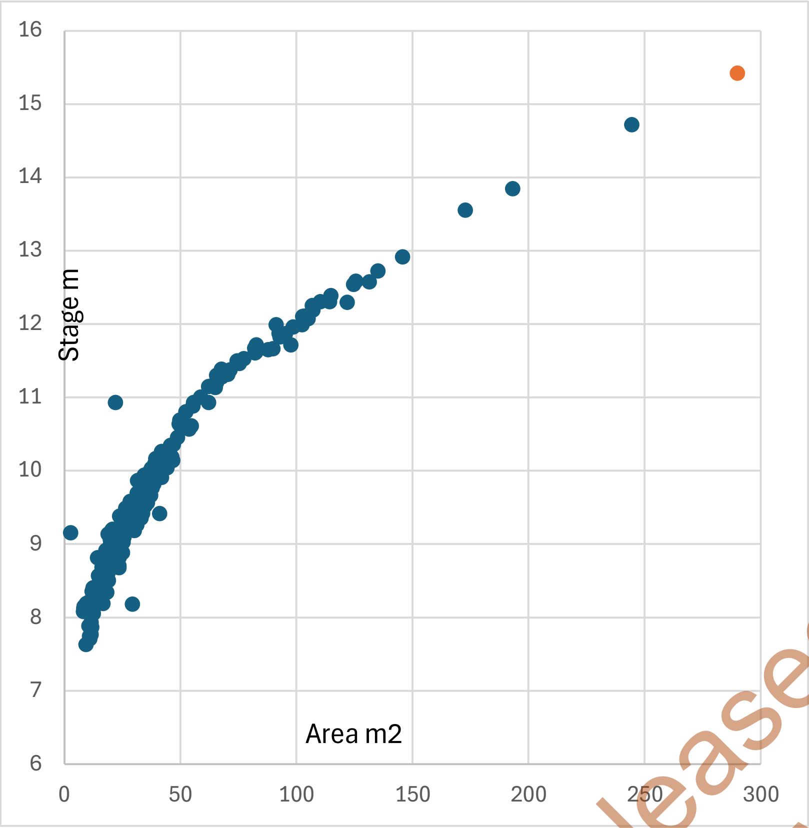
9/10/2014	12:47:00	9.091	12.868		
3/06/1992	11:22:00	9.085	5.183	23.033	0.225
11/12/1991	12:32:00	9.08	7.164	21.747	0.329
2/09/2014	15:33:00	9.074	12.3635		
10/02/1986	8:48:00	9.057	5.552	19.808	0.28
19/12/1988	12:22:00	9.051	9.497	21.654	0.439
8/10/1998	13:17:30	9.035	11.008	24.194	0.455
30/04/1998	15:15:00	9.03	7.0761	25.314	0.28
23/01/1996	14:05:00	9.029	7.541	23.19	0.325
6/08/1997	16:02:00	9.026	8.871	23.219	0.382
15/08/1989	13:05:00	9.021	9.229	21.271	0.434
4/10/1990	11:14:00	9.006	9.46	22.281	0.425
11/05/2009	13:15:00	8.996	10.499	24.703	0.425
8/01/1990	14:25:00	8.992	7.709	21.046	0.366
30/04/1992	14:12:00	8.99	4.88	19.804	0.246
1/12/2016	12:04:00	8.985	12		
10/05/1993	12:41:00	8.957	5.022	20.351	0.247
17/03/1998	10:40:00	8.929	6.1309	23.202	0.264
25/05/2000	13:10:00	8.927	6.2911	21.912	0.287
6/12/1989	14:07:00	8.921	7.79	19.217	0.405
21/05/1991	13:10:00	8.92	5.115	19.358	0.264
11/02/1988	13:42:00	8.913	3.812	17.849	0.214
26/10/2007	11:07:30	8.91	9.344	22.039	0.424
4/04/1986	12:22:00	8.904	3.825	18.314	0.209
28/01/1998	14:32:30	8.899	4.7559	20.867	0.228
21/09/2004	11:55:00	8.894	12.193	22.389	0.545
19/03/1991	12:45:00	8.889	5.445	20.58	0.265
23/02/2017	12:15:00	8.889	10.4		
11/06/2024	14:16:00	8.883	13.4	25.11	0.534
15/02/1994	12:24:00	8.874	3.437	18.165	0.189
28/01/1993	10:53:00	8.872	5.799	18.914	0.307
14/12/2015	13:10:00	8.859	9.673		
9/10/2001	14:27:30	8.857	6.5081	20.758	0.314
15/01/2004	8:45:00	8.851	11.551		
16/07/2010	12:00:00	8.831	9.6495	21.089	0.458
22/05/1989	9:47:00	8.822	5.954	17.674	0.337
5/02/1990	14:35:00	8.821	4.834	18.674	0.259
6/12/2018	11:30:00	8.821	13.36	23.7	0.564
27/11/2014	13:13:00	8.817	8.21583		
1/11/2012	12:16:00	8.814	11.6		
13/02/1987	12:15:00	8.812	3.787	14.345	0.264
16/04/1991	9:31:00	8.812	4.654	18.337	0.254
30/08/2005	10:42:30	8.8	9.6728	21.018	0.46
12/12/2000	13:50:00	8.797	7.1014	20.18	0.352
22/04/1999	15:20:00	8.769	5.2808	21.067	0.251
1/03/1993	11:22:00	8.764	4.226	18.627	0.227
9/06/2005	13:52:30	8.764	10.273		
26/11/1998	13:47:30	8.76	8.4074	19.763	0.425

14/12/2012	16:47:00	8.735	11.438			
28/03/1989	15:20:00	8.732	5.474	16.552	0.331	
28/03/1994	12:01:00	8.725	3.875	17.019	0.228	2
18/10/2023	8:23:00	8.718	11.96618			
28/02/1995	13:47:00	8.709	4.253	17.155	0.248	
1/08/2019	13:15:00	8.704	11.883	23.5	0.506	
11/03/2002	12:42:30	8.69	4.831			
26/04/1989	13:05:00	8.685	4.405	16.303	0.27	
29/10/2019	14:15:00	8.677	11.771	23.5	0.501	
19/05/1997	15:12:00	8.669	4.067	17.506	0.232	
23/01/1991	8:37:00	8.664	4.096	16.908	0.242	
9/06/2014	13:50:38	8.659	7.1956			
19/04/2002	10:17:30	8.654	4.299			
27/03/2002	11:20:00	8.652	4.312			
18/11/2020	13:55:00	8.649	10.86225			
19/11/2015	13:43:00	8.63	7.938			
20/05/2003	10:10:00	8.611	4.943			
13/08/2020	14:20:00	8.608	9.69	18.86	0.514	
15/04/2016	15:17:00	8.593	5.523			
20/12/1994	14:07:00	8.592	6.079	17.13	0.355	
23/03/2000	14:16:30	8.568	3.0166	14.727	0.205	
31/03/1999	11:15:00	8.563	3.457	15.62	0.221	
3/04/1997	14:57:00	8.562	4.113999	17.392	0.237	
2/11/2006	11:07:30	8.56	7.9546	18.358	0.433	
14/02/1997	12:00:00	8.528	4.462	15.217	0.293	
5/02/2003	8:07:30	8.52	3.691			
21/01/2005	9:00:00	8.516	8.888			
26/09/2006	12:50:00	8.513	6.2504	17.094	0.366	
28/04/2014	14:21:12	8.512	5.98575			
14/05/2019	13:40:00	8.502	9.12	19	0.48	
15/04/2011	12:32:30	8.498	5.7977	16.849	0.344	
26/02/2010	11:00:00	8.496	5.5611	17.144	0.324	
5/01/2017	11:52:00	8.478	7.153			
28/09/2011	13:22:30	8.476	8.0332	17.469	0.46	
23/11/2005	12:57:30	8.473	8.544			
13/12/2006	10:12:30	8.472	6.8993	15.571	0.443	
23/12/2009	11:45:00	8.46	7.17	16.761	0.428	
2/11/2017	13:07:00	8.442	9.465			
25/03/2003	8:07:30	8.439	3.39			
23/12/2008	8:22:30	8.428	7.0098	16.167	0.434	
26/01/1995	9:15:00	8.426	3.734	14.613	0.256	
10/08/2023	12:16:00	8.422	9.62226			
15/11/2011	11:50:00	8.421	7.2525	17.343	0.418	
31/03/2009	9:12:30	8.404	4.1	12.32	0.333	
13/12/2004	13:07:30	8.393	8.203			
14/01/1999	13:12:30	8.39	3.4822	14.1	0.247	
23/02/1999	13:15:00	8.37	2.9929	14.326	0.209	
12/12/2007	12:55:00	8.355	3.7201	12.026	0.309	

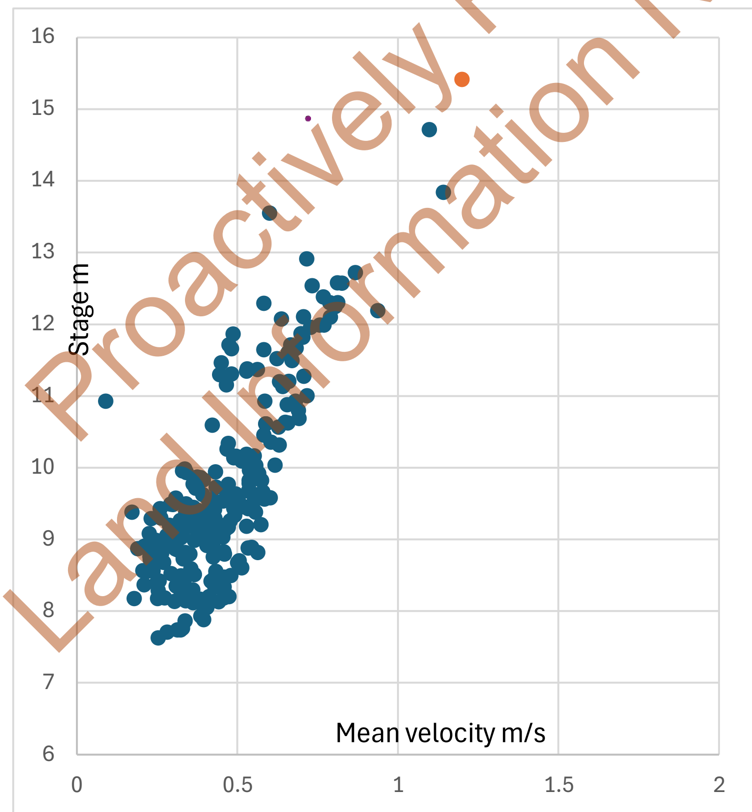
23/12/2019	10:45:00	8.341	8.395	18.3	0.459
26/02/2016	12:28:30	8.34	4.224		
24/02/2011	9:44:30	8.339	5.901	13.732	0.43
26/05/2020	13:40:00	8.336	7.332	16	0.458
24/03/2015	7:35:00	8.335	2.9405		
28/01/2015	13:56:00	8.32	3.433		
23/04/2018	13:10:00	8.308	8.255		
27/02/2006	10:55:00	8.299	4.8462	13.437	0.361
1/03/2018	12:30:00	8.293	7.856		
27/04/2007	11:40:00	8.289	3.3131	13.083	0.253
23/12/2013	13:47:00	8.287	6.4335		
26/02/2015	13:21:00	8.285	2.717		
11/01/2024	8:48:00	8.284	8.35624		
4/04/2023	9:23:00	8.236	7.39848		
7/02/2005	13:47:30	8.231	6.254		
20/04/2004	14:22:30	8.221	5.474		
27/02/2007	10:50:00	8.215	4.348	13.411	0.324
5/12/2005	10:57:30	8.206	4.9745	10.49	0.474
18/02/2005	10:30:00	8.205	5.339		
18/02/2005	10:05:00	8.204	4.909	11.91	0.412
5/12/2005	12:57:30	8.196	6.131		
11/03/2008	10:57:30	8.19	2.583	9.459	0.273
14/01/2019	12:15:00	8.19	7.607	16.6	0.458
29/02/2008	10:30:00	8.186	2.635		
25/03/2008	13:52:30	8.181	2.5461	10.163	0.251
20/04/2012	15:48:00	8.181	5.24	29.3	0.179
4/04/2005	14:17:30	8.169	3.7952	9.874	0.384
17/01/2008	14:42:30	8.168	3.617		
11/02/2005	12:42:30	8.166	5.428		
20/04/2010	11:05:00	8.149	3.37	8.5	0.396
20/04/2010	11:42:30	8.149	3.1993	9.426	0.339
5/02/2008	11:17:30	8.137	2.6859	8.84	0.304
23/11/2010	11:40:00	8.136	4.9551	11.211	0.442
20/04/2005	9:17:30	8.125	3.3496	8.375	0.4
11/01/2011	10:55:00	8.123	3.7537	10.356	0.362
20/04/2005	10:22:30	8.115	3.56		
17/03/2005	10:00:00	8.079	3.2583	8.264	0.394
17/03/2005	12:17:30	8.075	4.17		
27/05/2021	13:45:00	8.055	5.051	12.46	0.405
11/02/2014	13:13:00	8.05	3.8765		
7/12/2017	11:40:00	8.036	5.404		
24/10/2018	11:50:00	8.028	6.038		
25/03/2014	12:26:34	8.008	2.91371		
8/02/2013	15:00:00	7.978	4.925		
16/01/2018	12:05:00	7.956	4.8		
18/03/2024	15:52:00	7.946	5.67253		
23/04/2021	12:30:00	7.932	4.48	11.6	0.386
21/03/2013	13:30:30	7.914	4.0284		

10/02/2022	12:40:00	7.895	4.35306		
18/06/2020	11:20:00	7.883	4.191	10.6	0.395
12/02/2021	12:05:00	7.865	3.981	11.8	0.337
27/02/2013	13:30:00	7.788	2.9755		
15/03/2013	12:35:00	7.767	2.7865		
15/04/2019	12:40:00	7.765	3.818	11.6	0.329
21/01/2020	13:00:00	7.744	3.411	10.9	0.313
12/03/2019	14:25:00	7.741	3.62	11.2	0.323
25/02/2021	13:25:00	7.709	3.078	10.94	0.281
1/04/2022	12:42:00	7.705	3.06389		
3/03/2020	14:05:00	7.63	2.38	9.4	0.253
9/12/1959	10:07:00	0	4.786	48.804	0.098
19/02/1964	14:30:00	0	5.295	26.756	0.198
31/10/1967	10:00:00	0	5.295	34.852	0.152
5/03/1968	17:15:00	0	2.718	20.35	0.134
14/11/1969	11:30:00	0	4.417	27.499	0.161
10/02/1970	17:10:00	0	3.002	20.834	0.144
14/02/1973	10:45:00	0	4.044	23.325	0.173
21/01/1977	12:00:00	0	5.436	72.521	0.075
1/02/1979	14:40:00	0	3.204	19.22	0.167
14/02/1979	11:37:00	0	8.076999	38.08	0.212
14/12/1982	13:55:00	0	12.969	52.74	0.246
6/03/1983	14:30:00	0	8.04	44.799	0.179
13/12/1983	9:30:00	0	8.99	30.876	0.291
20/12/1983	7:45:00	0	7.734	28.684	0.27
10/01/1984	8:15:00	0	4.48	22.034	0.203
20/01/1984	8:00:00	0	20.95999	57.794	0.363
1/02/1984	8:00:00	0	5.432	26.419	0.206
15/03/1984	14:30:00	0	12.155	37.806	0.322
27/11/1984	12:07:00	0	7.598	28.652	0.265
14/12/1984	12:41:00	0	11.025	39.353	0.28
16/01/1985	13:02:00	0	5.889	25.487	0.231

Area Mean Velocity Max Depth

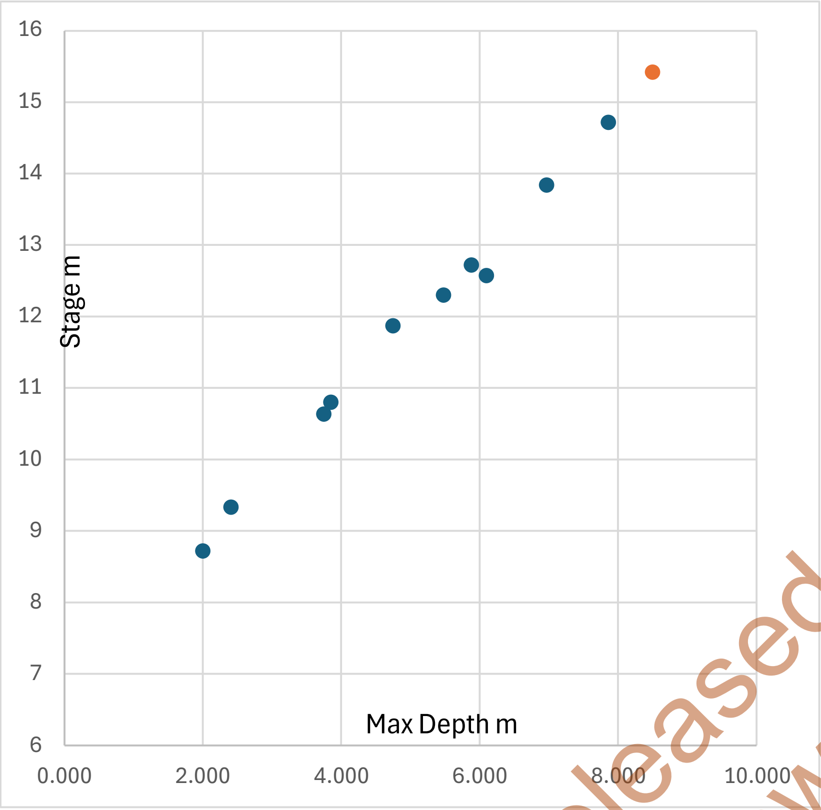


Estimated Maximum 15.421 290 m2



Estimated Maximum 15.421 1.2 m/s

Area Mean Velocity Max Depth



Estimated Maximum	15.421	8.5	m

ygoh@ftl.co.nz

From:	sfinnigan@ftl.co.nz
Sent:	Monday, 23 September 2024 10:11 am
To:	ygoh@ftl.co.nz
Subject:	FW: Puniu River flooding
Attachments:	Puniu at Bartons Cnr Annual Maximum 1985 to 2023.xlsx
Flag Status:	Flagged

Regards | Ngā mihi

Sean Finnigan - Director, Environmental Engineering

Fraser Thomas

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Christchurch | Hawkes Bay | Tauranga | Nelson | Blenheim

From: Doug Stewart <Doug.Stewart@waikatoregion.govt.nz>
Sent: Monday, 23 September 2024 8:37 am
To: sfinnigan@ftl.co.nz; Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Cc: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Subject: RE: Puniu River flooding

Hi Sean,
Attached file has Maximum Levels and Flows for Puniu at Bartons Cnr Rd (Pokuru Bridge)

"the gauge may not be that accurate"
The present water level sensor is a VegaPuls 61 Radar with and accuracy of =/- 2 mm
Previous to (16/8/2006 to 20/09/2023) that there was a VegaPuls 62 radar with an accuracy of +/- 3 mm

I have added a couple of old photos below in case they help. Flood gauging done 10/7/98 at 1047 13.845 metres

Date/Time	S [m]	Q [m^3/s]
16/10/1989 09:05:00	14.720	268.550
10/07/1998 10:47:30	13.845	220.530
01/03/2004 11:32:30	13.553	103.700

Maybe the levels haven't reached your edge of floodplain during the period of record????

Cheers, Doug

Doug Stewart | SENIOR ENVIRONMENTAL MONITORING SCIENTIST - HYDROLOGY | Hydrology and Air, Science, Policy and Information
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F: facebook.com/waikatoregion
Private Bag 3038, Waikato Mail Centre, Hamilton, 3240

From: sfinnigan@ftl.co.nz <sfinnigan@ftl.co.nz>
Sent: Saturday, 21 September 2024 13:43

To: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Cc: Doug Stewart <Doug.Stewart@waikatoregion.govt.nz>
Subject: RE: Puniu River flooding

Thanks Lauren

Just one more question and this may be for Doug. What is the maximum flow value and level the gauge goes up to at the Pokura Rd gauge? Just aware that sometimes in severe floods, the gauge may not be that accurate.

We tried to do a check on flood levels below by checking ground levels along edge of floodplain but results are quite variable (~33-35.9m) + higher than gauge depth (15.42 flood level + 13.22m adder is 28.64m) and don't really make sense.

Regards | Ngā mihi

Sean Finnigan - Director, Environmental Engineering

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From: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Sent: Friday, 20 September 2024 10:35 am
To: sfinnigan@ftl.co.nz
Cc: Doug Stewart <Doug.Stewart@waikatoregion.govt.nz>
Subject: RE: Puniu River flooding

Hi Sean,

The level data below is an elevation. The levels at this station are recorded to an assumed datum (i.e. not a recognised datum). It has been surveyed into NZVD2016 recently and a provisional add of 13.216 metres will be applied to the site when the changeover is made (sometime next summer at this stage).

I have CC'd Doug into this email who can answer any further questions you might have about the data.

Kind regards,
Lauren

Lauren Empson | REGIONAL RESILIENCE ASSISTANT | Regional Resilience, Integrated Catchment Management
WAIKATO REGIONAL COUNCIL | Te Kaunihera ā Rohe o Waikato
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Private Bag 3038, Waikato Mail Centre, Hamilton, 3240

From: sfinnigan@ftl.co.nz <sfinnigan@ftl.co.nz>
Sent: Monday, 16 September 2024 5:33 pm
To: Lauren Empson <Lauren.Empson@waikatoregion.govt.nz>
Cc: ygoh@ftl.co.nz
Subject: Puniu River flooding

Hi Lauren

Just checking with the level data below, is this an actual depth relative to bottom of stream or an elevation. If an elevation, do you know what datum this is in?

Puniu at Bartons Cnr Rd				
Maximum Recorded Level	15.421	m	16/10/1989	
Maximum Recorded Flow	322.2	m3/s	16/10/1989	
Estimated Mean Velocity at Peak	1.2	m/s		
Estimated Maximum Depth at peak	8.5	m		

Regards | Ngā mihi

Sean Finnigan - Director, Environmental Engineering

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Appendix D

Site Inspection Photos

2022 Walkover

Culvert 1 Inlet – showing signs of bank slumping/ subsidence

Culvert 1, looking along Te Mawhai Rd

Culvert 1 Outlet – note extensive debris/windfall

Culvert 1 Outlet, looking further downstream

Oct 2024 Walkover

Wastewater Pump Station (WWPS)

Culvert 1 Inlet Facing WWPS (South)

Culvert 1 Inlet

Culvert 1 Outlet

Culvert 1 Outlet

Farm Track @ Culvert 3

Culvert 3 Outlet

Culvert 3 Outlet

Unidentified feature at western bank - Culvert 3 Outlet

Post Flood - Pūniu River Care Water Take
(photo provided by them)

17/10/24 - Pūniu River Care Water Take

Wharekōrino @ Pūniu River Care Water Take

Upstream of Pūniu River Water Take

Pūniu River