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Tararu flood protection scheme design report

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Disclaimer

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Table of Contents

Figures

Tables

Executive summary

Tararu is located on the west coast of the Coromandel Peninsula, one kilometre to the north of Thames on State Highway 25 (SH25). In response to the severe floods generated by the “Weather Bomb 2002”, Waikato Regional Council (WRC) established the Peninsula Project to address river and catchment issues across the Peninsula through soil conservation, river management, animal pest control and flood protection measures. Tararu was one of the communities identified as having a very high risk to life and property, requiring actions that address these risks.

Since the introduction of the Peninsula Project in 2004, WRC and Thames Coromandel District Council (TCDC), worked with the Tararu community to develop a flood mitigation strategy to address the Tararu Stream flood hazards. Works have been completed at Tararu to mitigate the flood hazard from Tararu Stream, the details of which are provided in this Design Report.

Tararu is located at the base of the Tararu Stream catchment on a coastal alluvial fan. The presence of parts of Tararu on the low-lying land adjacent to Tararu Stream means that these properties are subject to flood hazard from the stream. The Tararu Stream catchment is susceptible to short duration but high intensity rain events causing flash flooding and debris flow in the streams and surrounding land with little or no warning.

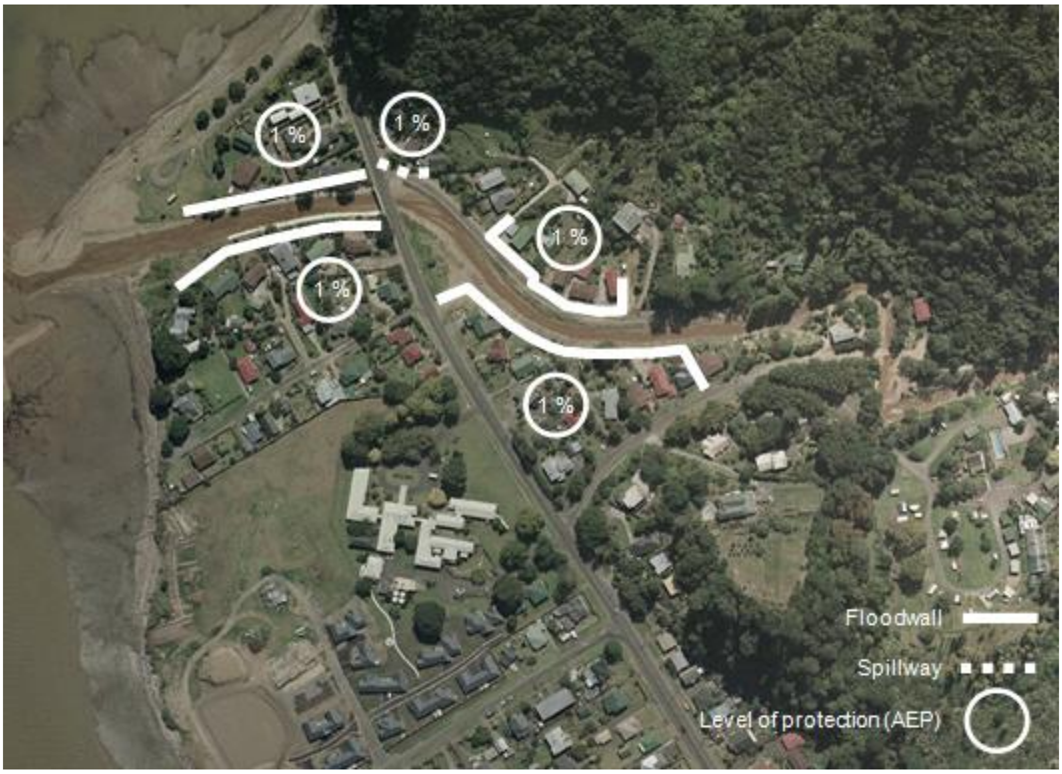
For the success of this project it was essential that the community was involved. A working party was established in the community to liaise with the various authorities, including WRC, as matters progressed. The working party met at regular intervals to scope the issues, discuss options and to work together to implement the project.

As a first step, the community agreed to WRC developing and undertaking an extensive channel maintenance program of the Tararu Stream to improve the condition of the channel and its capacity to convey flood flows. This work improved the stability and capacity of the Tararu Stream and reduced the risk to the Tararu community by containing flood events that would otherwise inundate adjacent land.

The initial technical investigation results demonstrated that while the channel maintenance discussed above would improve the channel capacity, it would not be adequate to prevent flooding. Hence, proposals to protect the Tararu community from flooding up to a design standard of the 1% Annual Exceedance Probability (AEP) event by way of engineering works were developed.

A catchment assessment was undertaken for the Tararu Stream catchment to inform the development of MIKE-21 and MIKE-11 hydraulic models which were then used to develop a proposed flood mitigation strategy for Tararu.

WRC worked with the community via the Tararu Working Group to develop the flood mitigation strategy for Tararu and then consulted with the community on what was proposed. The works were then implemented. Through the investigation work it was identified that the State Highway 25 (SH25) Bridge was under capacity and was contributing to flooding issues in the community. WRC approached the New Zealand Transport Agency and it was agreed that the SH25 Bridge would be upgraded.



Flood defences in the Tararu community

Catchment management and soil conservation works programmes have also been established in the Tararu Stream catchment to complement the flood mitigation works undertaken.

The main channel of the Tararu Stream is monitored and periodically maintained by WRC to remove accumulated sediment and debris. This work maintains the capacity of the stream and reduces the risk to adjacent land that would otherwise be inundated more frequently.

'Residual flood risk' is a term used to describe a river flood risk that exists due to the potential for 'greater than design' flood events to occur. Residual flood risk applies to the Tararu community from factors such as the greater than the design event, the impact of debris flow during a flood event and that the model excludes obstructions such as buildings and walls which may have localised effects.

Based on the flood hazard status of land in the community, TCDC has various planning controls in place via the Thames Coromandel District Plan, that restrict what land use activities can be undertaken. Refer to the Thames Coromandel District Plan and TCDC staff for details.

The flood mitigation scheme for the Tararu community should be reviewed in accordance with the Waihou Piako Zone Management Plan. In addition if there are any significant changes in land use in the community the scheme would need to be reviewed.

1 Introduction

1.1 Background

Tararu is located on the west coast of the Coromandel Peninsula, one kilometre north of Thames on State Highway 25 (SH25).

In response to the severe floods generated by the "Weather Bomb 2002", Waikato Regional Council (WRC) established the Peninsula Project to address river and catchment issues across the Peninsula through soil conservation, river management, animal pest control and flood protection measures. The Peninsula Project, an umbrella project for the Thames Coast Project was initiated in 2003 and adopted by Council in 2004, investigated all river and catchment issues within the whole Coromandel Peninsula area, identified general works programmes to address these and established the funding mechanisms that provide for these services to be implemented in a consistent and sustainable manner into the future.

Under the Peninsula Project, WRC and Thames Coromandel District Council (TCDC) worked together on flood mitigation plans for five Thames Coast communities. The work included risk assessments, technical investigations, development of risk mitigation options, development of a business case to central government for funding support and establishment of rating mechanisms. There was extensive community consultation on plans for these Thames Coast communities. Tararu was one of the communities identified as having a very high risk to life and property, requiring actions that address these risks.

The Tararu area is not covered by the Peninsula Project funding system as it was historically part of the Waihou Valley Scheme area and earlier channel improvement works were carried on the stream under this scheme. However, the flood hazard investigation and options investigation were updated and reconsidered as part of the Thames Coast investigations project.

Since the introduction of the Peninsula Project in 2004, WRC and TCDC worked with the Tararu community to develop a flood mitigation strategy to address the Tararu Stream flood hazard. A flood mitigation scheme has been constructed at Tararu, the details of which are provided in this Design Report.

1.2 Scope of report

The purpose of this Design Report is to provide a summary of the works that have been undertaken at Tararu to reduce the flood hazard from the Tararu Stream, including the rationale behind the scheme development, the agreed levels of service, the design details, as built information, the operation and maintenance requirements of the scheme, the residual flood risk and the scheme review requirements.

The Design Report includes the following sections:

- Catchment overview
- Hydrological assessment
- Hydraulic model development
- Flood protection scheme
- Agreed levels of service
- Operation and maintenance
- Flood hazard assessment

- Residual flood risk
- Planning controls, and
- Scheme review.

2 Catchment overview

2.1 Catchment description

Tararu is located on the west coast of the Coromandel Peninsula, one kilometre north of Thames on State Highway 25 (refer to Figure 1).

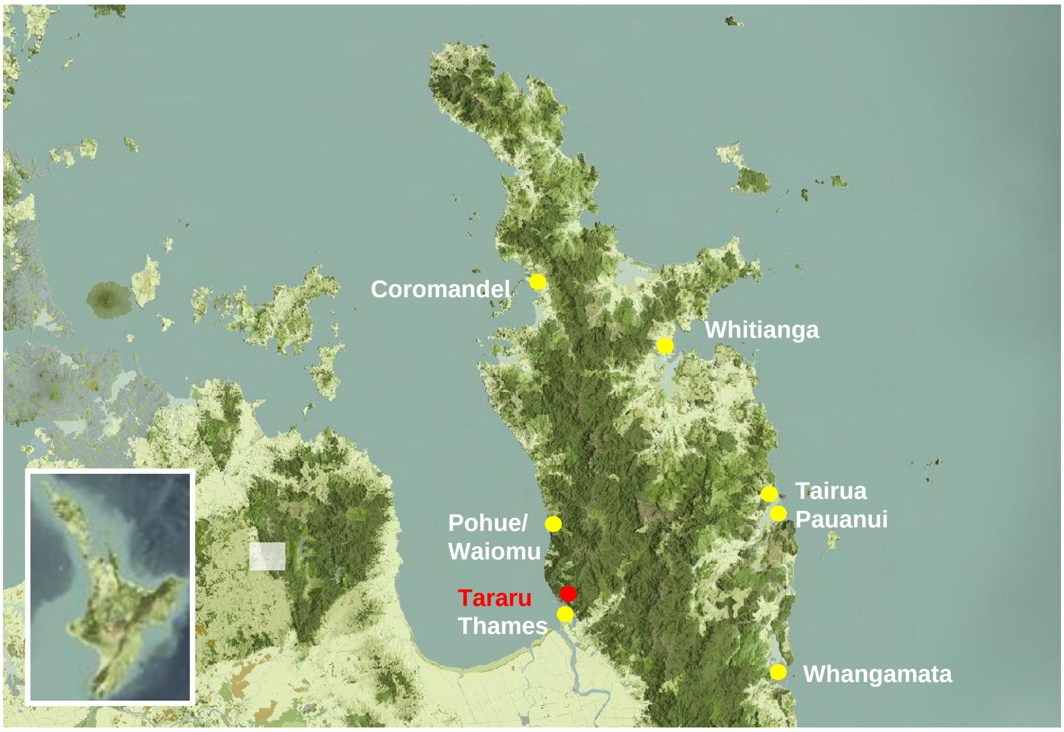


Figure 1 Thames-Coromandel District

The Tararu Stream has a 15.5 km^2 catchment that originates in the western Coromandel Ranges (refer to Figure 2). This catchment is relatively steep and covered in regenerating native vegetation and scrub. It is susceptible to short duration but high intensity rainfall events that cause flash flooding and debris flows in the Tararu Stream with little or no warning.

Figure 2 Tararu Stream catchment

2.2 Tararu Stream

2.2.1 General

The Tararu Stream flows out of the Coromandel Ranges and through the northern edge of the Tararu community before discharging to the Firth of Thames (refer to Figure 3).

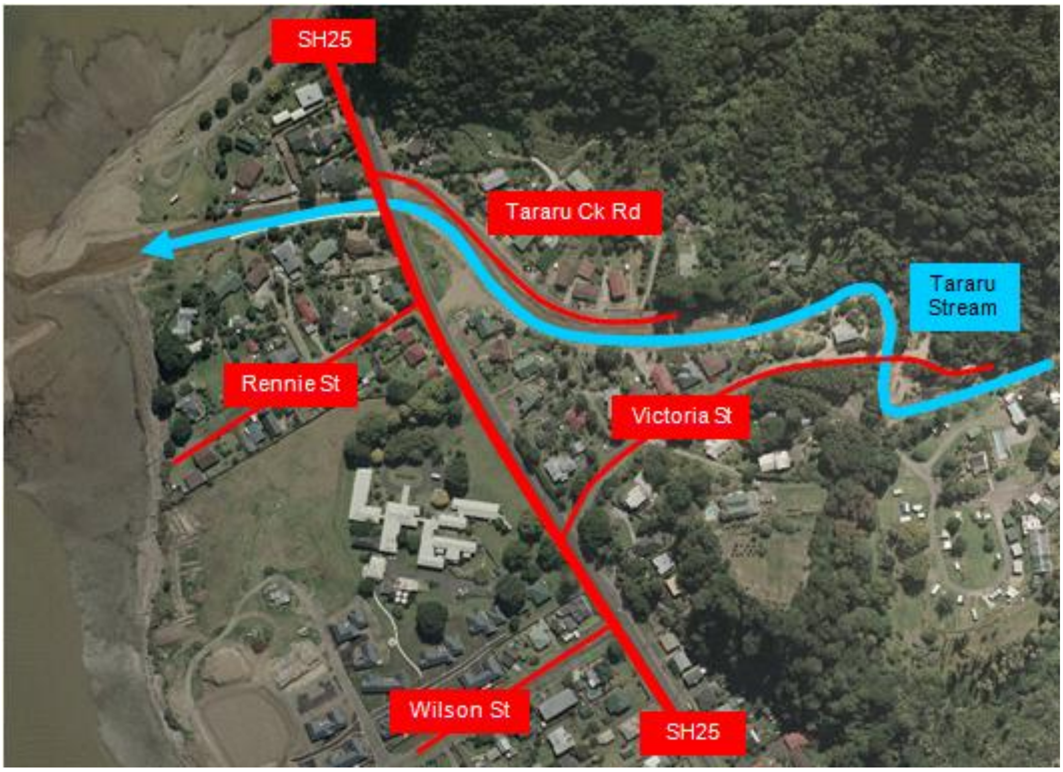


Figure 3 Northern Tararu community

Parts of the Tararu community are located on the floodplain and sediment/debris fan created by the Tararu Stream (refer to Figure 4 and Figure 5).

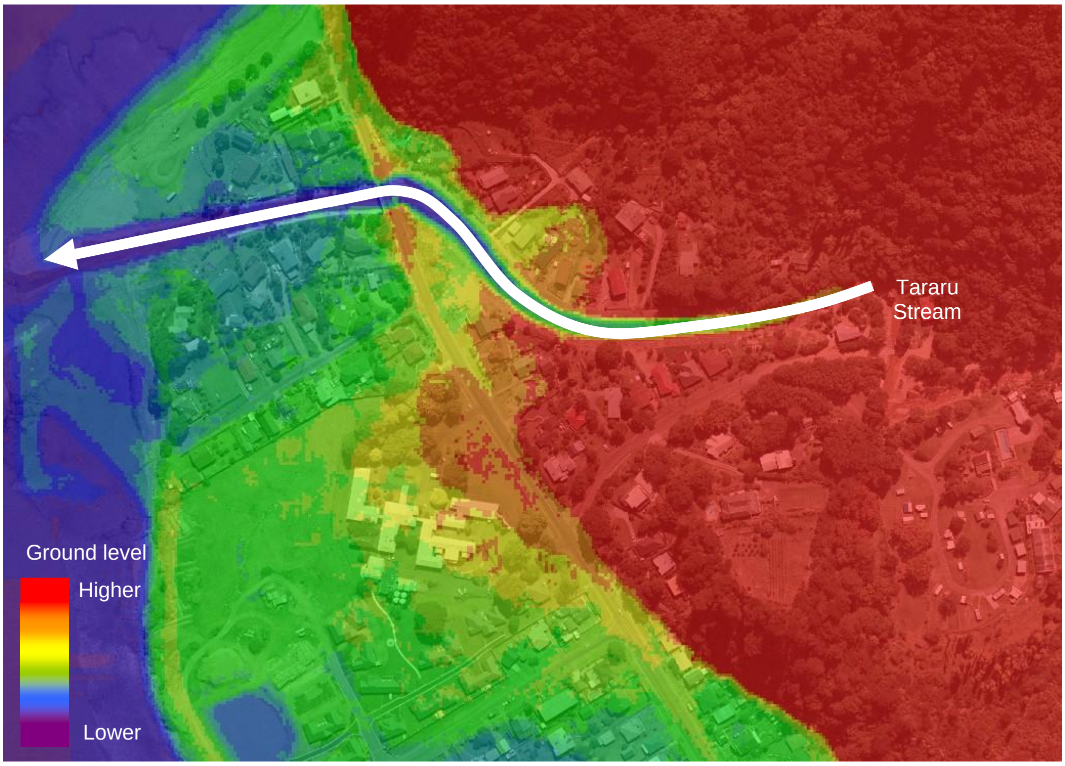


Figure 4 Ground level at Tararu

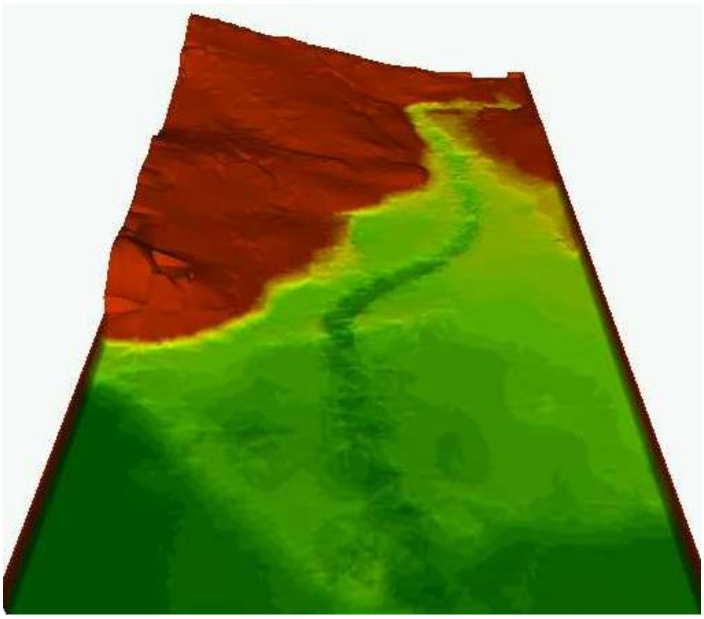


Figure 5 Tararu Stream coastal alluvial fan (looking inland from Firth of Thames)

2.2.2 Pre-scheme condition of Tararu Stream

Tararu Stream descends largely unaffected by human influence at a steep average gradient of 6% to its delta which starts approximately at Victoria Road Ford near the east end of the settlement. The rapid flattening of the grade at the delta is aggravated by the flow confining effect of buildings, the SH25 embankment and SH25 Bridge, leading to overtopping of the banks, deposition of material and stream aggradations downstream.

The bed material consists of gravel and cobbles of various sizes, though an accurate sediment size analysis is not available.

Earlier work under the Waihou Valley Scheme aimed at increasing the channel capacity and stabilizing the stream banks. These works included widening the stream channel and bank protection using rock and concrete (fabriform). However, extensive bank erosion was still occurring pre full flood protection scheme.

The SH25 Bridge, by its pre-upgrade width and orientation, constituted a major flow restriction. Overland flow and local flooding during major flood events occurred downstream of the ford as well as around both approaches to the SH25 Bridge. The orientation of the longitudinal face of the right hand abutment was hydraulically unfavourable as it acted as a reflector and caused significant turbulence, resulting in the bank upstream of the abutment showing signs of advanced scour.

A full annual stream maintenance programme was established under the Waihou Valley Scheme. The works include removal of gravel and sediment depositing in the channel and rock protection maintenance as discussed in Section 7.

2.3 Flooding issues

The Tararu community is located at the base of the Tararu Stream catchment on a coastal alluvial fan. The community consists of mainly residential development on both banks of the Tararu Stream. SH25 runs through the Tararu community and crosses the Tararu Stream using a dual lane single span bridge.

The presence of parts of the Tararu community on low-lying land adjacent to Tararu Stream means that these properties are subject to flood hazard from the stream. The Tararu Stream catchment is susceptible to short duration but high intensity rain events causing flash flooding and debris flow in the stream and surrounding land with little or no warning.

During significant flood events, overland flow occurs just downstream of the Victoria Road ford and around both approaches to the SH25 Bridge, as illustrated in the schematic below.

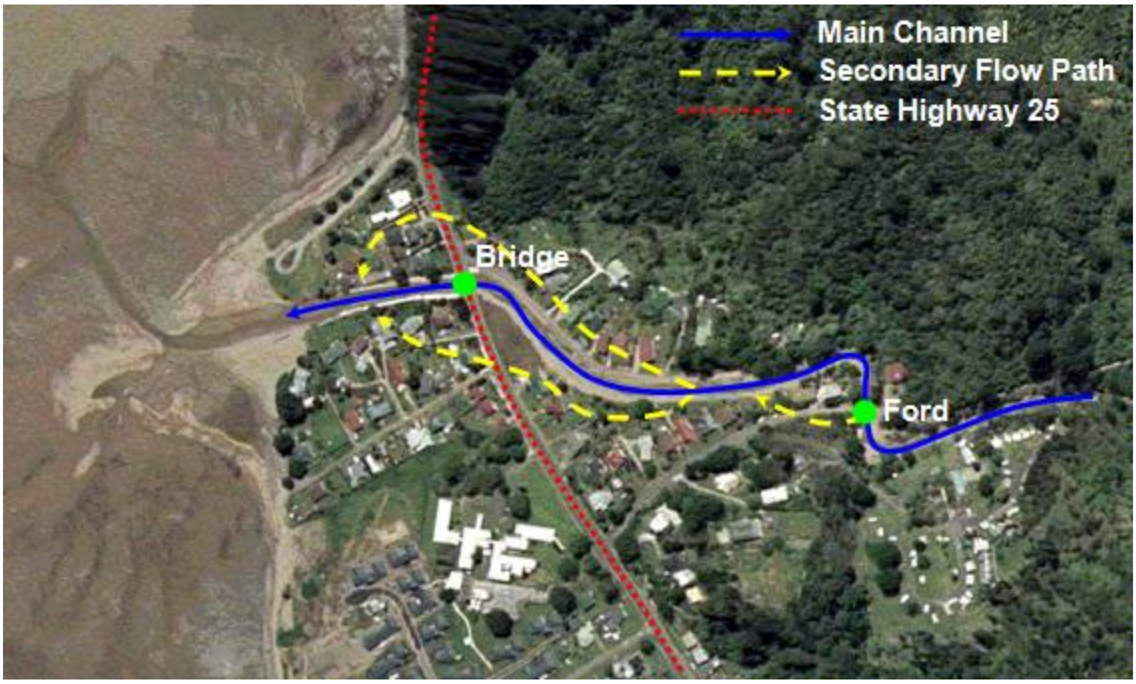


Figure 6 Predominant flooding mechanism at Tararu

Figure 7 below illustrates the predicted flood extents (pre-flood protection scheme) at Tararu for the 1% AEP event with an allowance for predicted climate change.

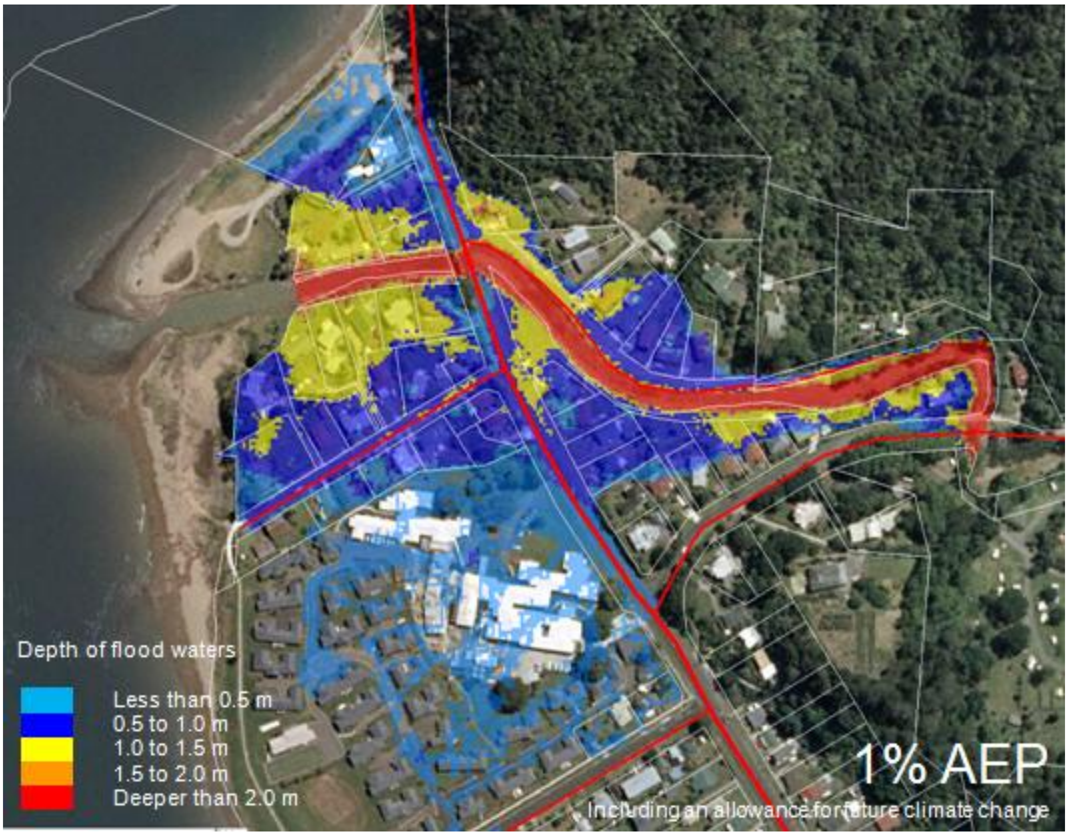


Figure 7 Predicted flood extents for 1% AEP (100 year ARI) event (with climate change)

The significance of the flood hazard to the Tararu community was demonstrated during the storm event that occurred on June 21, 2002 (also referred to as the 'Weather Bomb'). This event brought torrential rainfall to the Coromandel Peninsula (with unconfirmed intensities of up to 125 mm in 25 minutes) and caused widespread damage across the Thames-Coromandel and South Waikato Districts (Munro, 2002). Tararu suffered significant damage during this event.

Damage to properties within the Tararu community was focused on those properties immediately adjacent to the Tararu Stream and those that are within the secondary flow paths. An extensive fact finding exercise and meetings with the residents of the Tararu community determined that during the 'Weather Bomb' property damage occurred to approximately 10 houses, 28 basements and 5 non-developed sections. The figure below illustrates the property damage within the Tararu community following the 'Weather Bomb'.

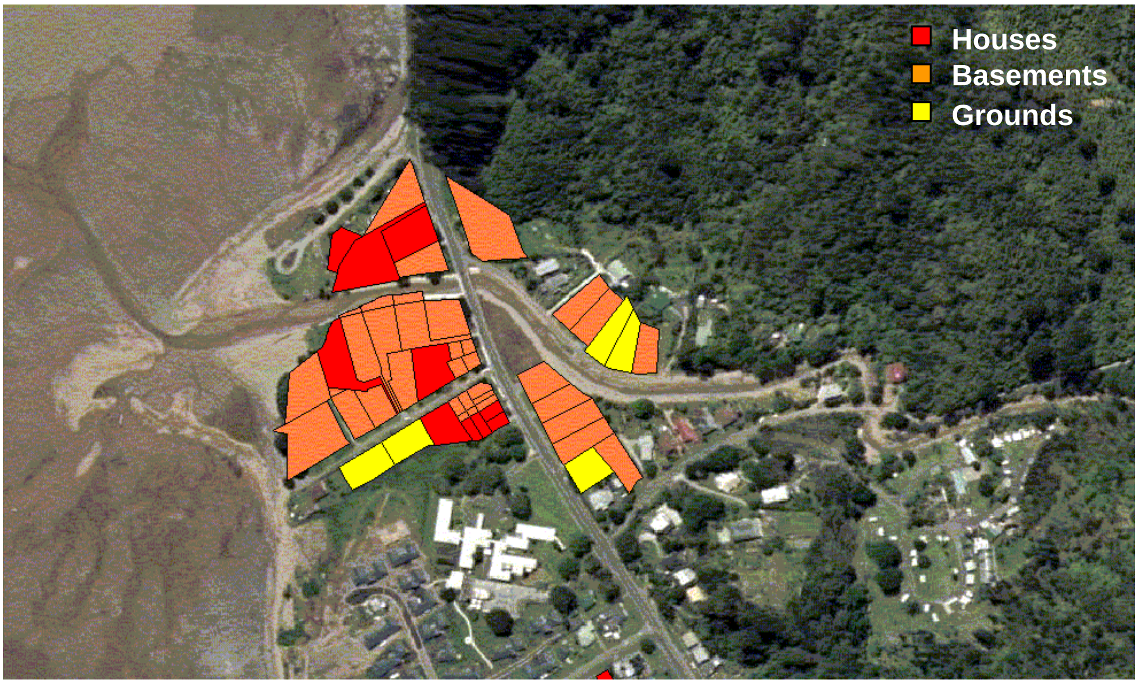


Figure 8 Property damage within the Tararu community during the 'Weather Bomb'

Following the 'Weather Bomb', WRC and TCDC initiated the Thames Coast Project to better understand the river flooding issues that affect the communities on the Thames Coast. This project also involved the identification of works to mitigate the impact of river flooding on people and property along the Thames Coast.

The Thames Coast Project focused on the five most vulnerable communities that were identified as being worst affected by both the weather bomb and historical flood events, which included Tararu.

Risk assessment based on the extent of flooding including depth and velocity of floods was undertaken by URS Consultants for Tararu. The assessment revealed that the risk to life arising from flooding within the area is higher than internationally acceptable standards. This required both WRC and TCDC to investigate and implement appropriate measures to reduce the risks.

3 Hydrological assessment

3.1 Technical information

During the development of the Thames Coast Project, WRC collected a significant amount of technical information covering the Tararu Stream catchment. This information is presented in WRC's Technical Report 2004/13 (Ryan GJ, 2004) and includes:

- Historical research
- Catchment hydrology
- Lower channel hydraulics (1 dimensional)
- Floodplain hydraulics (2 dimensional)
- Flood hazard analysis (including extent and severity).

Some of the key data sources and findings that have informed technical investigations are summarised below.

Table 1 Summary of technical reports covering flood events on the Thames Coast

Flood event	Technical reports
April 1981	HCB Report 109 and 123 (Sep 1981 and June 1982)
February 1985	HCB Report 190 (October 1985)
Cyclone Bola	No technical reports located
Cyclone Drena	No technical reports located
January 2002	No technical reports located
June 2002	EW Report 2002/10 (July 2002)

Table 2 Technical Reports covering flood mitigation and management at Tararu

Community	Previously completed technical investigations
Tararu	Channel improvements - HCB Report 130 (Nov 1982) Channel improvements - HCB Report 179 (May 1985) Flood hazard mgmt - EW Report 1995/4 (Aug 1995)

Table 3 Summary of completed flood mitigation works at Tararu

Community	Previously completed works
Tararu	Channel improvement works were completed during the 1980's by the HCB as part of the Waihou Valley Scheme. These works included widening the channel and installing erosion protection works (concrete fabriform and rock rip rap). These works are currently maintained by EW as part of the Waihou Valley Scheme.

Longsection information for Tararu Stream (pre-scheme) has been detailed in a WRC document number WRC DM# 912061. This longsection includes the following information:

- Bed level
- Top-of-bank level
- Design flood level for a variety of flood events
- Levels associated with proposed works (e.g. floodwalls)

The existing channel performance prior to the scheme works being implemented was assessed to be the following for Tararu:

- Upstream of the SH25 Bridge 20% AEP (5 year ARI) event
- Downstream of the SH25 Bridge 50% AEP (2 year ARI) event

3.2 Catchment characteristics

The Tararu Stream catchment is located on the steep western slopes of the Coromandel Ranges. The catchment is relatively steep and has elements of bush, and urban cover. The catchment area and characteristics for the Tararu Stream are described below.

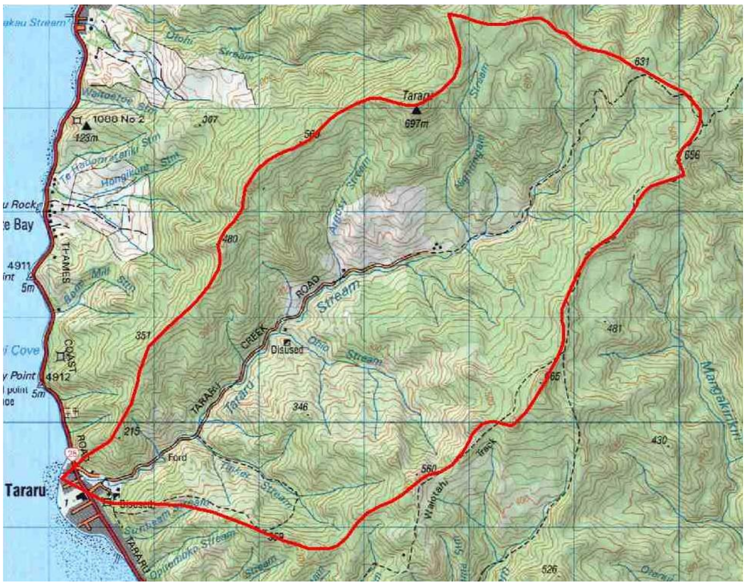


Figure 9 Tararu Stream catchment boundary

Table 4 Tararu Stream catchment summary

Catchment area	15.5 km^2
% urban	Low
% indigenous forest/ scrub	High
Channel slope	7%
Time of concentration	1 hour

3.3 Rainfall

Rainfall data was taken from NIWA's High Intensity Rainfall Design System (HIRDS) Version 2 (the most current version of HIRDS at the time of the model development). The standard error was added to the rainfall depth to give a conservative rainfall estimate and is shown below.

Table 5 Tararu Stream catchment predicted rainfall intensities (existing)

	Rainfall summary 45 minute duration event					
Annual exceedance probability (AEP) event	50%	20%	10%	5%	2%	1%
Predicted rainfall intensity (mm/hr)	31	38	45	52	65	78

Climate change effects have been estimated following the methods outlined by the Ministry for the Environment guidelines (MfE, May 2004 – the most current guidelines at the time of the assessment). The guidelines predict that the temperature within the Waikato Region will rise by up to 1.4^{0}C by 2030 and up to 3.8^{0}C by the year 2080. The guidelines also suggest that rainfall intensity will increase 7% to 8% per degree ^{0}C increase. Based on the above the rainfall intensities were estimated as outlined in the following table.

Table 6 Tararu Stream catchment predicted rainfall intensities (future)

	Rainfall summary 45 minute duration event					
AEP event	50%	20%	10%	5%	2%	1%
Predicted rainfall intensity 2030 (mm/hr)	34	42	49	58	72	87
Predicted rainfall intensity 2080 (mm/hr)	40	48	57	67	84	101

3.4 Flow estimates

The peak inflow for Tararu Stream including an allowance for climate change has been determined using several methods; the Rational Method, Relative Rational Method, and the Revised Regional Flood Estimation Method. The results have been compared with previous reports and historic events. The initial hydrological assessment undertaken by WRC for the Tararu Stream catchment was also reviewed by Opus Consultants (Opus Consultants, 2004).

Table 7 Tararu Stream peak flow estimates

	Peak flows estimates					
AEP event	50%	20%	10%	5%	2%	1%
Existing peak flow - 2006 (m^3/s)	94	114	149	175	203	222
Future peak flow - 2030 (m^3/s)	103	126	165	194	224	261
Future peak flow - 2080 (m^3/s)	119	145	191	225	260	303

To put these figures in perspective, the following flow estimates have been compiled from historical flood events that have significantly affected the Tararu community:

Table 8 Summary of historical flood events on Tararu Stream

Event	**Peak flood flow (m^3/s)**	**Estimated AEP event**
April 1981	70	< 50% (2 year ARI)
February 1985	150	5% (20 year ARI)
January 2002	200	1% (100 year ARI)
Weather Bomb	200	1% (100 year ARI)

It should be noted that in events exceeding the 2% AEP event, debris floods are likely to occur and cause increased flood levels, higher waves and significant blockages in the stream system.

The following graph shows the full continuum of flood events in the Tararu Stream for existing and future predicted climate change scenarios.

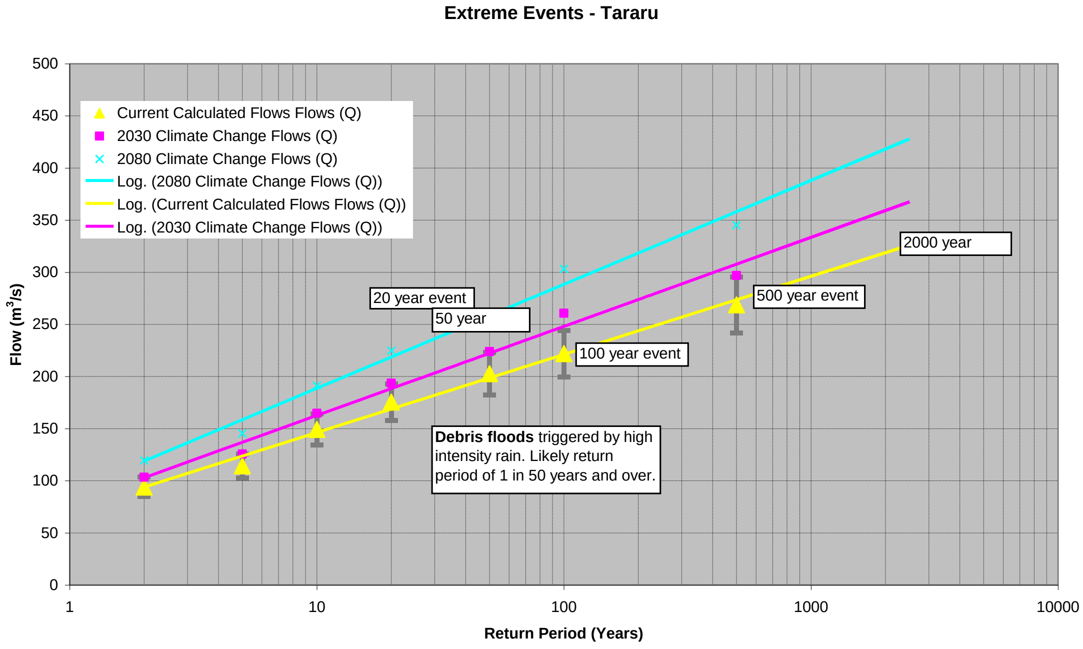


Figure 10 Tararu Stream hydrological summary

From the above figure, the existing 1% AEP event flood flow for Tararu Stream is estimated to be 222m^3/s and the future 1% AEP event flow is estimated to be approximately 267m^3/s.

3.5 Hydrograph

To allow realistic modelling it was necessary to create a hydrograph to input flows into the model. A dimensionless unit hydrograph was created by examining five historic floods recorded on the Kauaeranga River at Smiths (WRC recording site 9301). The dimensionless hydrograph used is shown below.

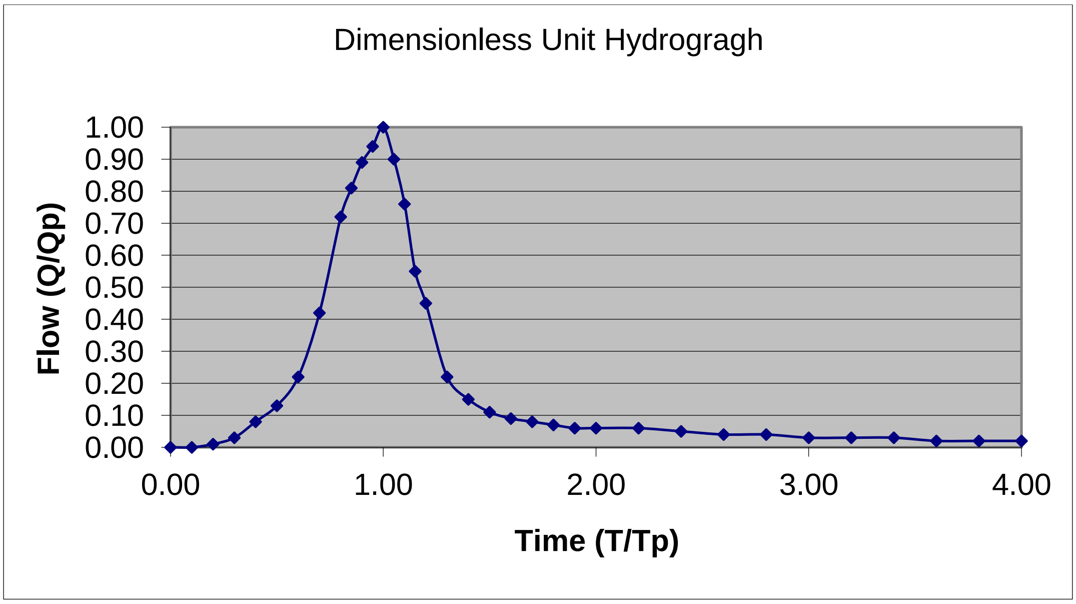


Figure 11 Dimensionless Unit Hydrograph

This was used to produce a unit hydrograph for the Tararu catchment. Where Tp used is the time of concentration and Qp is the peak flow.

4 Hydraulic model development

4.1 Introduction

A one-dimensional (MIKE-11) hydraulic model was used to develop a detailed design model for the Tararu Stream sufficient to inform the design of components of the flood protection scheme, such as stop banks and flood walls. The MIKE-11 model was also used to assess the performance of the old SH25 Bridge and to design the bridge upgrade, details are provided about this in Section 4.4 below. This model provides detailed information regarding flow, flow depth and velocity within the modelled stream channel and associated stream berm. This section outlines the development of both of the hydraulic models.

4.2 Model build

The MIKE-11 model was built to test options to mitigate the flooding issues at Tararu. Details about the model build are included in the Environment Waikato report entitled Tararu Stream Hydraulic Investigation (Ryan, no date, WRC DM# 780551).

4.3 Model inputs

4.3.1 Model datum

The model datum relates to a local datum - Origin of coordinates: SS70 S57224 (C3FK) – lead plug in Kapanga Road Bridge. The model has been developed with data relating to this datum, including any LiDAR information which has been corrected to this datum to complete cross sections where survey extents didn't extend far enough.

4.3.2 Channel cross section data

Cross section survey data was used to define the channel dimensions. The survey was undertaken by FW Millingtons Ltd in September 2004. Cross sections were surveyed at nominal 100m intervals. These cross sections were input into the MIKE-11 model to define the channel capacity.

4.3.3 Upper boundary condition

The upper boundary of the hydraulic model consists of the inflow hydrographs to represent the peak flows for the contributing sub-catchments to the Tararu Stream for the 1% AEP event, as per the MIKE-21 discussed in Section 4.2 above. The development of the inflow hydrograph is discussed in Section 3 above. The following table summarises the inflow data for the catchment for the existing and predicted future 1% AEP events (this is the same as for the MKE-21 model):

Existing 1% AEP design flow:	222 m^3/s
Future 1% AEP design flow:	267 m^3/s

4.3.4 Lower boundary condition

The lower boundary of the Tararu Stream is the Firth of Thames. The spring high tide level was used to replicate the backwater effect at the lower end of the stream. The current spring high tide is RL1.5m above mean sea level. This was used for the model runs for the existing climatic conditions.

Sea level is predicted to rise 0.5m by the end of the century according to MfE guidelines (MfE, May 2004). Hence the lower boundary condition used to simulate future climatic conditions was RL2.0m above mean sea level.

4.3.5 Roughness

MIKE-11 uses Manning's 'n' value to define channel roughness. The MIKE-11 model for Tararu Stream has been set up with a constant Manning's 'n' value of 0.06. This 'n' value has been selected to provide a conservative assessment for design purposes.

A Manning's 'n' value of 0.013 has been applied at the SH25 Bridge; this is the default value and is considered appropriate.

4.3.6 Model location

The MIKE-11 hydraulic model is located on the WRC system in the following folder:
G:\RCS\Technical Services\Projects\Waihou Piako\Tararu Stream\Hydraulics\MIKE 11

4.4 Bridge representation

4.4.1 Background

The SH25 Bridge at Tararu was identified to be a constriction to flood flows, hence WRC worked with the New Zealand Transport Agency (NZTA) to develop a flood mitigation solution for the community that included an upgrade of the SH25 Bridge.

Accurate modelling of the SH25 Bridge was critical to the success of this project. This section provides details about how the SH25 Bridge was modelled, further information is provided in WRC's Internal Series Report 2006/23 (Duffill Watts, 2006).

4.4.2 Model set up

The SH25 Bridge has been represented in the MIKE-11 model using the 'Weir' option. The 'Weir' option allows for the insertion of weirs to describe overflows to another channel or the flow through a bridge opening. Inside the weir option, a Q-H relationship is used to describe the behaviour of the structure. This relationship has been derived using an energy equation this follows recommendations from Opus Consultants (Opus Consultants, 2004).

Besides the main branch of the Tararu Stream, two additional branches had been part of the initial model accounting for break-out points of the stream. These break-out points were removed from the new model because of the lack of acceptable secondary flow paths. Since there are no accepted secondary flow paths, it is assumed that the total incoming flow is passed through the bridge opening. This assumption is used when deriving the Q-H relationship. It is this relationship and the use of the "Weir" option that allows water levels at the bridge to be determined and represented within the model. This assumption relies on floodwalls containing the flows within the stream channel.

The site of the SH25 Bridge is on a bend which is affected by the super elevation of water levels at the true right bank (northern side of the stream). Water levels in cross sections of a MIKE11 set-up are defined to be horizontal. To identify super elevation water levels in the bend of a watercourse, it is necessary to carry out auxiliary calculations and add the relevant values to MIKE11 results. This assessment was undertaken for the SH25 Bridge at Tararu and indicates an increase in water levels due to supper elevation of approximately 0.42m (refer to WRC DM#1117755 for super elevation calculations). Scour was also assessed at the SH25 Bridge; refer to WRC DM#1117743 for calculations).

4.4.3 Description of modelling scenarios

Three design scenarios were modelled as part of the SH25 Bridge upgrade project. The first scenario represented the existing (pre-upgrade) situation. This included a 13m wide bridge which acts as a major flow obstruction in events greater than a 10% AEP event. The other two scenarios deal with bridge widening, stream widening and flood protection measures such as flood walls. The first of these included an increase of the bridge span to 20m and the second included an increase of the bridge span to 25m.

Scenario A: Existing scenario (pre-upgrade)
This model was initially established by WRC as part of the initial investigations and consists of twelve cross sections representing the "current" situation, without floodwalls or channel alterations. The model was reviewed by Opus Consultants on behalf of NZTA (Opus Consultants, 2004) with recommendations made to adopt a different methodology in assessing the hydrological, hydraulic conditions and the bridge model representation. These changes were accepted and adopted by WRC.

Scenario B: 20 metre wide SH25 Bridge
This scenario increased the bridge span from 13m to 20m. This scenario included an increase in the bed width at the bridge to that of the bridge span. Revised Q-H calculations were developed and the result was used in the "Weir" option within the model. The stream cross sections in the vicinity of the bridge, immediately upstream and downstream were also modified to account for the new situation. Floodwalls were inserted on both sides of the stream, upstream and downstream of SH25. To carry out sensitivity tests, four different tailwater level conditions were used to compare water level results for the bridge cross section. Refer to WRC's Internal Series Report 2006/23 (Duffill Watts, 2006) for details.

Following NZTA's requirement of a 1.2m freeboard in the case of the 1% AEP event and a friction loss allowance at the bridge of 0.1m, the required soffit levels of a new bridge were calculated.

The same model configuration was used to simulate the expected future climate change effects. These included a 20% increase in the peak 1% AEP flows and a 0.5m rise in sea level. The inflow for this simulation for this scenario was 267m/s and the lower boundary condition was set at 2.0m

Scenario C: 25 metre wide SH25 Bridge
This scenario was modelled following a request by NZTA. Stream cross sections in the vicinity of the updated bridge were been modified (widened) and floodwalls assumed as before. Simulation of the future climate change scenario was also run for the 25m bridge, assuming a 20% increase in the 1% AEP flows and a 0.50 m rise in sea level.

4.5 Design models

Three model scenarios were developed, as follows:

- **1% AEP event (existing) -** Present day 1% AEP event discharge for existing situation.
- **1% AEP event (existing) with flood protection scheme** - Present day 1% AEP event discharge with inclusion of proposed stopbanks and upgraded SH25 Bridge.

- **1% AEP event (future) with flood protection scheme** – Future climate change 1% AEP event discharge (i.e. with climate change) with inclusion of stopbanks and upgraded SH25 Bridge

The design models were used to design the flood protection scheme and to test the proposed flood protection works during the option development stage, and to ensure that the proposals did not exacerbate any existing flood risk to any built up areas.

4.6 Model validation

Modelling of a natural system can never represent the actual environment exactly hence it is important to validate modelling results with actual events to check the overall fit of the modelling results. The estimated flood levels predicted by the MIKE-11 model for the existing climatic conditions scenario were compared with observations made during previous flood events. In-channel flow was calibrated using hydraulic design calculations contained in HCB Report 130. Out-of-channel flow is best represented in the MIKE-21 model, which is discussed in Section 4.2 above.

Comparison showed that the model was providing a reasonable representation of historic flooding in the Tararu Stream.

4.7 MIKE-11 model assumptions and limitations

The following outlines the assumptions made when building the MIKE-11 hydraulic model and model limitations:

- The modelling work has been undertaken for the current catchment characteristics. Any significant alteration to the catchment will affect the hydrology which will then affect the extent and magnitude of the design flood event. Alterations to the catchment that may affect the hydrology significantly include, land use changes, deforestation and development. Following significant alterations to the catchment a design review should be considered.

- The modelling work has been undertaken using channel cross sections surveyed in 2004. Any changes to the cross sections since this date have not been included in the model.

- All flood modelling has been undertaken for clear freely flowing water and does not model actual debris and sediment movement. However the derivation of the peak flows has been undertaken using methods derived from actual events. Therefore the modelling result capture the effects of debris and sediment load in a way similar to that experienced historically.

- While the model results capture typical debris and sediment movement effects, the results do not represent larger debris flows or blockages. Such occurrences are considered greater than design events and are considered a residual risk which is described in Section 9.

4.8 Peer review

The MIKE-11 hydraulic model was reviewed by Opus Consultants on behalf of NZTA (Opus Consultants, 2004) with recommendations made to adopt a different methodology in assessing the hydrological, hydraulic conditions and the bridge model representation. These changes were accepted and adopted by WRC.

The MIKE-11 model was also peer reviewed by Dr Steven Joynes, refer to WRC DM#1404126.

5 Flood protection scheme

5.1 Scheme history

The Tararu Stream was included in the Waihou Valley Scheme in 1965 because it was located in the former Thames Borough. The nature and objective of the works resulting from this inclusion have varied over the past 30 years and are summarised as follows:

- Prior to 1981 the capacity of the Tararu Stream was maintained at around 30-50 m^3/s.

- During 1982, in response to the significant damage caused by the April 1981 event, an engineering investigation was completed into the feasibility of improving the performance of the Tararu Stream below the Victoria Road ford (refer to Hauraki Catchment Board Report 130). The recommendations from this investigation were implemented in 1987 with the undertaking of works to widen and stabilise the Tararu Stream to a design standard of $100m^3/s$ (estimated as the 10% AEP or 10 year ARI event in 1985). These works included enlargement of the channel and stabilisation of the banks using either rock rip rap or concrete mattresses, refer Figure 12 below. This level of protection was selected for financial and practical reasons (the proximity of dwellings to the main channel hindered the feasibility of constructing stopbanks to further increase the capacity of the channel).

Figure 12 Engineering works constructed downstream of the SH25 Bridge in 1987

- From 1987 onwards, the Tararu Stream was maintained to the standards recommended by HCB Report 130 with slight variations to cross section profiles caused by re-excavation following significant flood events and channel in-filling.

Having adopted a design standard equivalent to the then 10% AEP event, properties adjacent to the Tararu Stream were still subject to flood hazard from the stream for greater than design events. As discussed in Section 2.3 above, the implications of this flood hazard were demonstrated during the January 2002 flash flood and the June 2002 'Weather Bomb', both of which involved flows well in excess of 100m^3/s and both caused significant damage to property and infrastructure.

The flood events in 2002 also damaged the Tararu Stream catchment, increasing the amount of debris carried by flood flows and exacerbating the issue of channel in-filling along the lower Tararu Stream.

The Peninsula Project began and WRC and TCDC worked with the community and NZTA to develop a flood protection scheme to provide a greater level of protection to the Tararu community from flood hazard from Tararu Stream from than what was already provided.

5.2 Scheme evolution

The proposed engineering works for the lower Tararu Stream have the following general objectives:

- Improvement of the performance of the Tararu Stream channel and floodway downstream of the Victoria Road ford.
- Provision of additional flood protection for the Tararu community where economic.
- Relieving the restriction created by the SH25 Bridge.

The key limitation on the engineering works in the lower Tararu Stream is the close proximity of residential development and Tararu Creek Road to the channel and the restriction created by the SH25 Bridge.

The performance of the Tararu Stream channel was assessed by constructing a one-dimensional hydraulic model (discussed in Section 4) extending from the Victoria Road ford to the Firth of Thames.

The modelling results indicated the following:

- The bank full capacity of the Tararu Stream was confirmed as 100m^3/s, which is close to the 20% AEP event flows.
- The unrestricted capacity of the SH25 Bridge (pre-upgrade) was around 100m^3/s, above which the road embankment acts as a dam causing back flow effect and restricts the flows through the bridge. The bridge full flow capacity without freeboard is approximately 130m^3/s, increasing to 150m^3/s when the water level increases to the level of the roadway.

Based on this modelling work it was identified that the capacity of the SH25 Bridge was a significant factor contributing to the flood hazard to the Tararu community from Tararu Stream. NZTA was approached and agreed to upgrading the SH25 Bridge at Tararu to provide capacity for the 1% AEP flood flows plus freeboard.

Waikato Regional Council developed a flood protection scheme that comprised the construction of flood walls to provide protection from the 1% AEP flood flows with freeboard. Flood walls were selected due to the limited space available between the

Tararu Stream and residential dwellings. The flood protection scheme was designed to complement the upgrade of the SH25 Bridge.

The flood protection scheme was constructed in two stages, with the first stage being constructed before the SH25 Bridge was upgraded, to provide protection to as many of the properties as possible. Then, once the SH25 Bridge was upgraded, the flood protection scheme was completed.

5.3 River and catchment works

As part of the Peninsula Project, river and catchment management works were proposed within the Tararu Stream catchment covering the following areas:

- Protection of existing indigenous vegetation from livestock through retiring and fencing land.
- Implementation of a goat and possum control programme.
- Removal of channel obstructions and accumulated sediment in the middle and upper reach of the Tararu Stream and tributaries (where there is appropriate access).
- Re-vegetation of areas prone to erosion (landslide material and riparian margins).

These items have been undertaken in collaboration with DOC and are ongoing to maintain catchment and river health.

5.4 Channel improvements

As part of previous channel improvement works, the Tararu Stream was enlarged by the Hauraki Catchment Board to pass a flow of $100m^3/s$. This work, which included some erosion protection, improved the stability and capacity of the Tararu Stream channel and reduced the risk to the Tararu community by containing flood events that would otherwise inundate adjacent land.

As part of the SH25 Bridge upgrade works the channel was further widened in the vicinity of the upgraded SH25 Bridge. In designing the Tararu channel within the SH25 Bridge reach, the channel needed to be widened from the pre-scheme width of 13m to 20-25 metres to accommodate flood flows. Such widening was proposed to occur gradually within a transition section starting at a point approximately 40m upstream of the SH25 Bridge and extending some 25m downstream. It was expected that widening the channel will encourage more sedimentation and deposition of material, which will need to be regularly removed to maintain the waterway capacity. Deep and confined channels are more efficient in sediment and bed load transport, as the depth and flow velocity are higher, however, over deepening is likely to be filled by sediment and sand due to bank erosion and the tidal dynamics within the SH25 Bridge reach. As such a low flow channel was incorporated into the design to ensure adequate channel dimensions for conveyance of low flows.

Refer to Figure 13 for the approximate extent of channel improvement works.

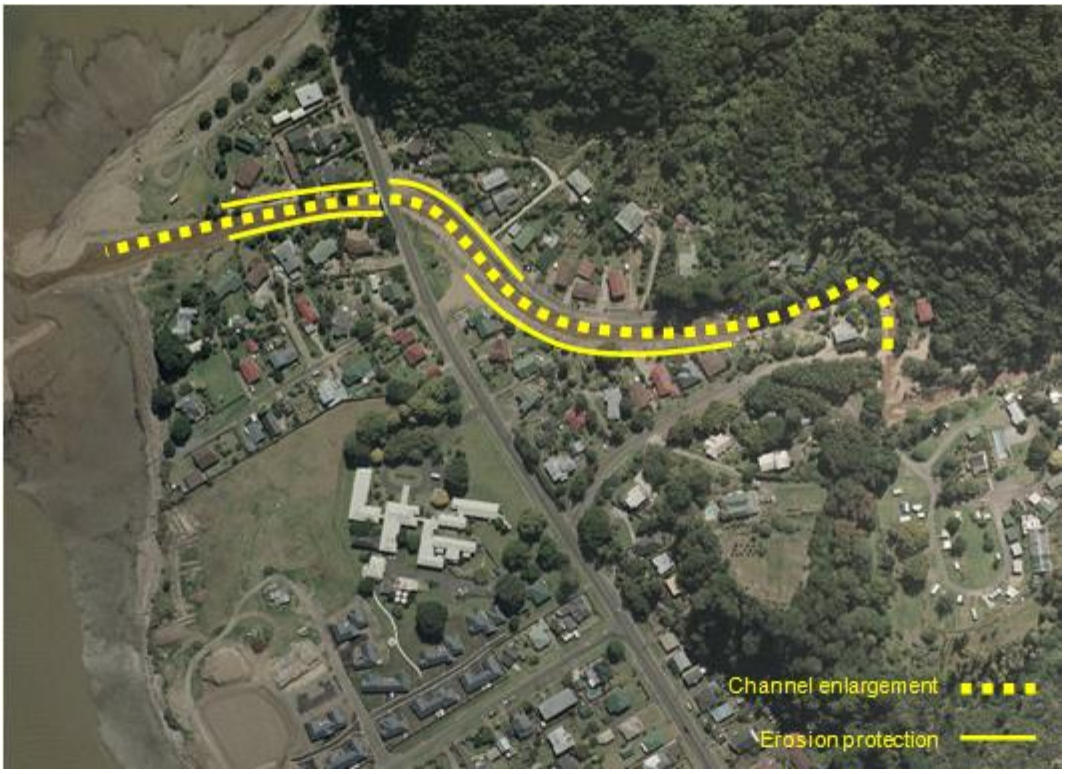


Figure 13 Extent of channel improvements

5.5 Flood defences

A number of options to provide flood protection for the Tararu community were investigated. The preferred option that was developed provided protection to the community for up to a 1% AEP design standard with 500mm of freeboard, generally through the provision of flood walls, channel improvements and the upgrade of the SH25 Bridge. This flood protection standard is similar to most urban protection works within the region. The freeboard height is designed to allow for wave action, design model uncertainties and blockage in the system due to floating debris or bed load depositions.

The preferred option improves the existing performance of the lower Tararu Stream floodway to contain the 1% AEP flood event (222m^3/s) by implementing the following works:

- Construction of a timber floodwall along both banks of the Tararu Stream (upstream of the SH25 Bridge) to eliminate the existing overland flow path around the southern and northern approaches of the bridge.

- Construction of timber floodwalls along both banks of the Tararu Stream (downstream of the SH25 Bridge) to improve the performance of the channel and prevent overflow onto adjacent properties. The downstream section of the scheme was constructed as earth stopbank on both sides of the stream.

- Placement of rock rip rap to improve the stability of the channel and protect the other works associated with this proposal.

- Replacement of the SH25 Bridge, with the primary objective of increasing its capacity to the 1% AEP flow with adequate freeboard to pass floating debris and accommodate higher flows.

- Provision of a spillway on the right bank of Tararu Stream, upstream of the SH25 Bridge. The spillway is designed to divert flows in greater than design events and to mange situations where huge amounts of debris and sediments are mobilised through the system during floods.

- Planning controls to ensure development is undertaken outside of the flood hazard area.

In designing these works, provision for greater than design events, climate change effects and possible sea level rise have been assessed and provided for as practicable.

The indicative alignment of the constructed flood defences is shown in Figure 14. Design details are provided in Appendix 2 and as-built survey information for the flood defences is provided in Appendix 3.

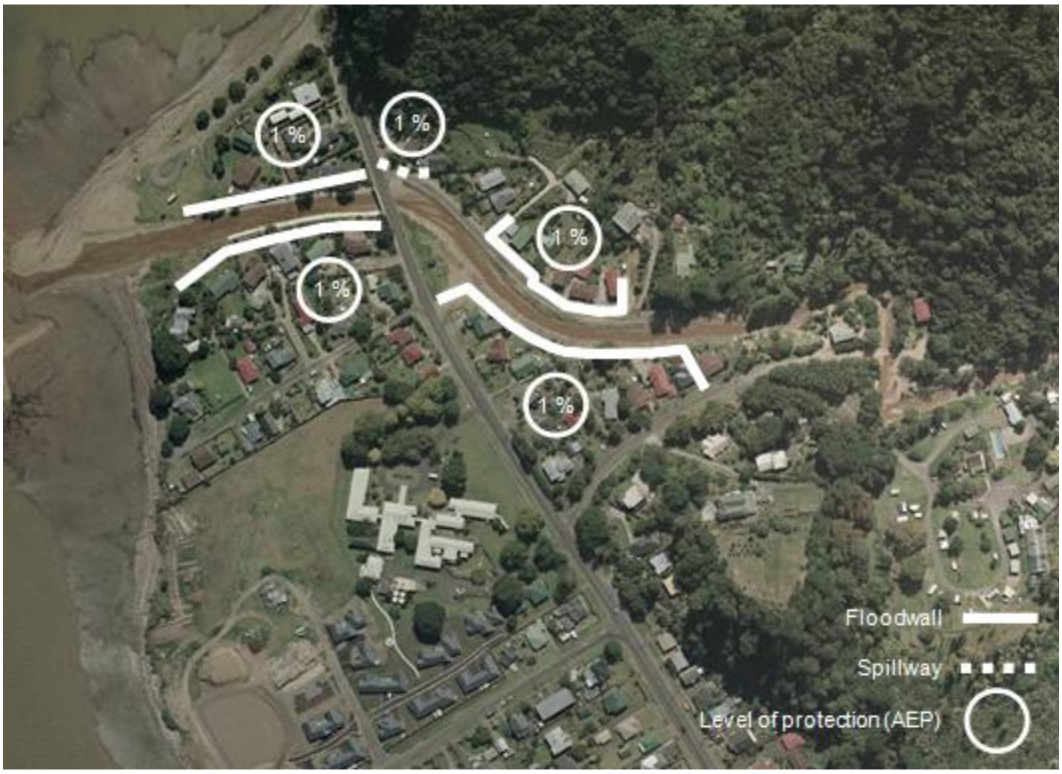


Figure 14 Flood defences in the Tararu community

The floodwalls were constructed in two stages. The first stage of the works was undertaken in 2005, prior to the SH25 Bridge upgrade, with flood walls being constructed to design level along the majority of the scheme, except for short reaches on both sides of the stream upstream of the SH25 Bridge, and short reaches on both sides of the stream at the river mouth. These sections could not be completed until after the SH25 Bridge was upgraded. Figure 15 illustrates the staging of the floodwall construction.

The design criteria for the downstream extension of the stopbank is the 1% AEP tide level (RL3.0m) plus 0.5m freeboard, hence RL3.5m, which is higher than the predicted 1% AEP flood level in Tararu Stream plus 500mm freeboard. This design criteria is consistent with other schemes in the Waihou/Piako zone.

The downstream portions of the scheme on both left and right bank comprise a section of flood wall (due to space restrictions) and then completes as an earth stopbank. The crest level heights of the end of the walls on both sides of the stream have been designed to a level of RL3.5m, and the earth stopbank drops down from this level to existing ground level at the stopbank termination point, at a constant grade. Design drawings for the downstream sections of the scheme are provided in Appendix 2.

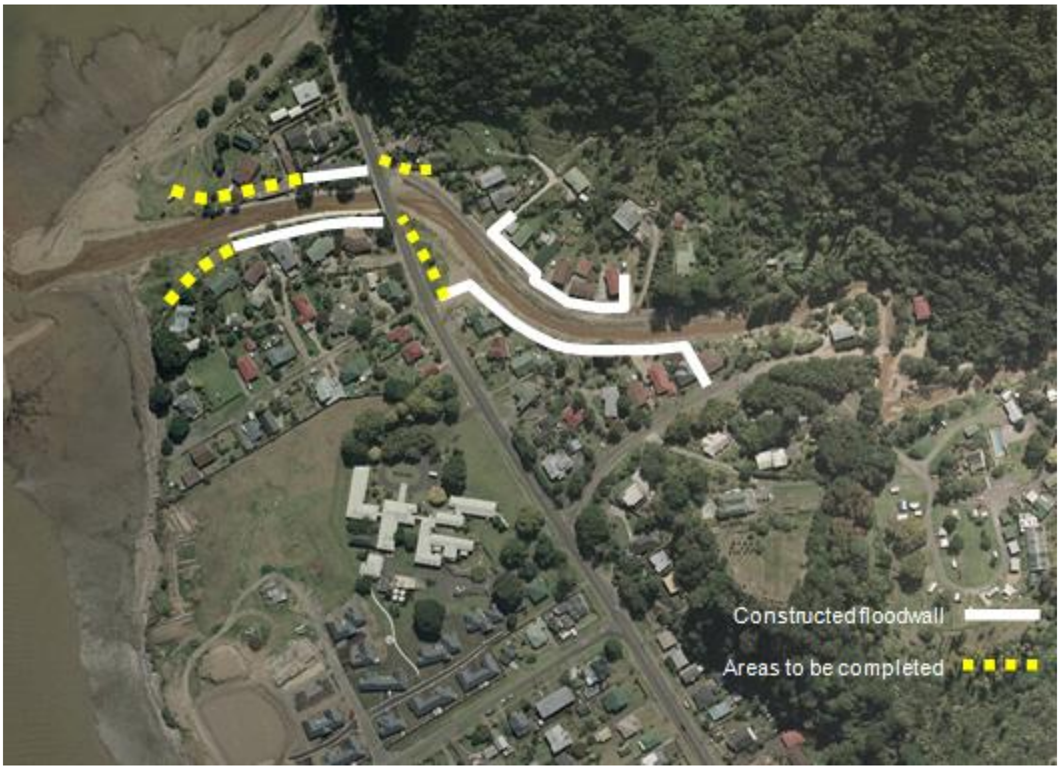


Figure 15 Staged construction of flood walls/stopbanks

5.6 SH25 Bridge upgrade

5.6.1 Bridge design

Several options were considered for the new SH25 Bridge at Tararu, including:

- A 20m or 25m span bridge
- Bridge located at the existing location or downstream of the existing location where the channel is straighter.

NZTA's design standards require that new bridges are designed with the soffit set at the 1% AEP flood level plus 1200mm freeboard. This is more freeboard than what is incorporated into the design of the floodwalls. The difference in freeboard between the bridge and stopbanks/floodwalls allows for the defences to be overtopped in extreme, greater than design events and ensure the integrity of the bridge is not compromised.

A spillway has been provided for by NZTA to divert flows in greater than design events so the integrity of the bridge is not compromised and to mange situations where huge amounts of debris and sediments are mobilised through the system during floods.

Prior to the scheme, floodwaters came out of channel on the left and right banks and flooded to the north and south of the stream. With the scheme in place the SH25 embankment on the left bank (to the south) stops flood waters draining to the south, hence only the right bank spillway is still able to operate. This spillway is located on the right bank, upstream of the bridge, and drains to the north through a private property.

NZTA has formalised the existing spillway to the north, however the capacity of the spillway is very limited due to the proximity to a residential dwelling and the extent of the SH25 embankment. This means that in a greater than design event the whole scheme will fail sooner than would otherwise if a larger spillway had been provided.

5.6.2 Bridge modelling

The SH25 Bridge at Tararu was identified to be a constriction to flood flows, hence WRC worked with the New Zealand Transport Agency (NZTA) to develop a flood mitigation solution for the community that included an upgrade of the SH25 Bridge.
Accurate modelling of the SH25 Bridge was critical to the success of this project. Section 4.4 provides details about how the SH25 Bridge was modelled and further information is provided in WRC's Internal Series Report 2006/23 (Duffill Watts, 2006). Opus Consultants were commissioned by NZTA to undertake a Water Analysis for the Tararu Bridge, refer to their report for details (Opus Consultants, Oct 2004, WRC DM#3126273).

Three design scenarios were modelled as part of the SH25 Bridge upgrade project. The first scenario represented the pre-upgraded situation, this included a 13m wide bridge which acts as a major flow obstruction in events greater than a 10% AEP event. The other two scenarios deal with bridge widening, stream widening and flood protection measures such as flood walls. The first of these included an increase of the bridge span to 20m and the second included an increase of the bridge span to 25m.

The results of the bridge modelling are provided in Appendix 3 and further details are provided in WRC's report mentioned above. Also in 2008, Dr Steven Joynes was commissioned to determine the flood mitigation benefit due to the upgrade of the SH25 Bridge. The findings of his assessment are provided in Appendix 4.

5.6.3 Preferred SH25 bridge design

The modelling work undertaken aimed at defining the height of the soffit (underside) level of the bridge beams spanning the Tararu stream. For the two bridge spans that were assessed, both bridge spans (20m and 25m wide) would adequately accommodate the flood flows of the design 1% AEP event at different water levels. The difference in soffit level when compared to the old bridge was 0.23m for the design event and 0.62m for the future climate change scenario.

In addition to upgrading the span of the bridge, the bridge upgrade was also an opportunity to relocate the bridge. The old bridge was located on a bend hence was subject to turbulent flows and super-elevation. WRC recommended locating the new bridge over the straight part of the channel downstream of the old bridge, refer to Figure 16 below which shows WRC's indicative preferred location.

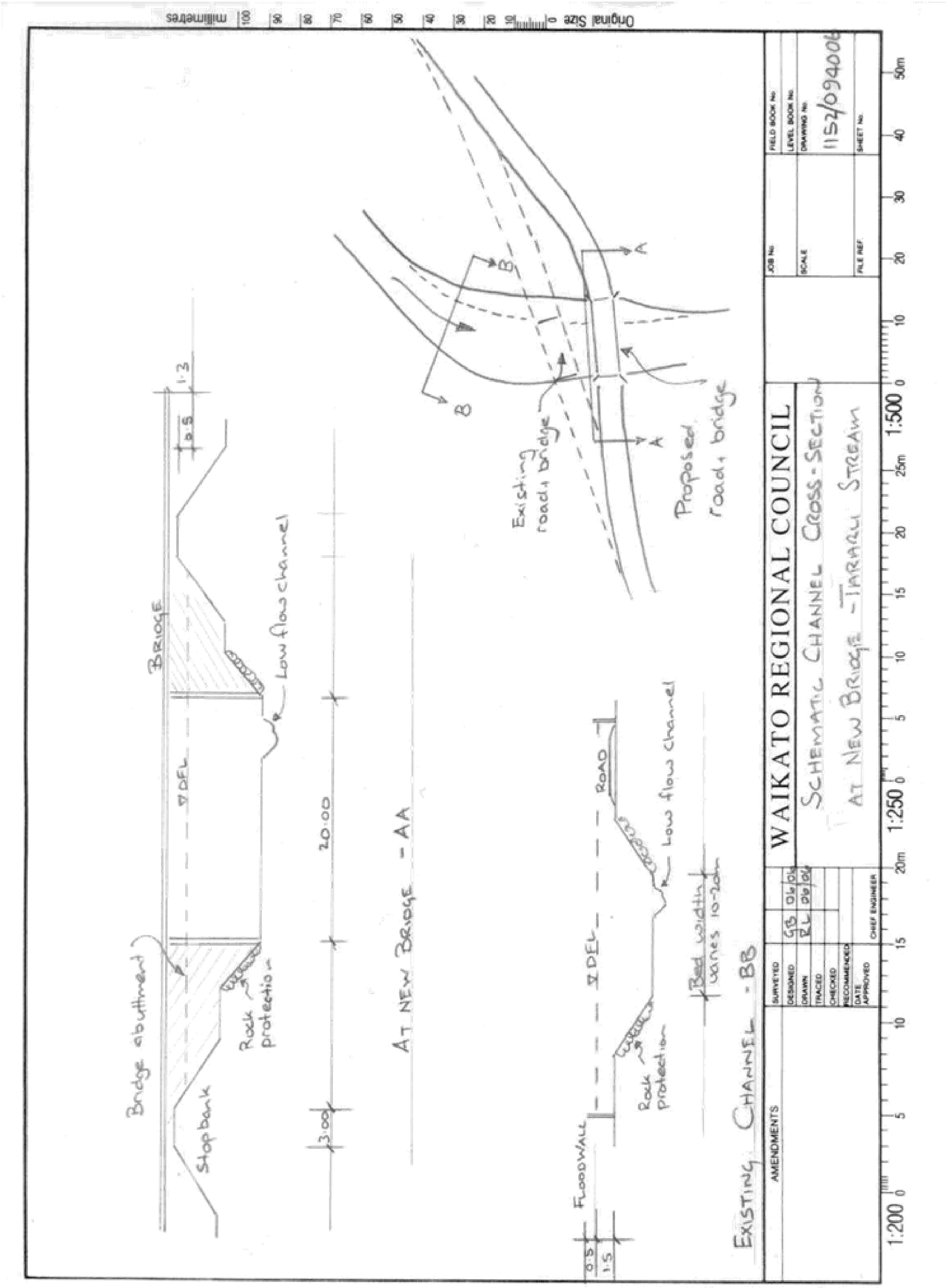


Figure 16 Proposed channel cross-sections at new SH25 Bridge (WRC's preferred option)

By locating the bridge over the straight part of the channel downstream of the old bridge, the soffit levels would be reduced significantly. This location would also provide some additional space for a safe overland flow path to the north of the bridge in greater than design events and debris flood conditions.

The implications of the height and width relationship are on the overall cost of the bridge. The additional height increases the costs of the abutments and earthworks of the approached on both sides of the bridge, while the increased width increases the cost of the bridge and decreases the approaches costs. The increased height would also affect the views and aesthetics of the structure.

The other aspect to consider is the channel maintenance required. As a general principle, wider bridges on aggrading streams are likely to encourage more accumulation of bed load material and sediment. Hence, would incur higher maintenance costs than more confined channels.

WRC's preference was for a 20m bridge to be constructed spanning the straight part of the channel downstream of the existing bridge with its soffit level raised at the elevation of the recommended future climate change scenario (RL 6.33 m). This option was considered by WRC to be the most sustainable option in the long term.

5.6.4 Constructed SH25 bridge

Assessment of the bridge options was undertaken by NZTA and they chose to construct a new 20m span bridge at the same location as the old bridge with the soffit based on the climate change scenario. Refer to the design drawings for the bridge upgrade provided in Appendix 5 and to WRC DM# 1387260 for the full set of design drawings. A full set of as-built drawings are provided in WRC DM#3131559.

5.6.5 Reduced freeboard

As discussed in Section 5.6.1, the old SH25 Bridge was to be replaced by a new bridge that was designed to pass the 1% AEP flows with 1200mm freeboard. During detailed design, NZTA identified that the 1200mm freeboard could not be achieved within the site limitations. The maximum available freeboard that could be achieved by the final bridge design was reduced to 660mm (160mm higher than the level of the floodwalls). Note the difference in freeboard between the bridge and stopbanks/floodwalls allows for the defences to be overtopped in extreme, greater than design events and ensure the integrity of the bridge is not compromised. Refer to WRC DM#1321290 for Maunsell's assessment of the revised soffit level.

Due to this limitation in providing the usual 1200mm freeboard for the Tararu Bridge, it was deemed essential that the capacity of the spillway be increased as much as possible, as the probability of its operation would be greater with the reduction in the capacity of the bridge, especially in the longer term when climate change effects become more evident. However as discussed in Section 5.6.1 above, the capacity of the spillway is compromised by its proximity to a residential dwelling and the extent of the SH25 embankment. What has been provided has been maximised considering the site constraints.

5.7 Future works

At this stage no further capital works are proposed at Tararu. If at some point in the future the community decides it requires additional protection, and is able to fund the works, then WRC would look to extend the works to include more of the community if practicable.

6 Agreed levels of service

The Waihou Piako Zone Management Plan (River and Catchment Services et al, May 2011) outlines the agreed levels of service for the Waihou Piako Zone.

As part of the works undertaken via the Peninsula Project, Tararu is identified as a high priority area for upper catchment protection through animal pest control (feral goats and possums). The Tararu Stream catchment has a direct relationship to the Firth of Thames. Pest control on the west coast of the Coromandel is in a maintenance phase currently, with a reduced frequency of operations. Buffer work is being undertaken on the eastern side of the ranges to stop reinfestation of areas located to the west.

The flood protection scheme at Tararu is identified as needing to be maintained and managed to ensure the level of service for flood protection assets is maintained. The level of service provided by the scheme at Tararu is the existing 1% AEP event (without climate change) plus 500mm freeboard. The general location of the flood protection assets is shown in Figure 17 below. Refer to Appendix 1 for design details for the flood protection works at Tararu. As-built survey data is provided in Appendix 2.

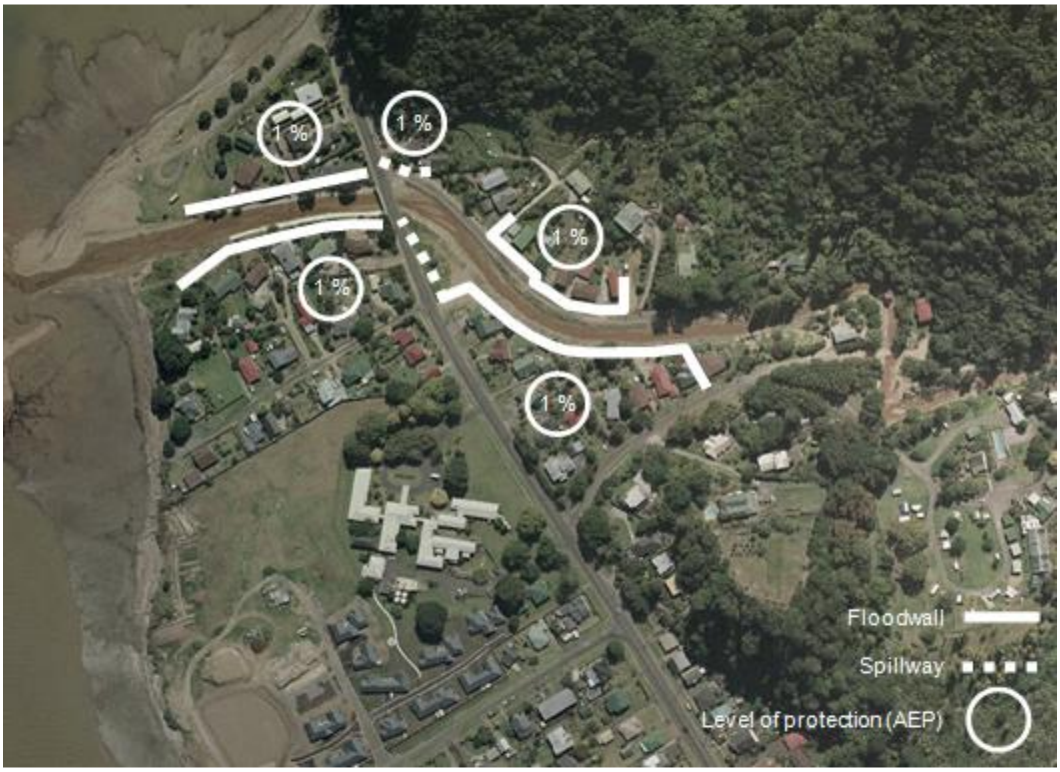


Figure 17 Flood defences in Tararu

Routine river management is identified for high priority catchments to reduce the risks of localised flooding through removal of willow congestion and blockages and to provide long term environmental benefits through improved water quality, keeping stock out of stream and fencing and planting of stream banks to reduce stream bank erosion. Details of the annual operation and maintenance programme undertaken on the Tararu Stream is discussed in Section 7.

7 Operation and maintenance

The Tararu Stream is monitored and periodically maintained by Waikato Regional Council to remove accumulated sediment and debris, refer to Figure 18 below for the indicative extent of works. This work maintains the capacity of this stream and reduces the risk to adjacent land that would otherwise be inundated more frequently from stream flooding.

Figure 18 Extent of channel maintenance

The annual maintenance programme includes the removal of accumulating gravel and sediment in the Tararu Stream, based on current cross sectional areas. These works are carried after annual inspection and monitoring of changes in the streams. The specific activities associated with this annual work programme include:

- Removal of accumulated gravel, sand and debris from the Tararu Stream between the SH25 Bridge and the Victoria Street ford (i.e. 400 m length of channel).

- Removal of accumulated gravel, sand, silt and debris from under the SH25 Bridge across the Tararu Stream.

- Removal of accumulated sand, silt and debris from the Tararu Stream between the SH25 Bridge and Firth of Thames (i.e. 240 m length of channel).

- Disposal of excavated gravel, sand and silt on the local foreshore below the high tide level.

Constructed flood protection works at Tararu (predominantly flood wall with some sections of constructed earth stopbank) are inspected annually for:

- Visible damage to the sections of flood wall.

- Visible damage to the batter slope and crest of the sections of earth stopbank.

- Any associated stream channel erosion and scour and potential undermining of flood protection assets.

Any necessary repair work is undertaken as required.

Crest levels of the stopbanks are surveyed each five to ten years, depending on the foundation material. A five yearly cycle applies to stopbanks built on peat and marine mud, while a ten yearly cycle is for stopbanks on sand and clay foundations. Stopbanks are topped up where necessary.

General maintenance for stopbanks is identified in the Waihou Piako maintenance schedule as:

General maintenance	Minor repairs of stopbanks, fences, weed spray, mowing (specific banks only)	As required
Renewal	Reconstruction and topping of banks due to settlement and other major damages	15 -30 yrs

This maintenance programme is consistent with other stopbanks managed by Waikato Regional Council in the Waikato region (eg Lower Waikato Waipa Control Scheme).

8 Flood hazard assessment

8.1 River flood hazard classification

A river flood hazard classification describes the significance of river flooding with regard to the likely impact on people and property. The classification that forms part of this assessment has been developed using the following considerations:

- Floodwaters have the potential to cause a person to become unstable and unable to manoeuvre. International research suggests that there is a danger of being knocked over when the product of the flood depth and flood speed exceeds 0.5, with a significantly greater risk to life when the same product exceeds 1.0.

- Floodwaters have the potential to impede a person's ability to rescue themselves or others. When the flood depth exceeds 1.0 m (i.e. waist depth), a person's ability to navigate through flood waters (both on foot and using a vehicle) is restricted, therefore impeding the rescue of themselves and others.

- Floodwaters have the potential to damage buildings, both superficially and structurally. International research suggests that structural damage is likely when the flood speed exceeds 2 m/s. It is also likely that structurally weak points such as doors and windows will be damaged when the flood speed exceeds 1 m/s.

These considerations have been translated into a river flood hazard classification by first defining four distinct levels of river flood hazard based on the likely impact on people and property. These levels are outlined in Table 9.

Table 9 Description of river flood hazard categories

Category	Impact on people	Damage to property
Low	The combined depth and speed of floodwaters are unlikely to impede the manoeuvrability or stability of the average person.	Damage to property is likely to be non-structural and mainly due to inundation and deposition of sediment.
Medium	The combined depth and speed of floodwaters are likely to start to impede the manoeuvrability or stability of the average person.	Damage to property is unlikely to be structural provided that weak points such as windows and doors are retained above flood level.
High	The combined depth and speed of floodwaters are likely to significantly impede the manoeuvrability or stability of the average person.	Damage to property is likely to be widespread and structural, including instances where buildings have been raised above the 'flood level'.
Defended	This flood hazard category identifies land that is within an identified river flood hazard area but has been subsequently included in a flood protection scheme that is managed and maintained by the Waikato Regional Council.	

The three levels of river flood hazard (low, medium and high) have then been quantified through the creation of a matrix that assigns a river flood hazard level based on the predicted depth and speed of flooding (refer to Figure 19).

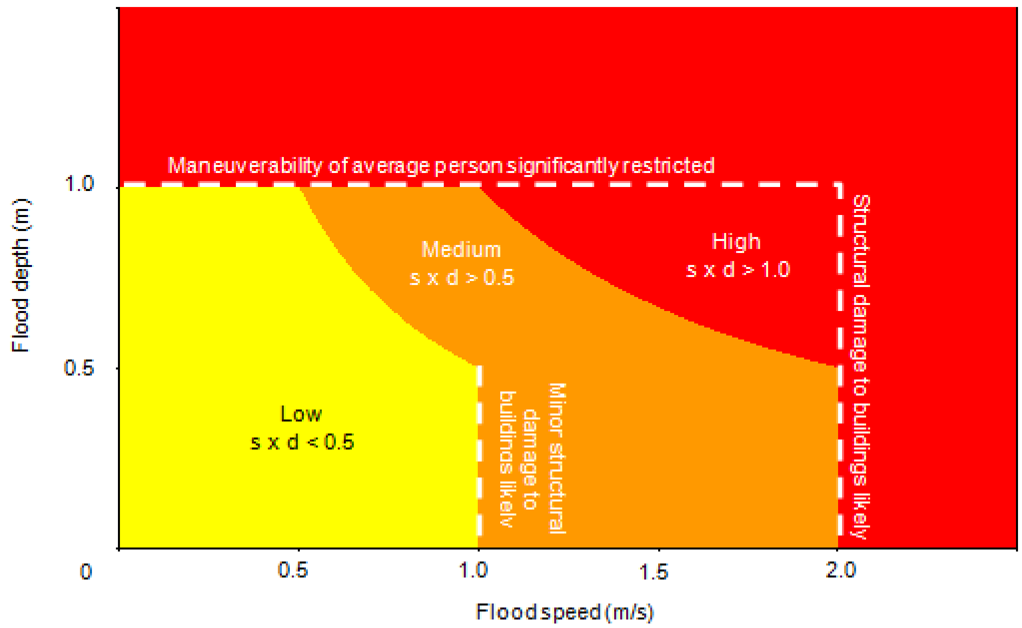


Figure 19 River flood hazard classification matrix

The following two scenarios also result in a ‘high’ flood hazard classification:

- Land that is surrounded by flooding that is classified as a ‘high’ flood hazard.
- Instances where floodwaters are directed by flood defences, including formal spillways.

The fourth level of flood hazard (i.e. defended) is intended to represent instances where a property is located within the natural floodplain but benefits from flood defences (e.g. floodwalls and stopbanks).

8.2 River flood hazard map

The river flooding information described in the sections above has been used to produce a river flood hazard map for Tararu due to the Tararu Stream. Figure 20 shows the flood hazard map for Tararu with the land protected by the scheme shaded in blue to reflect its “Defended” status.

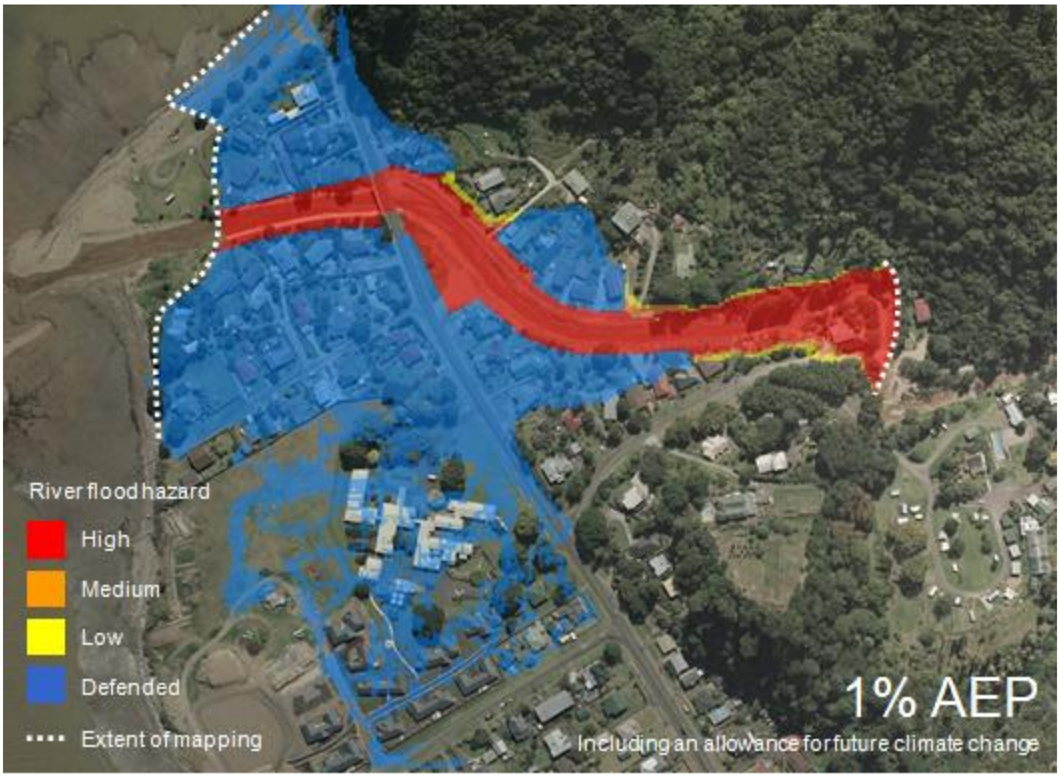


Figure 20 River flood hazard map for Tararu

9 Residual flood risk

'Residual flood risk' is a term used to describe a river flood risk that exists due to the potential for 'greater than design' flood events to occur. The concept of residual flood risk is relatively new, but provides a more complete assessment of risk when compared with traditional approaches that rarely look beyond 'design conditions'.

The residual flood risks that affect the Tararu community are described as follows:

- The river flood model used to design the flood protection scheme is based on a 'design flood event'. There is however the potential for larger flood events to occur, resulting in wider, higher and faster flood waters.

- The river flood model used to design the flood protection scheme is based on surveyed channel cross sections for Tararu Stream and detailed ground level information, but excludes obstructions in the streams and associated floodplains such as informal bridges, buildings and walls. These obstructions may result in wider, higher and faster flood waters.

- The river flood model used to design the flood protection scheme incorporates the impacts of sediment and debris. However, there may be instances where sediment and debris causes localised changes to the flood extent, depth and speed. This includes debris flow events that will produce significantly different flooding characteristics.

- This river flood model used to design the flood protection scheme is only relevant to flooding caused by the Tararu Stream. However, there is also the potential for flooding to occur in other waterways and due to the overwhelming (or lack) of local land drainage infrastructure.

- The river flood model is based on the existing condition of the Tararu Stream catchment. Any significant change to this condition will affect the river flood hazard that affects the Tararu community. For example, land use changes, deforestation and the intensification of development. Where significant changes do occur, this river flood model and associated flood protection scheme should be reviewed.

Following the completion of the protection works and bridge replacement, there remains some residual risks arising from extreme (greater than design) and debris flood events. The criteria for managing the residual risk include the following:

- The structural integrity of the SH25 Bridge should not be compromised by the protection works, as the bridge is considered as a national strategic asset.

- Overtopping should occur in well defined reaches and overland flows controlled to pass safely.

- The protection structures should not fail catastrophically when overtopped in greater than design events.

- The risks should be recognised in existing and future development and specific planning controls be implemented to avoid and/or mitigate these in the long term.

10 Planning controls

Based on the flood hazard status of land in the community, TCDC has various planning controls in place via the Thames Coromandel District Plan, that restrict what land use activities can be undertaken. The planning controls include measures such as:

- No development or re-development allowed in the floodway, and in residual high risk areas.

- Minimum floor level restrictions and construction requirements (e.g. flood proofing) for areas not protected by the works.

- For other protected areas within the present flood hazard areas, limited floor level restrictions would have to apply.

Refer to the Thames Coromandel District Plan and Thames Coromandel District staff for details.

11 Scheme review

The Waihou Piako Zone Management Plan outlines agreed levels of service for the flood protection schemes at Tararu, including commentary on scheme reviews. It is stated that river and flood protection schemes will provide the standard of flood protection agreed with the community, and that this will be achieved by:

- Maintaining stopbanks to the stopbank design heights, achieving performance grade 4 or better.
- Maintaining all stopbanks, pump stations, flood gates, detention dams and control structures at Condition Grade 3 or better.
- Asset operating as designed (capacity and function).
- By reporting, recording and investigating all health and safety incidents to comply with Council Health and Safety Policy.
- Responding to flood events by alerting communities prior to events, continuously monitoring river systems, undertaking emergency remedial works and reviewing system performance and maintenance requirements following flood events.
- Undertaking ongoing visual inspections of flood protection structures, reporting formally on an annual basis and following up on maintenance and repair requirements following flood events.
- Reporting annually to the subcommittee and Catchment Services Committee on flood protection performance measures.
- Making the likelihood and consequences of greater-than-design flood events clear to communities and providing advice for communities on managing these risks (residual flood risks).

The following procedures will measure whether performance targets are achieved:

- 5-10 yearly crest level survey
- Annual performance and condition inspections
- Monthly operational inspections and failure reports
- 10-yearly capacity audits
- Design level flood review
- Annual health & safety audits

The river flood model and hence the design of the flood mitigation scheme is based on the existing condition of the Tararu Stream catchment. Any significant change to this condition, for example land use intensification or deforestation, will affect the assumptions of the river flood model and hence compromise the basis of the scheme design. Where significant changes do occur, the river flood model and associated flood mitigation scheme should be reviewed.

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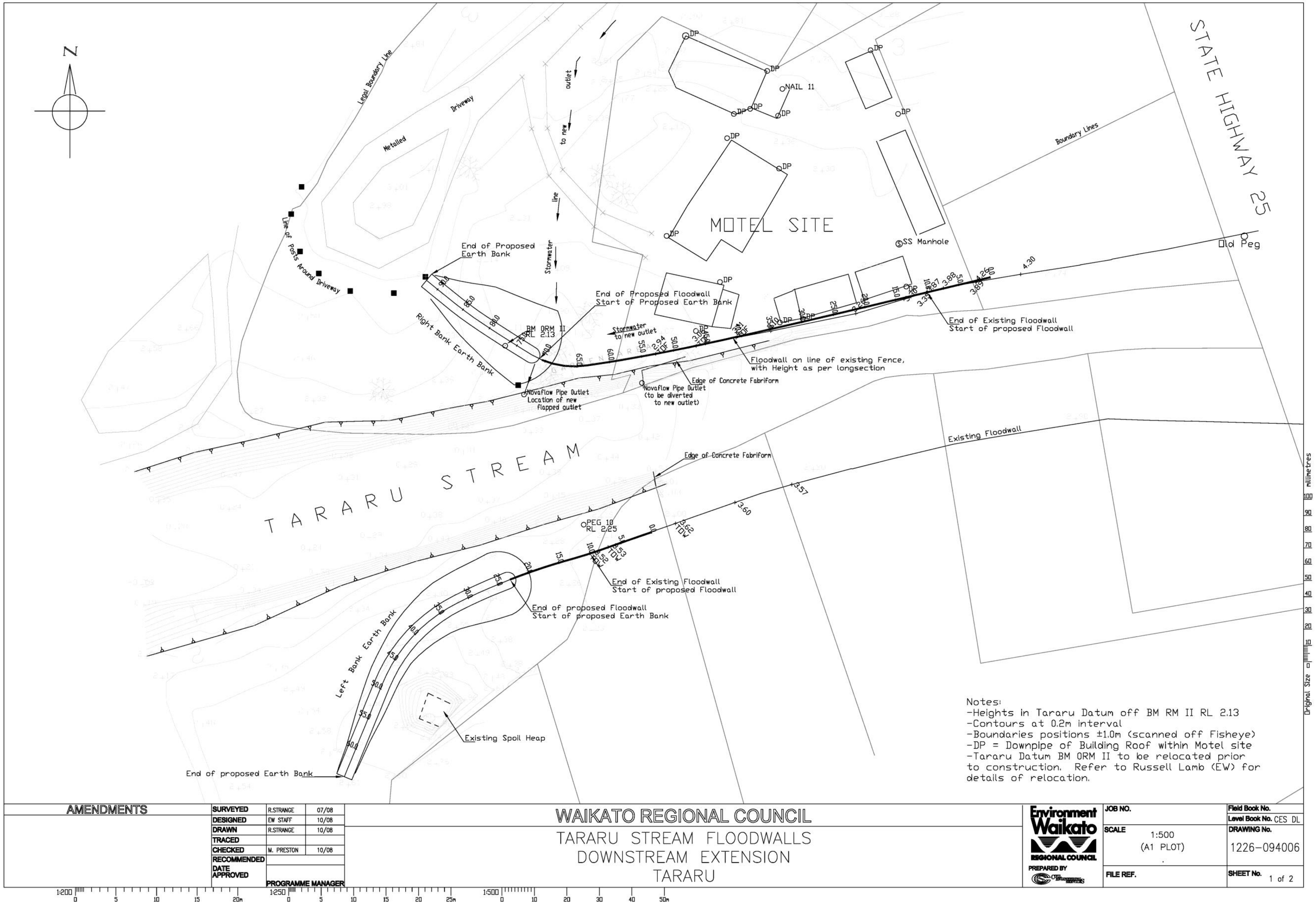
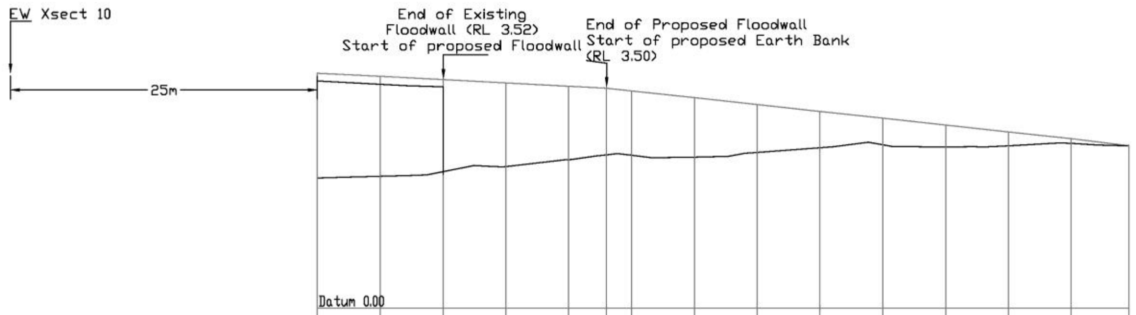
Appendix 1 Flood protection scheme design

Refer to WRC DM#912061 (electronic file saved to WRC's document management system) for design levels for the flood protection scheme at Tararu.

Design crest levels are also provided on the as-built drawings in Appendix 2.

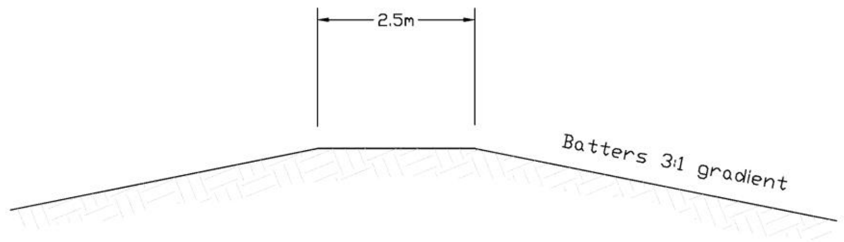


N
Legal Boundary Line
Driveway
Metalled
outlet
to new
Stormwater
line
Line of Posts Around Driveway
MOTEL SITE
DP
NAIL 11
SS Manhole
Old Peg
STATE HIGHWAY 25
Boundary Lines
End of Proposed Earth Bank
Right Bank Earth Bank
BM ORM II RL 2.13
End of Proposed Floodwall Start of Proposed Earth Bank
Stormwater to new outlet
Novaflow Pipe Outlet Location of new flapped outlet
Novaflow Pipe Outlet (to be diverted to new outlet)
Edge of Concrete Fabriform
Floodwall on line of existing Fence, with Height as per longsection
End of Existing Floodwall Start of proposed Floodwall
Existing Floodwall
TARARU STREAM
Edge of Concrete Fabriform
PEG 10 RL 2.25
End of Existing Floodwall Start of proposed Floodwall
End of proposed Floodwall Start of proposed Earth Bank
Left Bank Earth Bank
Existing Spoil Heap
End of proposed Earth Bank
Notes:
-Heights in Tararu Datum off BM RM II RL 2.13
-Contours at 0.2m interval
-Boundaries positions ±1.0m (scanned off Fisheye)
-DP = Downpipe of Building Roof within Motel site
-Tararu Datum BM ORM II to be relocated prior to construction. Refer to Russell Lamb (EW) for details of relocation.
Original Size millimetres
AMENDMENTS
SURVEYED R.STRANGE 07/08
DESIGNED EW STAFF 10/08
DRAWN R.STRANGE 10/08
TRACED
CHECKED M. PRESTON 10/08
RECOMMENDED
DATE APPROVED
PROGRAMME MANAGER
WAIKATO REGIONAL COUNCIL
TARARU STREAM FLOODWALLS
DOWNSTREAM EXTENSION
TARARU
Environment Waikato
REGIONAL COUNCIL
PREPARED BY
JOB NO.
SCALE 1:500 (A1 PLOT)
FILE REF.
Field Book No.
Level Book No. CES DL
DRAWING No. 1226-094006
SHEET No. 1 of 2
1:200
1:250
1:500

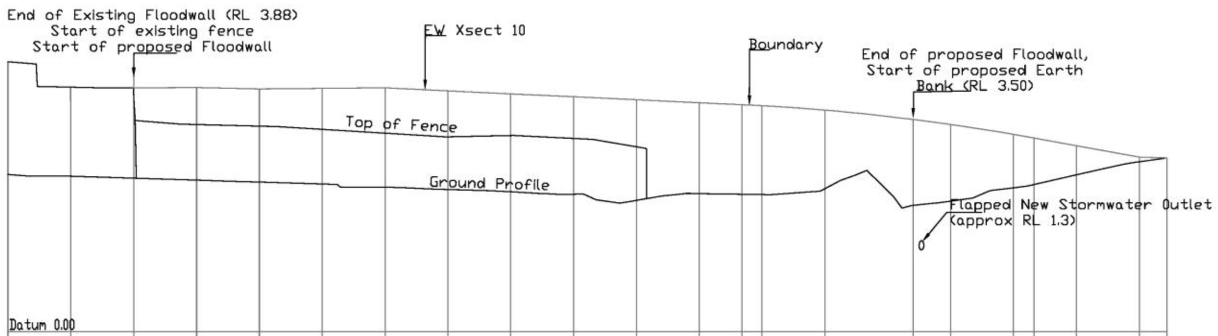


Chainage	Wall / Bank Height	Design Wall Level	Natural Surface
0.0	1.67	3.74	2.07
5.0	1.59	3.69	2.10
10.0	1.42	3.64	2.22
15.0	1.33	3.58	2.25
20.0	1.17	3.53	2.36
23.0	1.06	3.50	2.44
25.0	1.02	3.46	2.43
30.0	0.94	3.35	2.40
35.0	0.76	3.24	2.48
40.0	0.58	3.13	2.55
45.0	0.42	3.02	2.60
50.0	0.35	2.91	2.57
55.0	0.22	2.81	2.58
60.0	0.08	2.70	2.62
64.6		2.58	2.58

Left Bank Longsection



Typical Earth Bank Cross Section
(not to Scale)



Chainage	Wall / Bank Height	Design Wall Level	Natural Surface
0.0	1.79	4.29	2.50
5.0	1.41	3.88	2.47
10.0	1.44	3.88	2.44
15.0	1.47	3.88	2.41
20.0	1.49	3.87	2.38
25.0	1.52	3.87	2.35
30.0	1.57	3.87	2.30
35.0	1.57	3.83	2.26
40.0	1.56	3.78	2.22
45.0	1.55	3.74	2.19
50.0	1.60	3.69	2.09
55.0	1.45	3.64	2.20
58.4	1.42	3.61	2.19
60.0	1.42	3.59	2.18
65.0	1.25	3.52	2.28
72.0	1.26	3.50	2.24
75.0	1.22	3.30	2.08
80.0	0.85	3.14	2.29
81.6	0.74	3.08	2.34
85.0	0.47	2.96	2.49
90.0	0.07	2.78	2.70
92.2		2.76	2.76

Right Bank Longsection

Notes:
-Heights in Tararu Datum off BM RM II RL 2.13
-Wall design levels taken off drawing supplied by Environment Waikato and existing floodwall levels
-Chainages set with end of existing wall at 10.00m

Original Size 0 10 20 30 40 50 60 70 80 90 100 millimetres

AMENDMENTS

SURVEYED	R.STRANGE	07/08
DESIGNED	EW STAFF	10/08
DRAWN	R.STRANGE	07/08
TRACED		
CHECKED	M. PRESTON	10/08
RECOMMENDED		
DATE APPROVED	PROGRAMME MANAGER	

WAIKATO REGIONAL COUNCIL

TARARU STREAM FLOODWALLS DOWNSTREAM EXTENSION TARARU

Environment Waikato REGIONAL COUNCIL
PREPARED BY

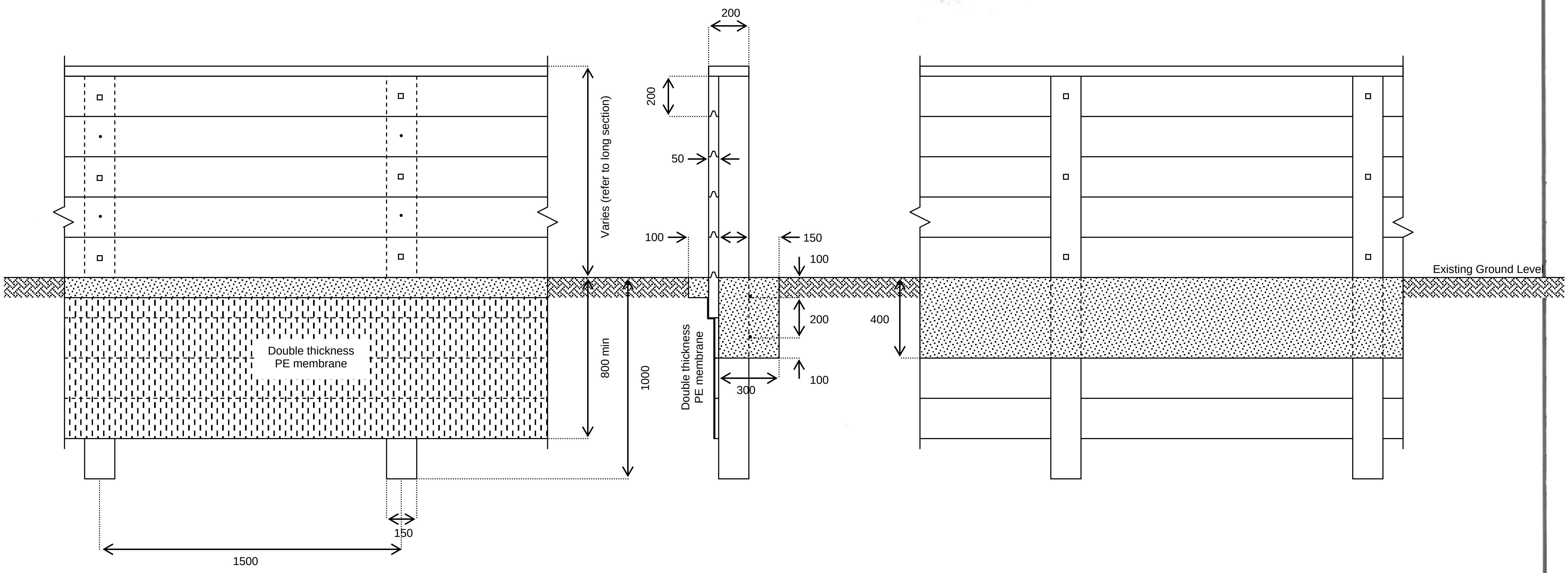
JOB NO.	
SCALE	Hz 1:250 Vt 1:50 (A1 Plot)
FILE REF.	
Field Book No.	
Level Book No.	CES DL
DRAWING No.	1226-094006
SHEET No.	2 of 2

1:200 0 5 10 15 20m 1:250 0 5 10 15 20 25m 1:500 0 10 20 30 40 50m

Notes to accompany Tararu floodwall design 1 (< 1.0 m above ground level)

Posts:	150 mm SED timber posts at 1.5 m centres Heights vary (refer to long sections)
Planks (above ground):	200 x 50 mm timber tongue and groove. Every second plank anchored with 12 mm hot dip galvanised engineers bolts with square washers. Remaining planks to be nailed. Tongue and groove planks to extent one board (minimum) below existing ground level.
Planks (below ground):	200 x 25 mm rough sawn timber. To start below tongue and groove timber, which extends one board (minimum) below existing ground level. Planks to be nailed. Planks to be lined (on stream side) with double thickness polyethylene membrane
Capping board:	200 x 50 mm nailed to each post and to the top plank at 200 mm centres.
Foundation (below ground):	Excavated to 1.0 m depth. Trench backfilled with compacted clay.
Foundation (ground level):	Stream side - 100 x 100 mm concrete mowing strip flush with existing ground level. Land side - 300 x 400 mm concrete pad flush with existing ground level, including steel reinforcement (two 12 mm diameter reinforcing bars stapled to each post with a cover of 100 mm and vertical spacing of 200 mm). *Note: Landside concrete strip may be reduced to a 100 mm x 100 mm standard concrete mowing strip if the wall height is less than 0.6 m.*
Timber treatment:	H5.
Concrete:	17.5 MPa.
Drawing key:	Concrete Polyethylene Existing ground Timber

AMENDMENTS			WAIKATO REGIONAL COUNCIL		JOB No.	FIELD BOOK No.
	SURVEYED					LEVEL BOOK No.
	DESIGNED		Tararu Flood Protection Scheme		SCALE 1:20	DRAWING No. Tararu
	DRAWN					
08/03/05: First draft (for review by RP Spooner) 24/03/05: Second draft (for review by DJ Shilton) 05/05/05: Third draft (for review by RP Spooner)	TRACED		Floodwall Design 1 (< 1.0 m height above ground)			
	CHECKED					
	RECOMMENDED					
	DATE APPROVED	CHIEF ENGINEER			FILE REF. 82 06 93	SHEET No. 1a



Front Elevation (river)

Side Elevation

Rear Elevation (land)

AMENDMENTS

08/03/05: First draft (for review by RP Spooner)
24/03/05: Second draft (for review by DJ Shilton)
05/05/05: Third draft (for review by RP Spooner)

SURVEYED
DESIGNED
DRAWN
TRACED
CHECKED
RECOMMENDED
DATE APPROVED
CHIEF ENGINEER

WAIKATO REGIONAL COUNCIL

Tararu Flood Protection Scheme

Floodwall Design 1 (< 1.0 m height above ground)

JOB No.

SCALE 1:20

FILE REF. 82 06 93

FIELD BOOK No.

LEVEL BOOK No.

DRAWING No. Tararu

SHEET No. 1b

Notes to accompany Tararu floodwall design 2 (1.0 to 1.8 m above ground level)

Posts: 200 mm SED timber posts at 1.0 m centres
Heights vary (refer to long sections)

Planks (above ground): 200 x 50 mm timber tongue and groove.
Every second plank anchored with 12 mm hot dip galvanised engineers bolts with square washers.
Remaining planks to be nailed.
Tongue and groove planks to extent one board (minimum) below existing ground level.

Planks (below ground): 200 x 25 mm rough sawn timber.
To start below tongue and groove timber, which extends one board (minimum) below existing ground level.
Planks to be nailed.
Planks to be lined (on stream side) with double thickness polyethylene membrane

Capping board: 250 x 50 mm nailed to each post and to the top plank at 200 mm centres.

Foundation (below ground): Excavated to required depth (refer to Table 1 for required depth).
100 mm thick concrete punch pad (design 2B only).
Trench backfilled with compacted clay.

Table 1: Minimum foundation depth requirements

Design	Wall height above ground (m)	Foundation depth (m)
2A	1.0 to 1.5	1.2
2B	1.5 to 1.8	1.7

Foundation (ground level): Stream side - 100 x 100 mm concrete mowing strip flush with existing ground level.
Land side - 300 x 400 mm concrete pad flush with existing ground level, including steel reinforcement (two 12 mm diameter reinforcing bars stapled to each post with a cover of 100 mm and vertical spacing of 200 mm).

Timber treatment: H5.

Concrete: 17.5 MPa.

Drawing key:
- Concrete
- Polyethylene
- Existing ground
- Timber

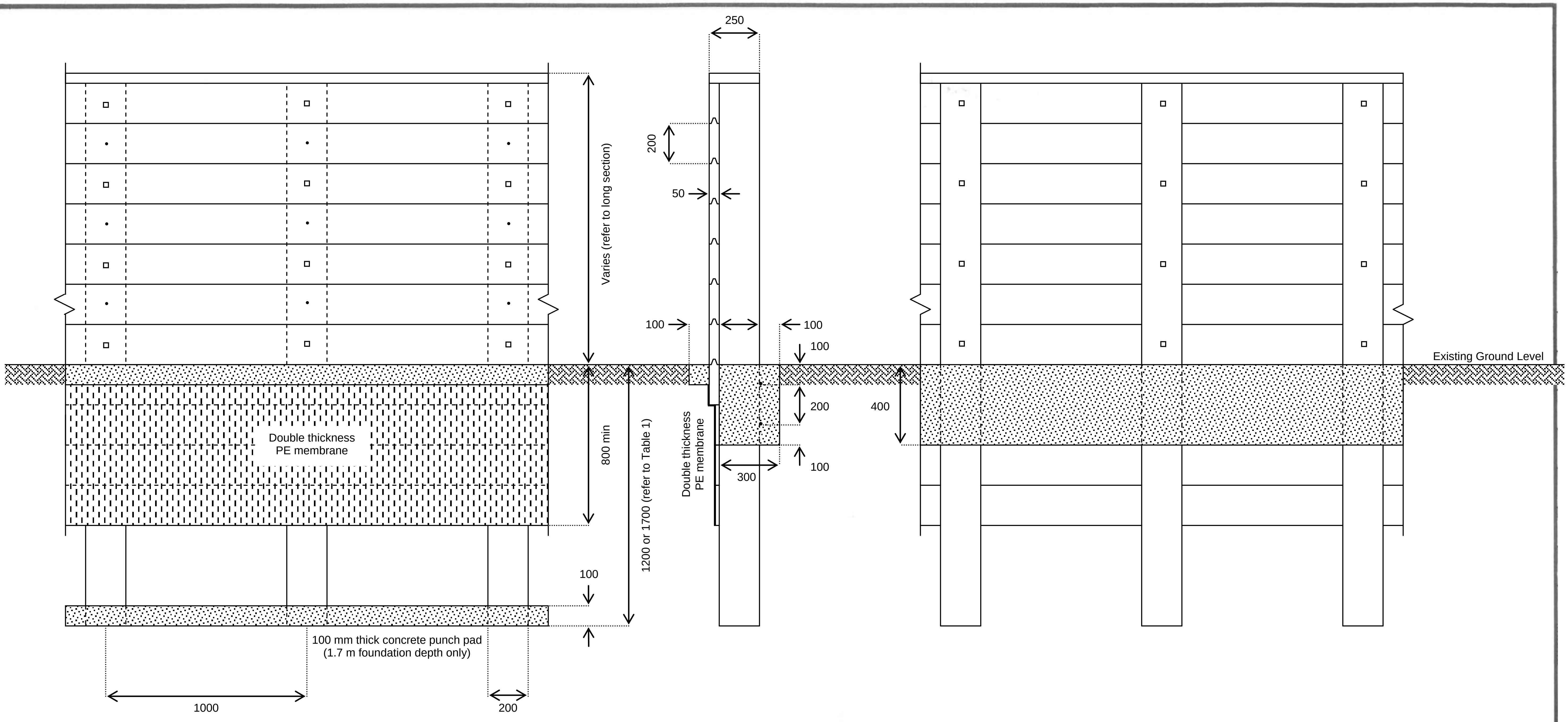
AMENDMENTS		
08/03/05: First draft (for review by RP Spooner) 24/03/05: Second draft (for review by DJ Shilton) 05/05/05: Third draft (for review by RP Spooner)	SURVEYED DESIGNED DRAWN TRACED CHECKED RECOMMENDED DATE APPROVED	CHIEF ENGINEER

WAIKATO REGIONAL COUNCIL

Tararu Flood Protection Scheme

Floodwall Design 1 (1.0 to 1.8 m height above ground)

JOB No.	FIELD BOOK No.
	LEVEL BOOK No.
SCALE 1:20	DRAWING No. Tararu
FILE REF. 82 06 93	SHEET No. 2a



Front Elevation (river)

Side Elevation

Rear Elevation (land)

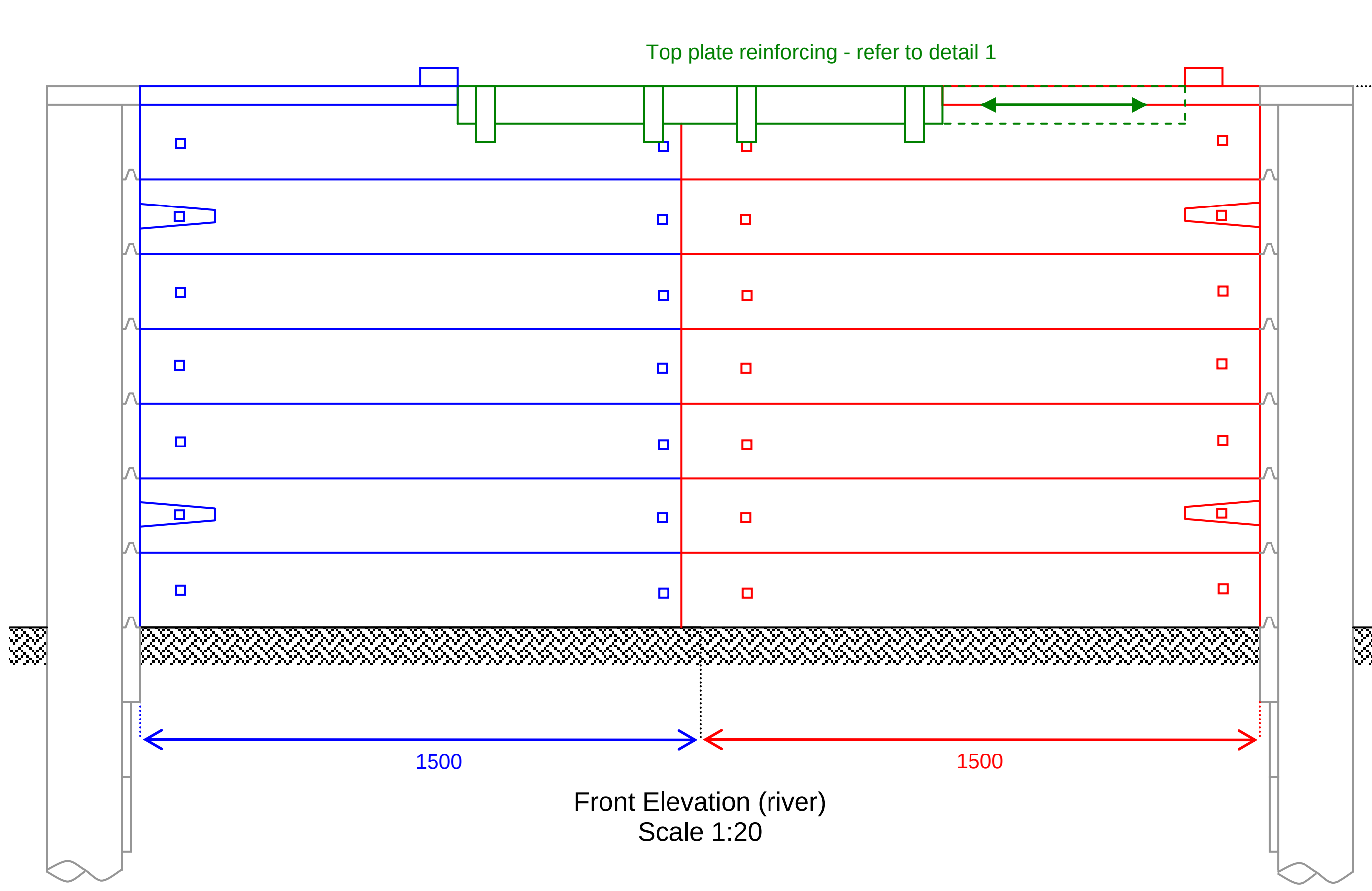
AMENDMENTS				
08/03/05: First draft (for review by RP Spooner) 24/03/05: Second draft (for review by DJ Shilton) 05/05/05: Third draft (for review by RP Spooner)	SURVEYED			
	DESIGNED			
	DRAWN			
	TRACED			
	CHECKED			
	RECOMMENDED			
	DATE APPROVED	CHIEF ENGINEER		

WAIKATO REGIONAL COUNCIL

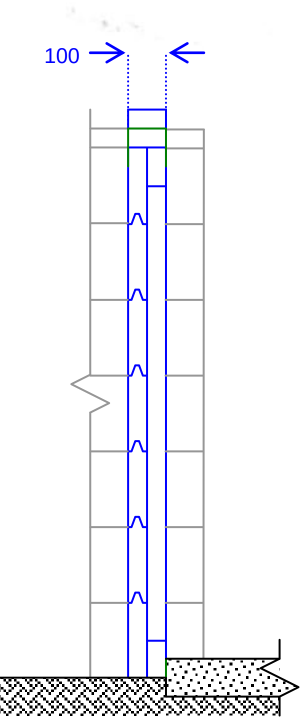
Tararu Flood Protection Scheme

Floodwall Design 1 (1.0 to 1.8 m height above ground)

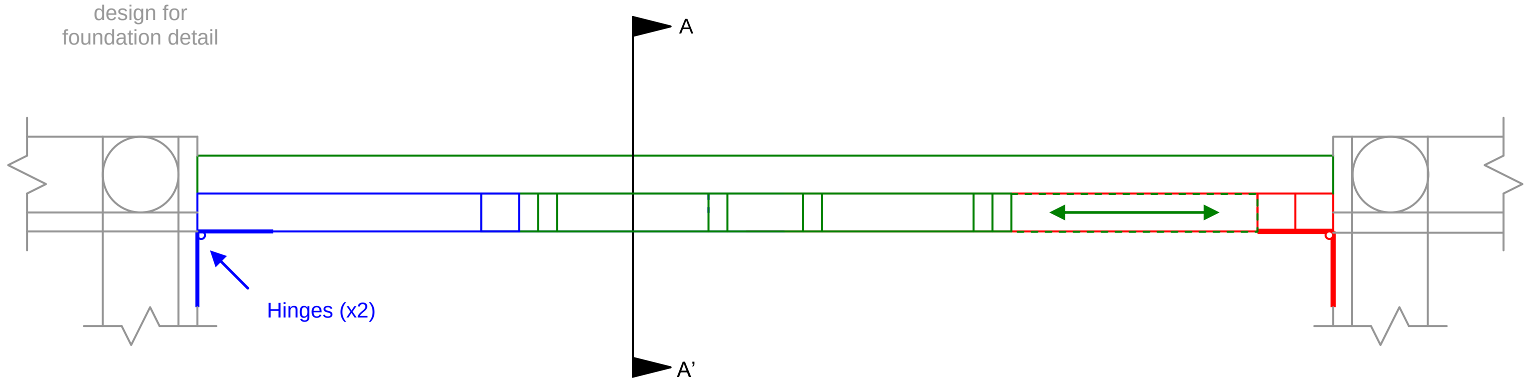
JOB No.	FIELD BOOK No.
	LEVEL BOOK No.
SCALE 1:20	DRAWING No. Tararu
FILE REF. 82 06 93	SHEET No. 2b



Front Elevation (river)
Scale 1:20



Cross Section A – A'
Scale 1:20



Plan
Scale 1:20

Notes:

Vertical bracing:	200 x 50 mm timber anchored to planks with 12mm hot dip galvanised engineers bolts and square washers.
Diagonal bracing:	100 x 50 mm timber anchored to each plank with nails.
Horizontal bracing:	100 x 50 mm timber anchored to top and bottom plank with nails at 200 mm centres.
Planks:	200 x 50 mm tongue and groove anchored using 12mm hot dip galvanised engineers bolts with square washers.
Capping board:	100 x 50 mm timber anchored to top plank with nails at 200 mm centres.
Driveway plate:	100 x 25 mm mild steel u-section anchored with 10 mm countersunk dynabolts.
Top plate reinforcing:	100 x 50 mm mild steel U section to slide along top of gates with mild steel brackets anchored using 12mm hot dip galvanised engineers bolts with square washers.
Hinges:	Heavy duty stainless steel.
Timber treatment:	H5.

AMENDMENTS

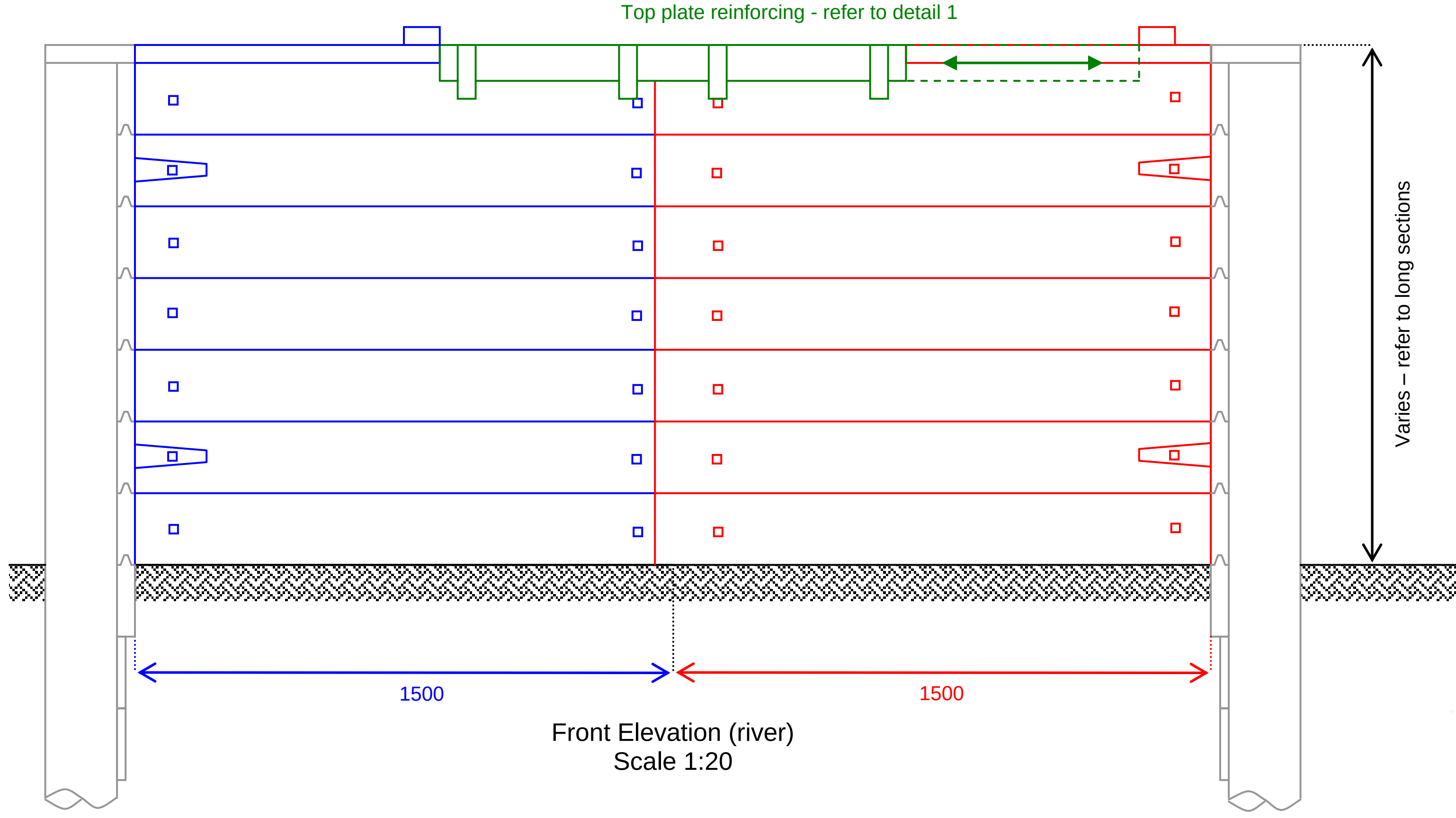
SURVEYED
DESIGNED
DRAWN
TRACED
CHECKED
RECOMMENDED
DATE APPROVED
CHIEF ENGINEER

WAIKATO REGIONAL COUNCIL

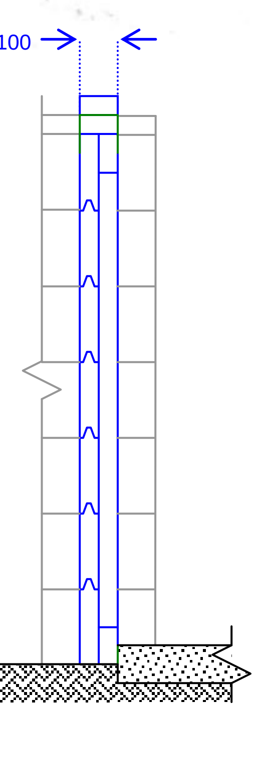
Tararu Flood Protection Scheme

Entrance Way Design (no hidden detail)

JOB No.
SCALE As Shown
FILE REF. 82 06 93
FIELD BOOK No.
LEVEL BOOK No.
DRAWING No. Tararu
SHEET No. 3

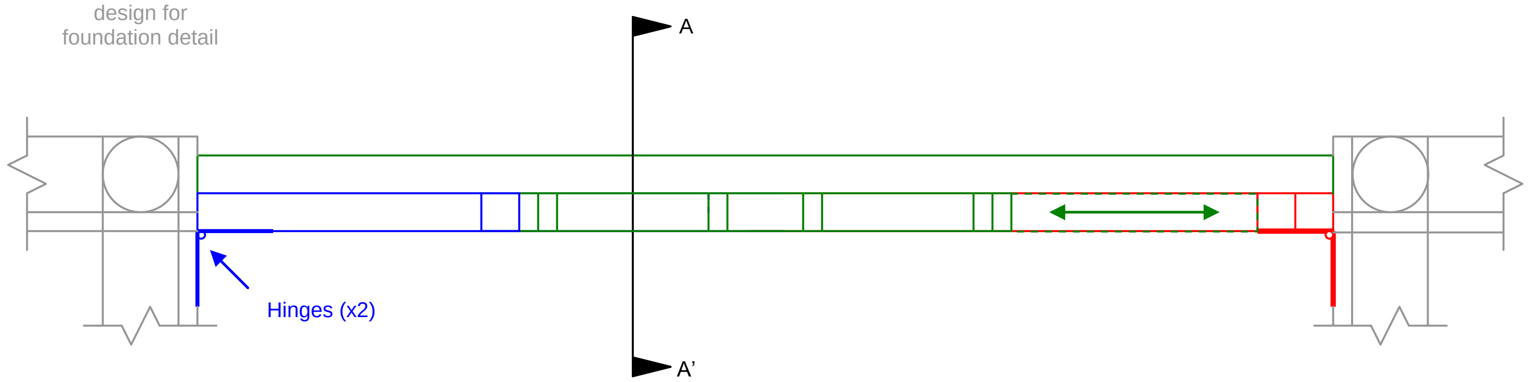


Front Elevation (river)
Scale 1:20



Cross Section A – A'
Scale 1:20

Refer to floodwall design for foundation detail



Plan
Scale 1:20

Notes:

Vertical bracing:	200 x 50 mm timber anchored to planks with 12mm hot dip galvanised engineers bolts and square washers.
Diagonal bracing:	100 x 50 mm timber anchored to each plank with nails.
Horizontal bracing:	100 x 50 mm timber anchored to top and bottom plank with nails at 200 mm centres.
Planks:	200 x 50 mm tongue and groove anchored using 12mm hot dip galvanised engineers bolts with square washers.
Capping board:	100 x 50 mm timber anchored to top plank with nails at 200 mm centres.
Driveway plate:	100 x 25 mm mild steel u-section anchored with 10 mm countersunk dynabolts.
Top plate reinforcing:	100 x 50 mm mild steel U section to slide along top of gates with mild steel brackets anchored using 12mm hot dip galvanised engineers bolts with square washers.
Hinges:	Heavy duty stainless steel.
Timber treatment:	H5.

AMENDMENTS

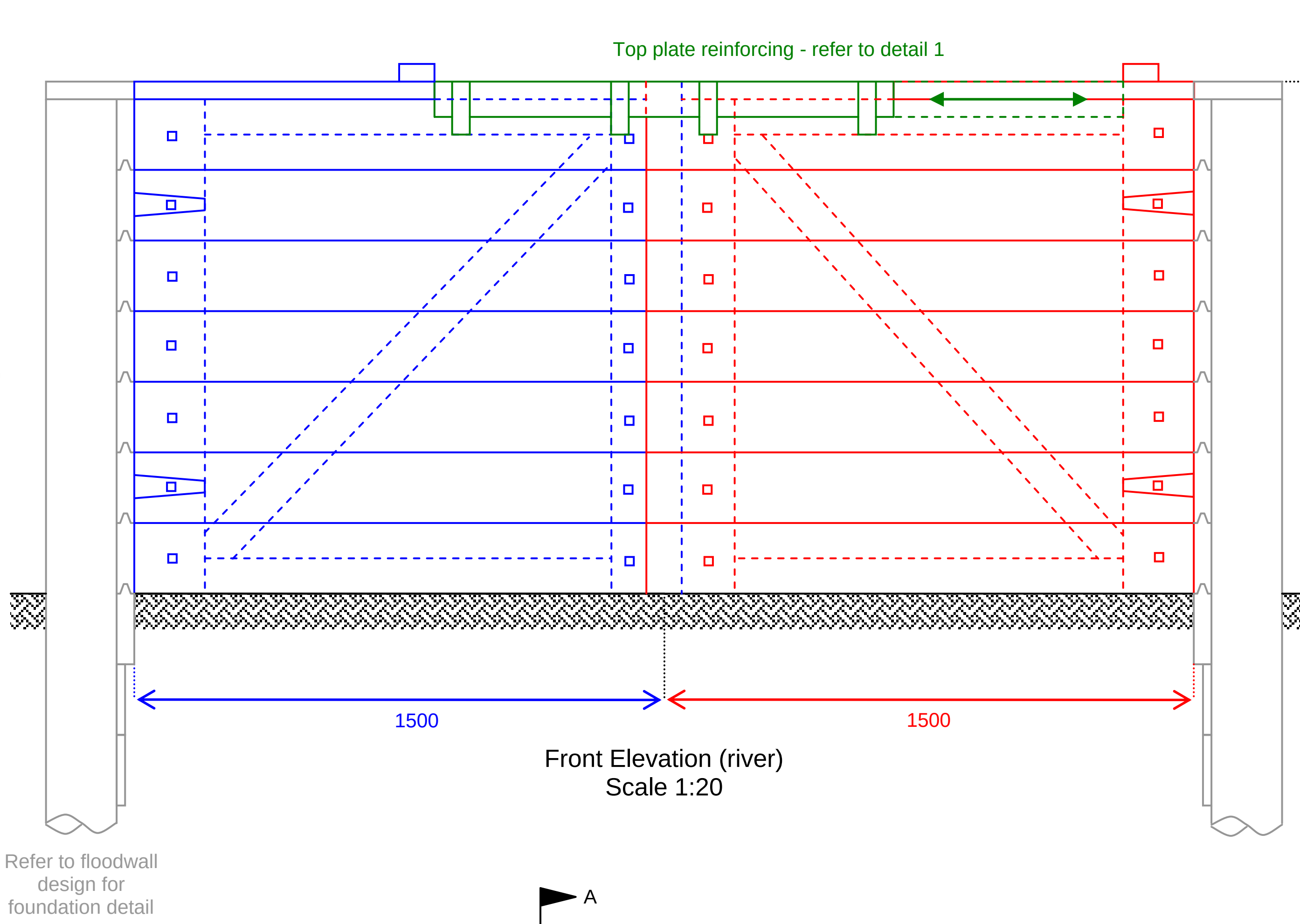
SURVEYED
DESIGNED
DRAWN
TRACED
CHECKED
RECOMMENDED
DATE APPROVED
CHIEF ENGINEER

WAIKATO REGIONAL COUNCIL

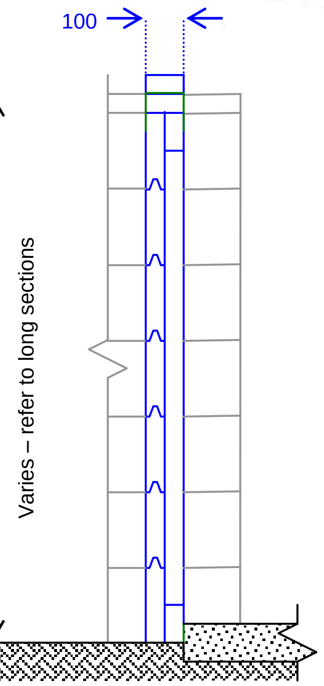
Tararu Flood Protection Scheme

Entrance Way Design (no hidden detail)

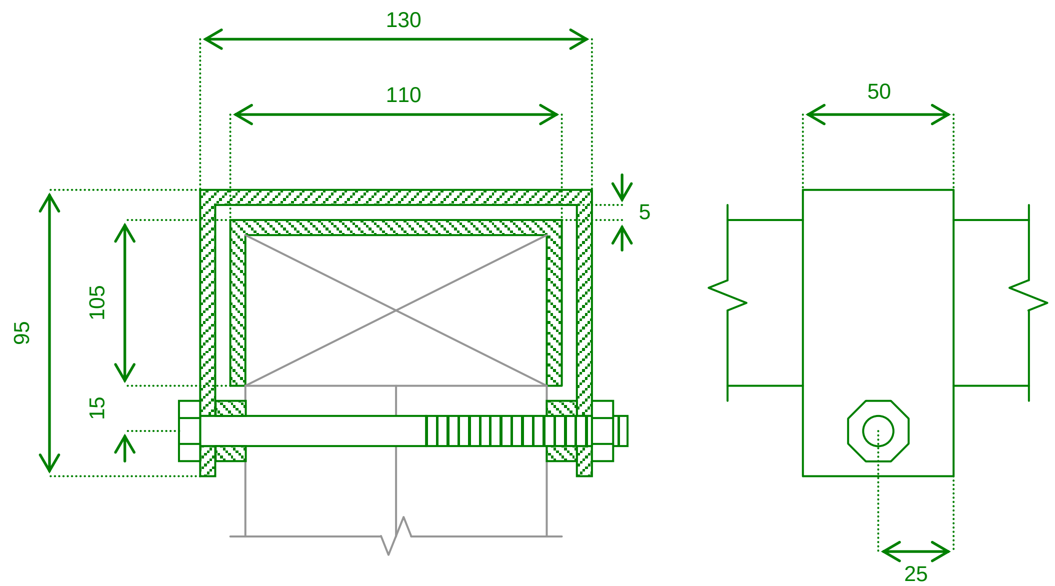
JOB No.
SCALE As Shown
FILE REF. 82 06 93
FIELD BOOK No.
LEVEL BOOK No.
DRAWING No. Tararu
SHEET No. 3



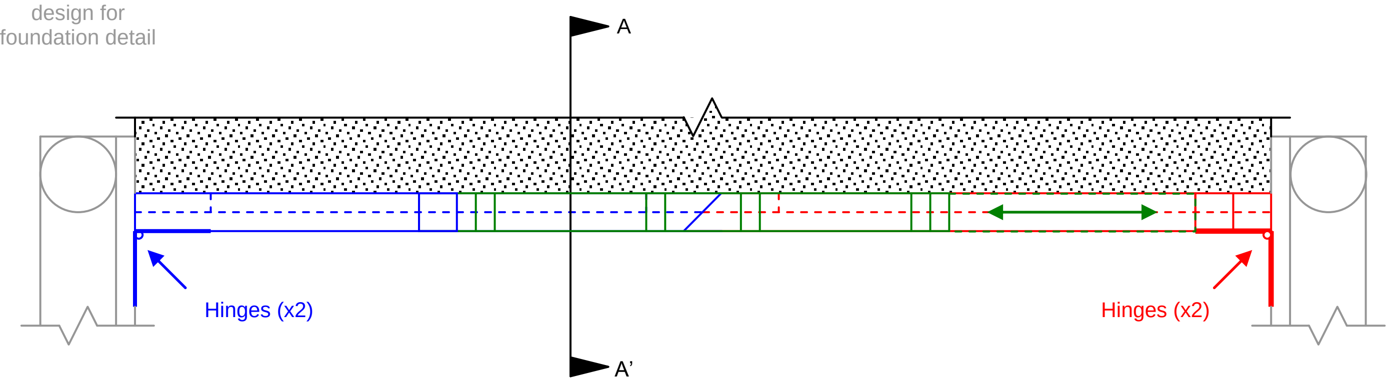
Front Elevation (river)
Scale 1:20



Cross Section A – A'
Scale 1:20



Detail 1 – Top Plate Reinforcing
Scale 1:2.5



Plan
Scale 1:20

Notes:

Vertical bracing:	200 x 50 mm timber anchored to planks with 12mm hot dip galvanised engineers bolts and square washers.
Diagonal bracing:	100 x 50 mm timber anchored to each plank with nails.
Horizontal bracing:	100 x 50 mm timber anchored to top and bottom plank with nails at 200 mm centres.
Planks:	200 x 50 mm tongue and groove anchored using 12mm hot dip galvanised engineers bolts with square washers.
Capping board:	100 x 50 mm timber anchored to top plank with nails at 200 mm centres.
Driveway plate:	50 x 5 mm mild steel plate anchored to a concrete step with10 mm countersunk dynabolts.
Top plate reinforcing:	100 x 50 mm mild steel U section to slide along top of gates with mild steel brackets anchored using 12mm hot dip galvanised engineers bolts with square washers.
Hinges:	Heavy duty stainless steel.
Timber treatment:	H5.

AMENDMENTS

SURVEYED
DESIGNED
DRAWN
TRACED
CHECKED
RECOMMENDED
DATE APPROVED
CHIEF ENGINEER

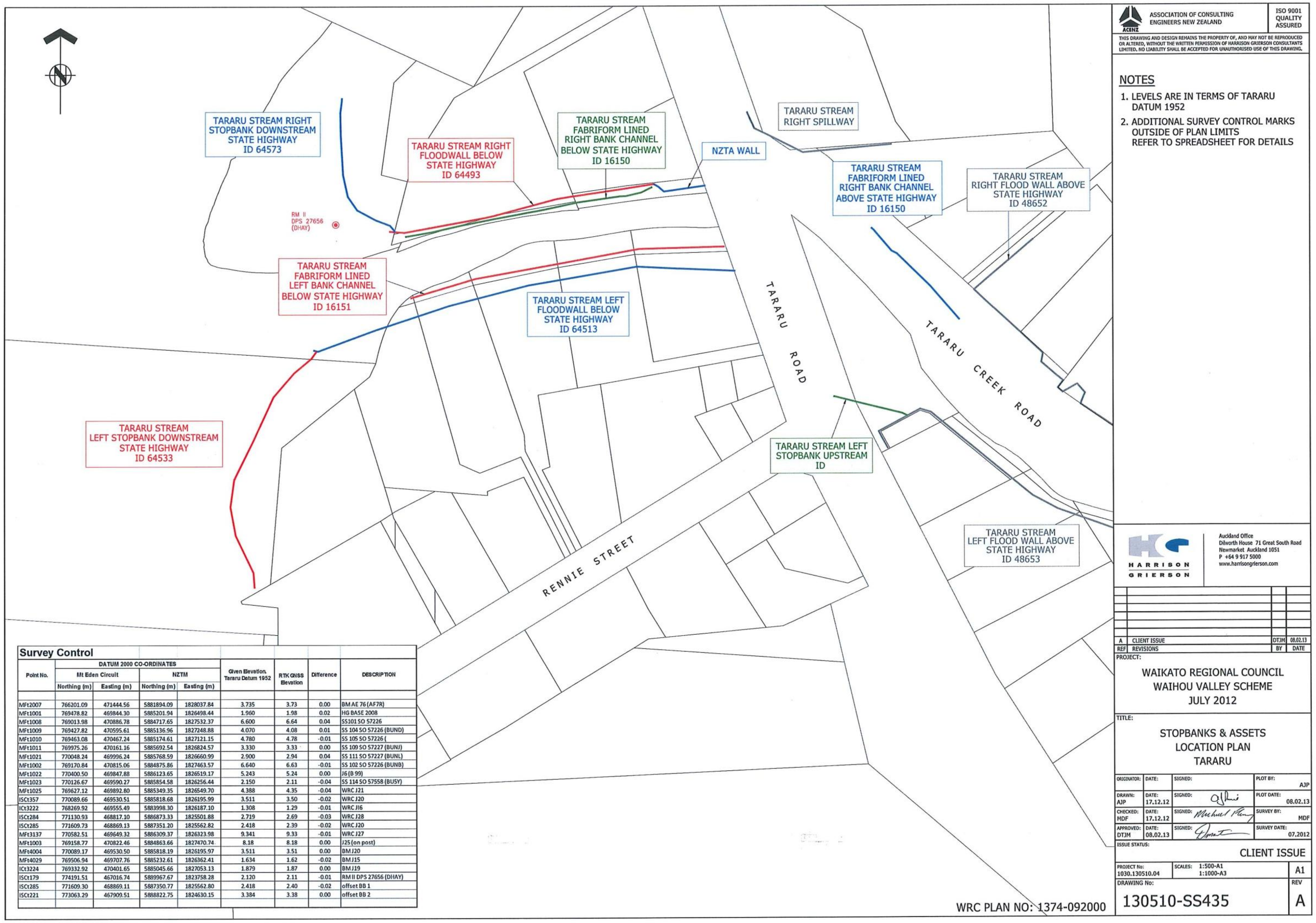
WAIKATO REGIONAL COUNCIL

Tararu Flood Protection Scheme

Entrance Way Design (perpendicular to floodwall)

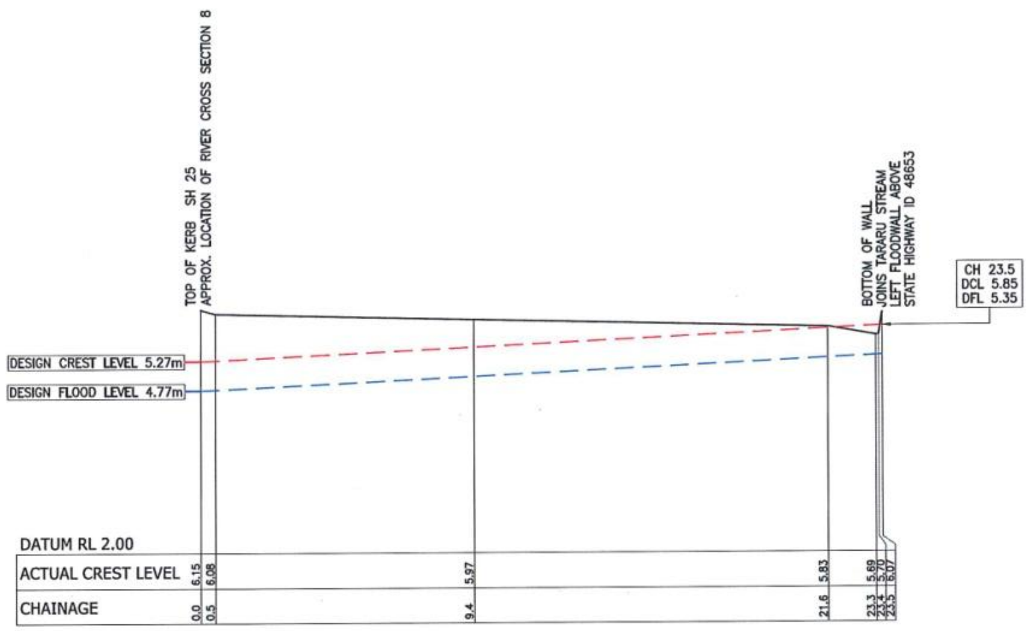
JOB No.
FIELD BOOK No.
LEVEL BOOK No.
SCALE As shown
DRAWING No. Tararu
FILE REF. 82 06 93
SHEET No. 1

Appendix 2 As-built survey



Survey Control

Point No.	DATUM 2000 CO-ORDINATES Mt Eden Circuit Northing (m)	Mt Eden Circuit Easting (m)	NZTM Northing (m)	NZTM Easting (m)	Given Elevation. Tararu Datum 1952	RTK GNSS Elevation	Difference	DESCRIPTION
MFt2007	766201.09	471444.56	5881894.09	1828037.84	3.735	3.73	0.00	BM AE 76 (AF7R)
MFt1001	769478.82	469844.30	5885201.94	1826498.44	1.960	1.98	0.02	HG BASE 2008
MFt1008	769013.98	470886.78	5884717.65	1827532.37	6.600	6.64	0.04	SS101 SO 57226
MFt1009	769427.82	470595.61	5885136.96	1827248.88	4.070	4.08	0.01	SS 104 SO 57226 (BUND)
MFt1010	769463.08	470467.24	5885174.61	1827121.15	4.780	4.78	-0.01	SS 105 SO 57226 (
MFt1011	769975.26	470161.16	5885692.54	1826824.57	3.330	3.33	0.00	SS 109 SO 57227 (BUNJ)
MFt1021	770048.24	469996.24	5885768.59	1826660.99	2.900	2.94	0.04	SS 111 SO 57227 (BUNL)
MFt1002	769170.84	470815.06	5884875.86	1827463.57	6.640	6.63	-0.01	SS 102 SO 57226 (BUNB)
MFt1022	770400.50	469847.88	5886123.65	1826519.17	5.243	5.24	0.00	J6 (B 99)
MFt1023	770126.67	469590.27	5885854.58	1826256.44	2.150	2.11	-0.04	SS 114 SO 57558 (BUSY)
MFt1025	769627.12	469892.80	5885349.35	1826549.70	4.388	4.35	-0.04	WRC J21
ISCt357	770089.66	469530.51	5885818.68	1826195.99	3.511	3.50	-0.02	WRC J20
ICt3222	768269.92	469555.49	5883998.30	1826187.10	1.308	1.29	-0.01	WRC JI6
ISCt284	771130.93	468817.10	5886873.33	1825501.88	2.719	2.69	-0.03	WRC J28
ISCt285	771609.73	468869.13	5887351.20	1825562.82	2.418	2.39	-0.02	WRC J20
MFt3137	770582.51	469649.32	5886309.37	1826323.98	9.341	9.33	-0.01	WRC J27
MFt1003	769158.77	470822.46	5884863.66	1827470.74	8.18	8.18	0.00	J25 (on post)
MFt4004	770089.17	469530.50	5885818.19	1826195.97	3.511	3.51	0.00	BM J20
MFt4029	769506.94	469707.76	5885232.61	1826362.41	1.634	1.62	-0.02	BM J15
ICt3224	769332.92	470401.65	5885045.66	1827053.13	1.879	1.87	0.00	BM J19
ISCt179	774191.51	467016.74	5889967.67	1823758.28	2.120	2.11	-0.01	RM II DPS 27656 (DHAY)
ISCt285	771609.30	468869.11	5887350.77	1825562.80	2.418	2.40	-0.02	offset BB 1
ISCt221	773063.29	467909.51	5888822.75	1824630.15	3.384	3.38	0.00	offset BB 2



TARARU STREAM LEFT STOPBANK UPSTREAM STATE HIGHWAY

LONG SECTION BETWEEN 0.0 AND 23.5

SCALES (A1) - 1:100-HOR 1:50-VER

NOTES:

1. NEW ASSET NOT YET IN CONQUEST
   DESIGN DATA FROM MAUNSELL: WRC DOC #1321290
2. DFL AT THE WALL HAS BEEN BASED ON THE FLAT GRADIENT BETWEEN RIVER CROSS SECTIONS 6 & 7 WITH A 0.5m FREEBOARD

1. LEVELS ARE IN TERMS OF TARARU DATUM 1952
2. DESIGN LEVELS DERIVED FROM WAIKATO REGIONAL COUNCIL CONQUEST DATABASE UNLESS OTHERWISE STATED

WRC PLAN NO: 1374-092000

REF	REVISIONS	BY	DATE
A	CLIENT ISSUE	DTJM	08.02.13

ORIGINATOR:	DATE:	SIGNED:	PLOT BY: AJP
DRAWN: AJP	DATE: 16.12.12	SIGNED:	PLOT DATE: 08.02.13
CHECKED: MDF	DATE: 20.12.12	SIGNED:	SURVEY BY: MDF
APPROVED: DTJM	DATE: 08.02.13	SIGNED:	SURVEY DATE: 12.2012

ASSOCIATION OF CONSULTING ENGINEERS NEW ZEALAND ACENZ

ISO 9001 QUALITY ASSURED

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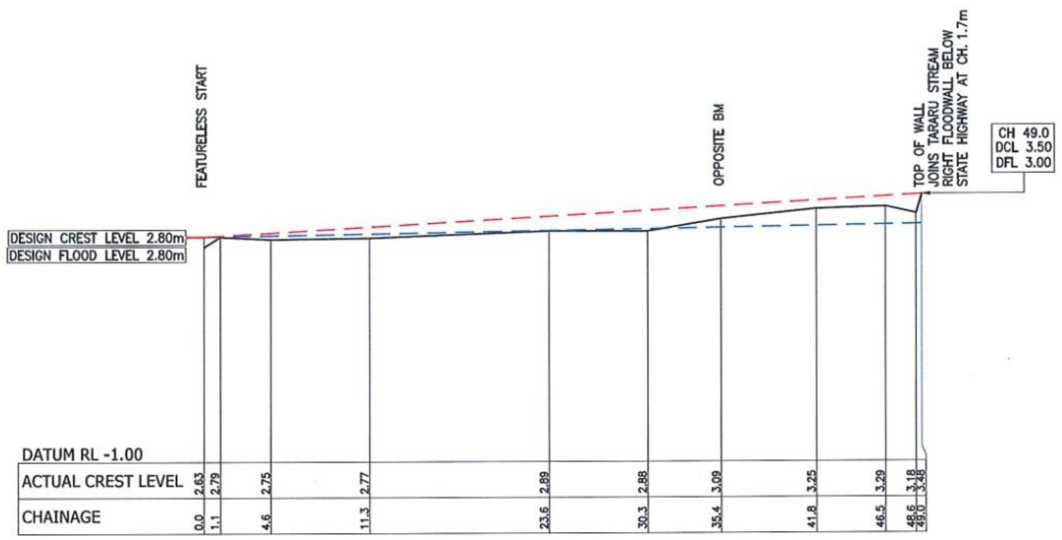
PROJECT:
WAIKATO REGIONAL COUNCIL
WAIHOU VALLEY SCHEME
JULY 2012

TITLE:
TARARU
LONG SECTIONS

ISSUE STATUS: CLIENT ISSUE

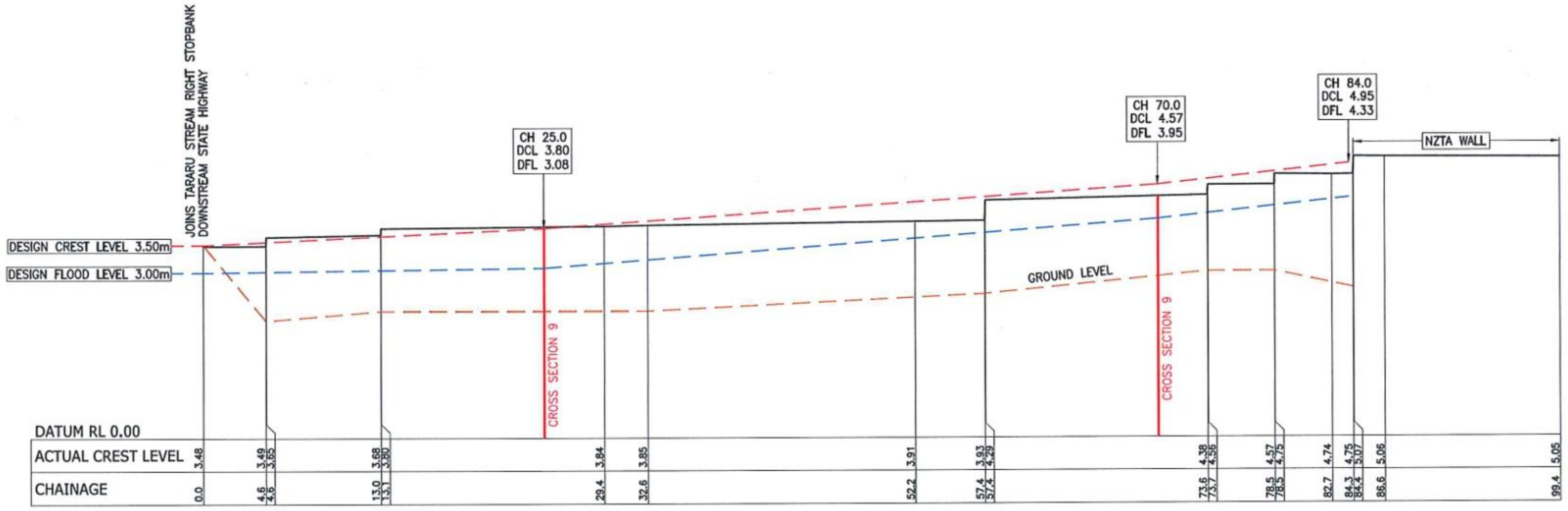
PROJECT No: 1030.130510.04 | SCALES: AS SHOWN | A1

DRAWING No: 130510-SS438 | REV A



NOTE:
DESIGN LEVELS FROM WRC PLAN NO. 1226-094006

TARARU STREAM RIGHT STOPBANK DOWNSTREAM STATE HIGHWAY ID 64573
LONG SECTION BETWEEN 0.0 AND 49.0
SCALES (A1) - 1:200-HOR 1:50-VER



NOTE:
DESIGN LEVELS FROM WRC PLAN NO. 1226-094006
& MAUNSELL MODELLING REFER TO DOC # 1321290

TARARU STREAM RIGHT FLOODWALL BELOW STATE HIGHWAY ID 64493
LONG SECTION BETWEEN 0.0 AND 99.4
SCALES (A1) - 1:200-HOR 1:50-VER

1. LEVELS ARE IN TERMS OF TARARU DATUM 1952
2. DESIGN LEVELS DERIVED FROM WAIKATO REGIONAL COUNCIL CONQUEST DATABASE UNLESS OTHERWISE STATED

WRC PLAN NO: 1374-092000

REF	REVISIONS	BY	DATE				
A	CLIENT ISSUE	DTJM	08.02.13				
				ORIGINATOR:	DATE:	SIGNED:	PLOT BY: AJP
				DRAWN: AJP	DATE: 16.12.12	SIGNED:	PLOT DATE: 08.02.13
				CHECKED: MDF	DATE: 20.12.12	SIGNED:	SURVEY BY: MDF
				APPROVED: DTJM	DATE: 08.02.13	SIGNED:	SURVEY DATE: 12.2012

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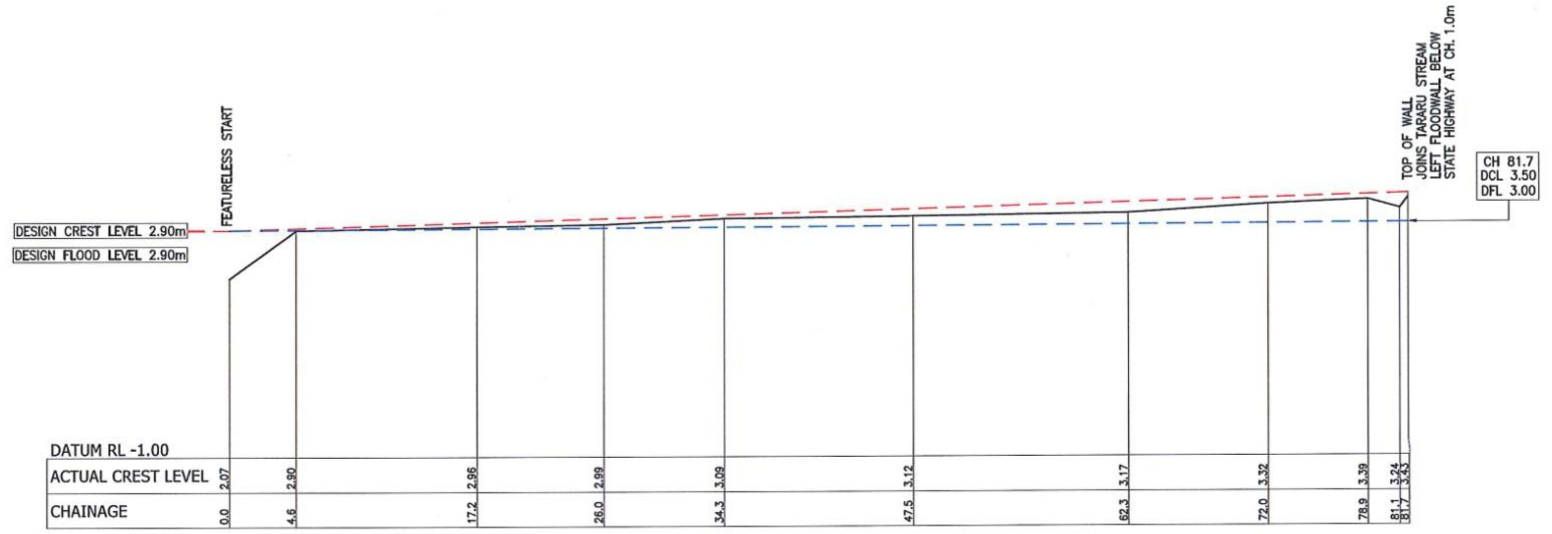
WAIHOU VALLEY SCHEME
JULY 2012

TITLE: TARARU
LONG SECTIONS

ISSUE STATUS: CLIENT ISSUE
PROJECT No: 1030.130510.04 | SCALES: AS SHOWN | A1
DRAWING No: 130510-SS437 | REV: A

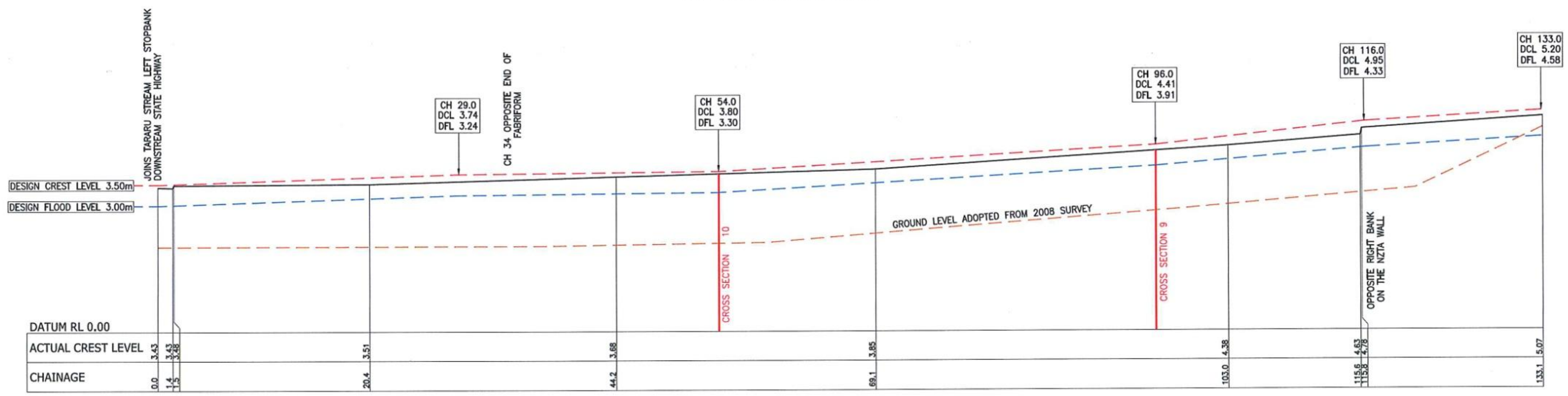


NOTE:
DESIGN LEVELS FROM WRC PLAN NO. 1226-094006

TARARU STREAM LEFT STOPBANK DOWNSTREAM STATE HIGHWAY ID 64533

LONG SECTION BETWEEN 0.0 AND 81.7

SCALES (A1) - 1:200-HOR 1:50-VER



NOTE:
DESIGN LEVELS FROM WRC PLAN NO. 1226-094006
& MAUNSELL MODELLING REFER TO DOC # 1321290

TARARU STREAM LEFT FLOODWALL BELOW STATE HIGHWAY ID 64513

LONG SECTION BETWEEN 0.0 AND 133.1

SCALES (A1) - 1:200-HOR 1:50-VER

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WRC PLAN NO: 1374-092000

REF	REVISIONS	BY	DATE
A	CLIENT ISSUE	DTJM	08.02.13

ORIGINATOR: AJP DATE: 16.12.12 SIGNED:
DRAWN: AJP DATE: 16.12.12 SIGNED:
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APPROVED: DTJM DATE: 08.02.13 SIGNED:
PLOT BY: AJP
PLOT DATE: 08.02.13
SURVEY BY: MDF
SURVEY DATE: 12.2012

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JULY 2012

TITLE: TARARU
LONG SECTIONS

ISSUE STATUS: CLIENT ISSUE
PROJECT No: 1030.130510.04 SCALES: AS SHOWN A1
DRAWING No: 130510-SS436 REV A

Appendix 3 Bridge modelling results

Background

A MIKE-11 model was used to assess the performance of the old SH25 Bridge and to design a bridge upgrade.

Three design scenarios were modelled as part of the SH25 Bridge upgrade project. The first scenario represented the existing (pre-upgrade) situation. This included a 13m wide bridge which acts as a major flow obstruction in events greater than a 10% AEP event. The other two scenarios deal with bridge widening, stream widening and flood protection measures such as flood walls. The first of these included an increase of the bridge span to 20m and the second included an increase of the bridge span to 25m. The following provides the main results for the three different scenarios.

Model results

Scenario A: Existing scenario (pre-upgrade)

The model of the current bridge and channel scenario was run with an inflow hydrograph for the 1% AEP event flows ($222m^3/s$). The results from this confirmed wide-spread flooding and the role of the SH25 Bridge in restricting the flood flows.

Scenario B: 20 metre wide SH25 Bridge

This scenario increased the bridge span from 13m to 20m. To carry out sensitivity tests, four different tailwater level conditions had been used to compare water level results for the bridge cross section with an inflow of $222m^3/s$.

The same model configuration was used to simulate the expected future climate change effects. These included a 20% increase in the peak 1% AEP flows ($267m^3/s$) and a 0.5m rise in sea level (2.0m).

Using NZTA's requirement of a 1.2m freeboard in the case of the 1% AEP event and a friction loss allowance at the bridge of 0.1m, the required soffit levels of a new bridge were calculated.

The results of all simulations are shown in the following table:

Table A1 Modelling results for a 20 metre wide SH25 Bridge

Tailwater level (m)	Modelled WL (m)	Superelevation allowance (m)	Actual WL (m)	Required soffit level (m)
-0.1	4.37	0.42	4.79	6.09
0.7	4.38	0.42	4.80	6.10
1.5	4.40	0.41	4.81	6.11
1.9	4.44	0.41	4.85	6.15
Climate change simulation*				
2m	5.08	0.41*	5.59	6.79

* Super-elevation is assumed to remain the same with climate change.

It should be noted that the levels provided in the table above are for a new bridge located at the same location as the existing SH25 Bridge. If the new SH25 Bridge was constructed at WRC's preferred location (downstream of the current bridge on a straight part of the channel), the soffit level would be lowered by at least 0.16m and potentially by up to 0.46m or (RL6.33 m).

Scenario C: 25 metre wide SH25 Bridge

This scenario increased the bridge span from 13m to 25m. This scenario was run for one tailwater level (1.5m) and an inflow of 222m^3/s for the existing climate and 267m^3/s for the future climate change scenario with a tailwater level of 2.0m.

The results obtained on the basis of a single tailwater level are shown in Table A2 below. The reduction in soffit height for the 1.5m tailwater case is 0.23m as compared to a 20m bridge.

Table A2 Modelling results for a 25m wide SH25 Bridge

Tailwater level (m)	Modelled WL (m)	Superelevation allowance (m)	Actual WL (m)	Required soffit level (m)
1.5	4.26	0.32	4.58	5.88
Climate change simulation*				
2.0	4.55	0.32*	4.97	6.17

* Super-elevation is assumed to remain the same with the climate change.

The same comment above about the location of the bridge is relevant to the results in this table as well. If the new SH25 Bridge was constructed at WRC's preferred location (downstream of the old bridge on a straight part of the channel), the soffit level would be lowered by at least 0.16m and potentially by up to 0.37m or (RL5.85 m).

Appendix 4 Bridge assessment

Tararu Stream Bridge Assessment

Objective
To determine the flood mitigation benefit due to the upgrade of the SH25 bridge at Tararu.

Methodology
A MIKE11 model was used to undertake a hydraulic analysis of the stream with the impact of the old bridge, the new bridge and the flood walls. Previous studies had determined that the 100-year return period flow would be 220m^3/s. By design, this was the flow at which the new flood walls would be "at risk" (in terms of flood levels being 500mm below the top of the walls). The flow was input as steady state because the reach is short and there are no volume/attenuation issues. The tide level was set to RL1.5m.

Three scenarios were modelled.

- The old bridge and no flood walls
- The new bridge and no flood walls
- The new bridge and new flood walls

The old bridge details are: height to deck = 3.23m, flow width = 13m. The new bridge details are: height to deck = 4.75m, flow width = 18.9m. The new bridge represents an increase in area from 42m^2 to 90m^2.

Results

Table 1 – Summary of Peak Flood Levels for 220m^3/s Flow

XS	Model XS Label	Distance (m)	Old bridge, no flood walls	New bridge, no flood walls	New bridge, flood walls
	TARARU STREAM 0.00	0	8.67	8.67	8.68
	TARARU STREAM 28.00	28	8.21	8.20	8.22
	TARARU STREAM 85.00	85	7.41	7.39	7.44
4	TARARU STREAM 134.00	134	6.51	6.43	6.58
5	TARARU STREAM 174.00	174	6.12	5.88	6.09
6	TARARU STREAM 226.00	226	5.99	5.19	5.37
7	TARARU STREAM 279.00	279	5.90	4.76	4.73
8	TARARU STREAM 320.00	320	5.89	4.39	4.27
	TARARU STREAM 325.00	325	5.81	4.40	4.40
	TARARU STREAM 342.00	342	3.48	3.48	3.81
9	TARARU STREAM 373.00	373	3.36	3.36	3.66
10	TARARU STREAM 416.00	416	2.91	2.91	3.13
	TARARU STREAM 550.00	550	1.50	1.50	1.50

Figure 1 – Hydraulic Profile for Peak Flood Levels for 220m^3/s Flow

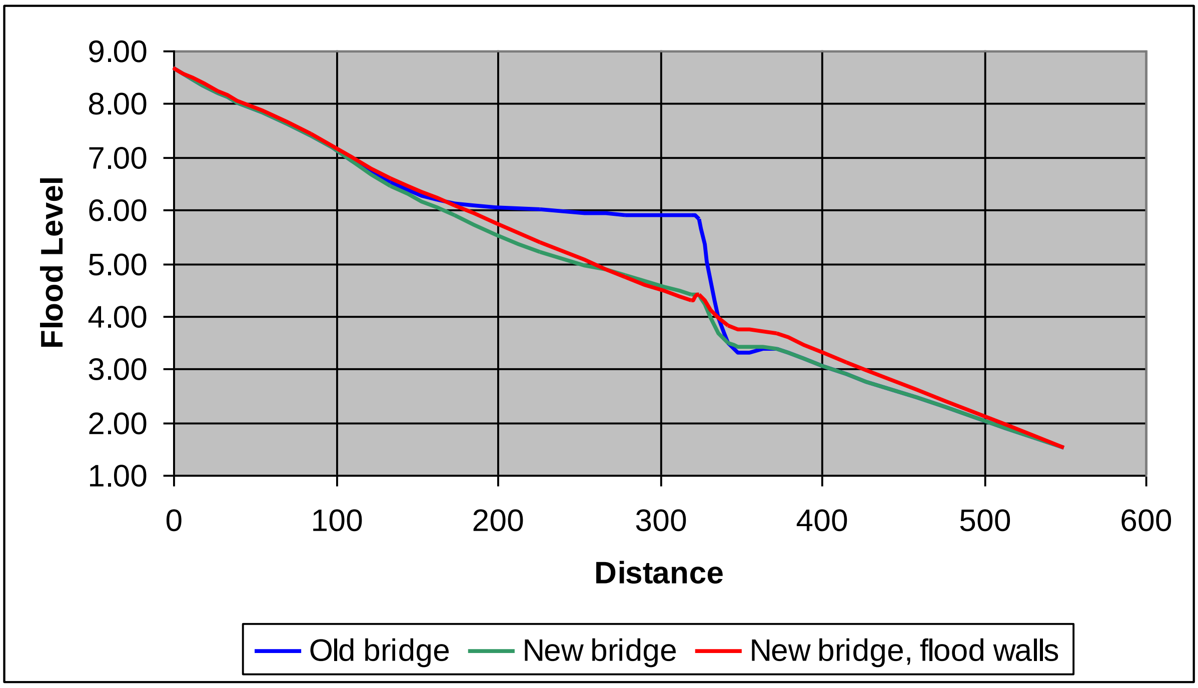


Figure 1 clearly shows the benefit of the new bridge profile. The new bridge allows the flow gradient to be constant whereas the old bridge caused a major restriction. At the bridge itself the flood has been lowered from RL5.81m to RL4.40m (1.41m). The installation of the flood walls have no detrimental impact.

The reduction in flood level due to new bridge extends about 140m upstream to XS5 although the introduction of the flood walls raises the flood level slightly due to reduced flow area.

The extra flow under the new bridge coupled with the flood walls has raised flood levels downstream. The flood walls raise the flood level by 300mm to RL3.66m for XS9 and 220mm to RL3.13m for XS 10. The top of the flood walls at XS 9 and XS10 are RL4.25m and RL3.62m respectively. Therefore these walls are high enough to transmit the extra flow.

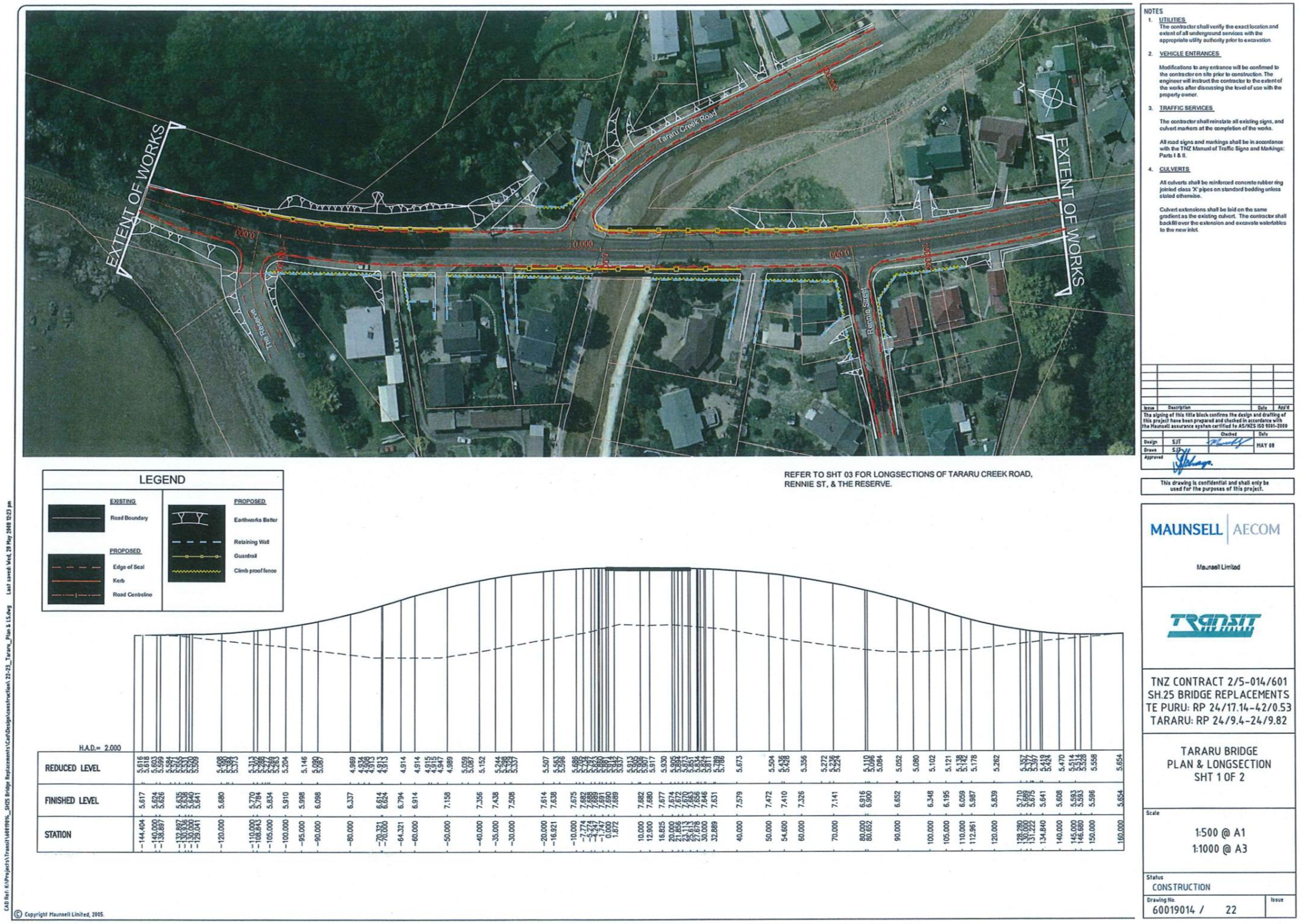
Summary

The new bridge conveys major flows efficiently compared to the old bridge. The flow area is increased 100% which ensures that the 100-year return period flow passes safely. The benefit is a maximum reduction in flood level of 1.41m and covers a reach of 140m.

The installation of flood walls does not compromise the new bridge configuration.

Dr S A Joynes
December 2008

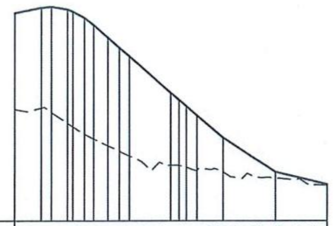
Appendix 5 Bridge upgrade drawings (design)



H.A.D.= 4.000

REDUCED LEVEL	5.696 5.627 5.562 5.513 5.447 5.343 5.317 5.234 5.152 5.068 4.981 4.952 4.887 4.829 4.792 4.789 4.782 4.776 4.774 4.763 4.757 4.759 4.762 4.764 4.766 4.859 4.843 4.892 4.912 4.948 4.976 4.986 5.056 5.061 5.050 5.080 5.233 5.203 5.123 5.275 5.287 5.330 5.281 5.524 5.367 5.496
FINISHED LEVEL	7.651 7.590 7.529 7.455 7.380 7.300 7.206 7.101 6.977 6.820 6.696 6.360 6.033 5.774 5.583 5.461 5.416 5.407 5.422 5.465 5.494 5.511 5.515 5.513 5.511 5.508 5.506 5.504 5.501 5.499 5.496 5.496
STATION	0.890 2.945 5.000 7.500 10.000 12.500 15.000 17.428 20.000 22.913 25.000 30.000 35.000 40.000 45.000 50.000 53.520 55.000 60.000 65.000 70.000 75.000 80.000 85.000 90.000 95.000 100.000 105.000 110.000 115.000 120.000 120.727

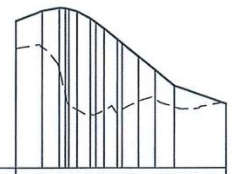
TARARU CREEK ROAD



H.A.D.= 3.000

REDUCED LEVEL	5.127 5.080 5.147 5.057 4.859 4.727 4.629 4.560 4.432 4.328 4.239 4.136 3.959 4.114 4.059 4.053 3.979 4.005 3.973 3.955 3.835 3.891 3.878 3.817 3.825 3.844 3.776 3.806 3.698 3.680
FINISHED LEVEL	6.949 7.049 7.069 7.018 6.979 6.861 6.722 6.486 6.293 6.128 5.437 5.302 5.182 5.009 4.580 3.931 3.695
STATION	0.000 5.000 6.901 10.000 11.012 13.173 15.000 17.758 20.000 21.928 30.000 31.577 32.972 35.000 40.000 50.000 60.000

RENNIE STREET



H.A.D.= 3.000

REDUCED LEVEL	5.282 5.359 4.996 4.198 4.097 4.029 4.128 4.118 4.223 4.321 4.250 4.165 4.128 4.196 4.221
FINISHED LEVEL	5.808 5.996 6.057 6.049 6.037 5.992 5.857 5.782 5.661 5.460 5.379 5.126 4.874 4.573 4.221
STATION	0.000 5.000 8.187 9.305 10.000 11.500 14.000 15.000 [illegible] 16.000 19.000 20.000 23.134 26.268 30.000 40.000

THE RESERVE

NOTES

1. UTILITIES

The contractor shall verify the exact location and extent of all underground services with the appropriate utility authority prior to excavation.

2. VEHICLE ENTRANCES

Modifications to any entrance will be confirmed to the contractor on site prior to construction. The engineer will instruct the contractor to the extent of the works after discussing the level of use with the property owner.

3. TRAFFIC SERVICES

The contractor shall reinstate all existing signs, and culvert markers at the completion of the works.

All road signs and markings shall be in accordance with the TNZ Manual of Traffic Signs and Markings: Parts I & II.

4. CULVERTS

All culverts shall be reinforced concrete rubber ring jointed class 'X' pipes on standard bedding unless stated otherwise.

Culvert extensions shall be laid on the same gradient as the existing culvert. The contractor shall backfill over the extension and excavate watertables to the new inlet.

Issue	Description	Date	App'd

The signing of this title block confirms the design and drafting of this project have been prepared and checked in accordance with the Maunsell assurance system certified to AS/NZS ISO 9001-2000

		Checked	Date
Design	SJT		MAY 08
Drawn	SJT		
Approved			

MAUNSELL | AECOM

Maunsell Limited

TRANSIT

TNZ CONTRACT 2/5-014/601
SH.25 BRIDGE REPLACEMENTS
TE PURU: RP 24/17.14-42/0.53
TARARU: RP 24/9.4-24/9.82

TARARU BRIDGE
PLAN & LONGSECTION
SHT 2 OF 2

Scale

1:500 @ A1
1:1000 @ A3

Status
CONSTRUCTION

Drawing No. 60019014 / 23
Issue

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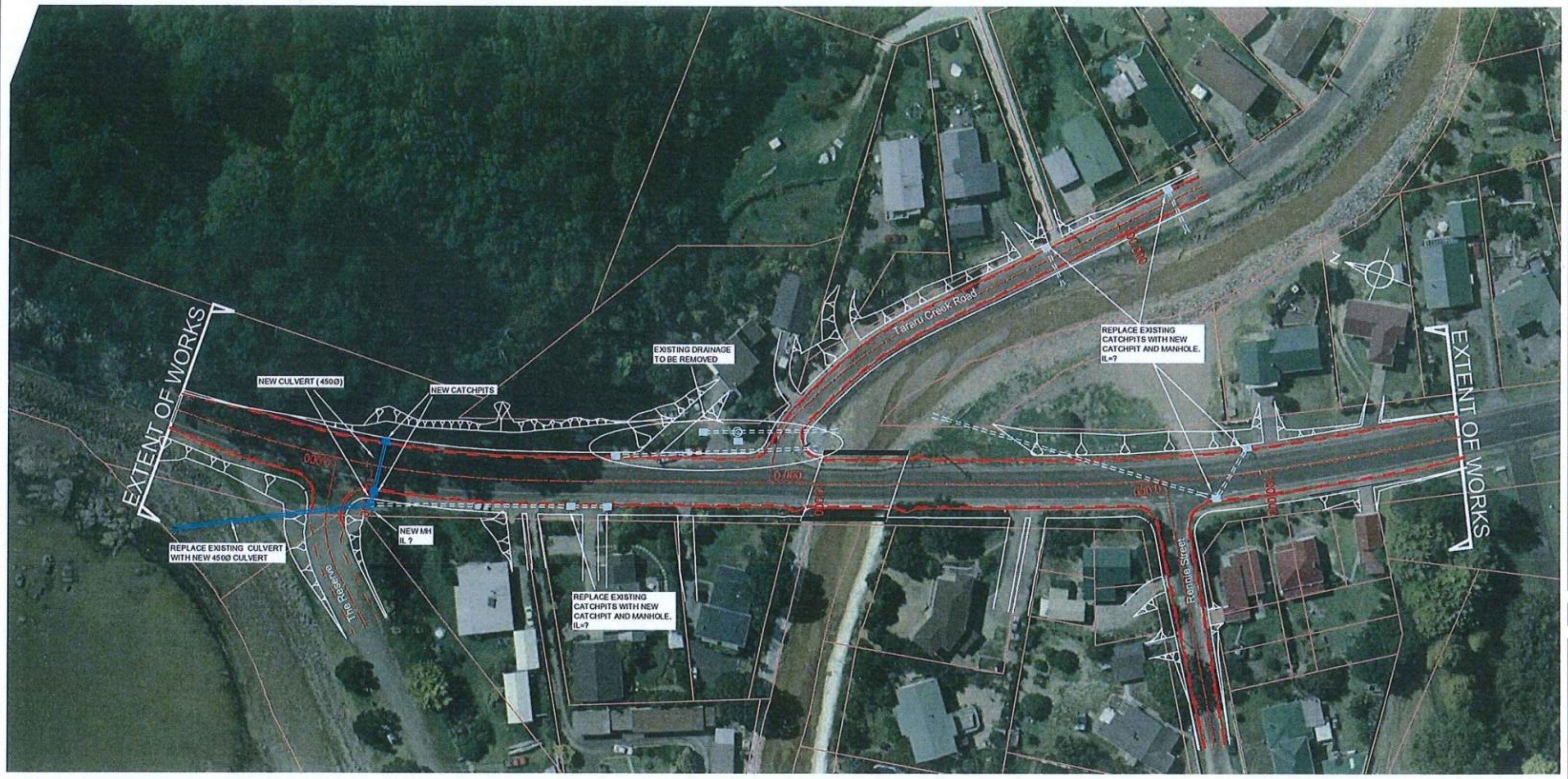

ALL EXISTING SERVICES SHOWN ARE INDICATIVE ONLY

LEGEND

EXISTING	PROPOSED
Road Boundary	Edge of Seal
	Kerb
	Road Centreline
	Earthworks Batter
	Retaining Wall
	Guardrail

NOTES

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		Checked	Date
Design	SJT	[signature]	MAY 08
Drawn	CDE		
Approved	[signature]		

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Maunsell Limited

TRANSIT

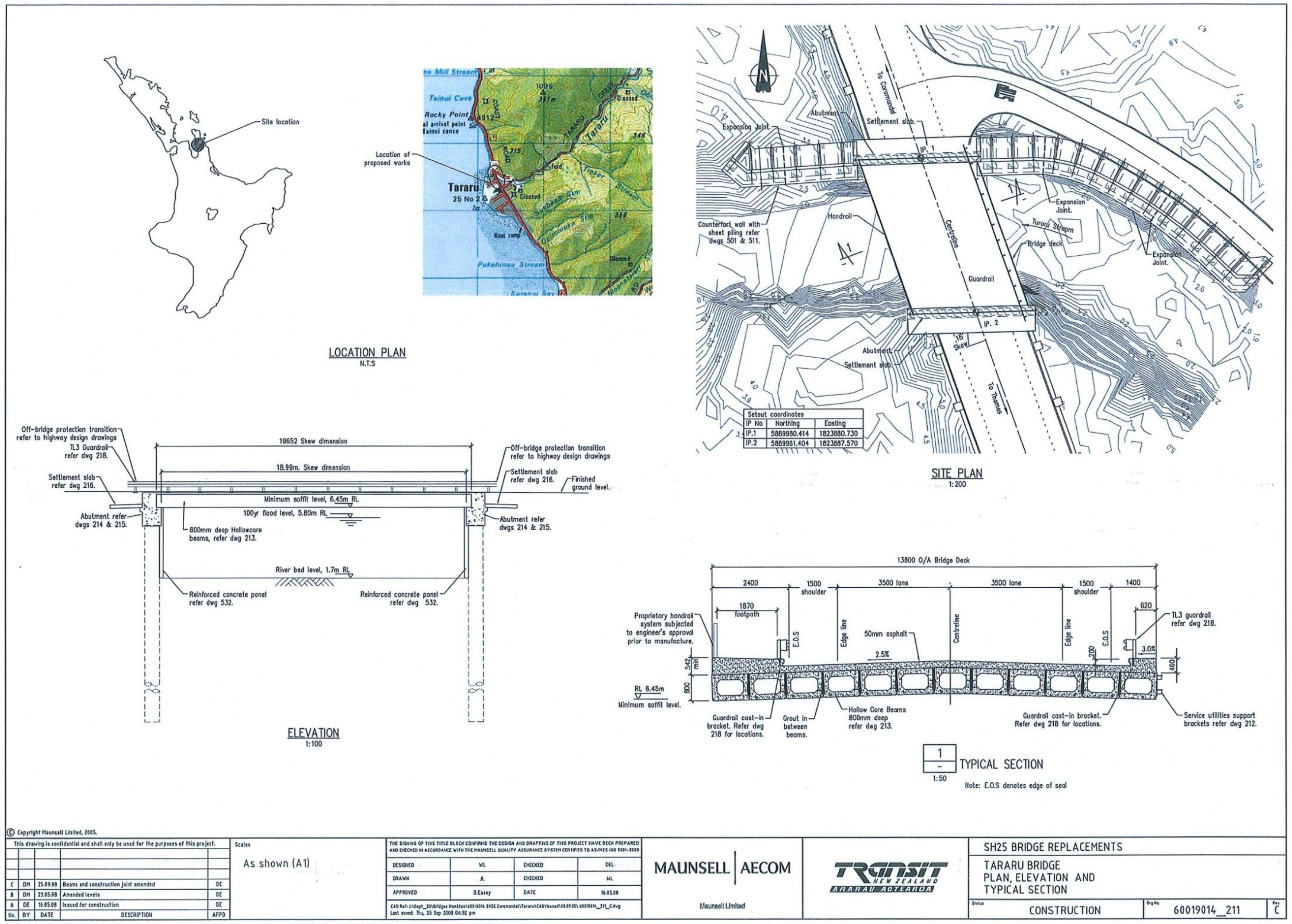
TNZ CONTRACT 2/5-014/601
SH.25 BRIDGE REPLACEMENTS
TE PURU: RP 24/17.14-42/0.53
TARARU: RP 24/9.4-24/9.82

TARARU BRIDGE
DRAINAGE PLAN
SHT 1 OF 1

Scale
1:500 @ A1
1:250 @ A3

Status
CONSTRUCTION

Drawing No. 60019014 / 27
Issue


LOCATION PLAN
N.T.S
Site location
Location of proposed works
Tararu
SITE PLAN
1:200
To Coromandel
To Thames
Expansion Joint
Abutment
Settlement slab
Handrail
Counterfort wall with sheet piling refer dwgs 501 & 511.
Centreline
Guardrail
Tararu Stream
Bridge deck
Setout coordinates
IP No | Northing | Easting
IP.1 | 5889980.414 | 1823880.730
IP.2 | 5889961.404 | 1823887.570
ELEVATION
1:100
19652 Skew dimension
18.99m. Skew dimension
Off-bridge protection transition refer to highway design drawings
TL3 Guardrail refer dwg 218.
Settlement slab refer dwg 216.
Finished ground level.
Minimum soffit level, 6.45m RL.
100yr flood level, 5.80m RL.
Abutment refer dwgs 214 & 215.
800mm deep Hollowcore beams, refer dwg 213.
River bed level, 1.7m RL.
Reinforced concrete panel refer dwg 532.
13800 O/A Bridge Deck
2400
1500 shoulder
3500 lane
3500 lane
1500 shoulder
1400
1870 footpath
620
Proprietary handrail system subjected to engineer's approval prior to manufacture.
E.O.S
Edge line
50mm asphalt
Centreline
2.5%
3.0%
TL3 guardrail refer dwg 218.
RL 6.45m
Minimum soffit level.
Guardrail cast-in bracket. Refer dwg 218 for locations.
Grout in between beams.
Hollow Core Beams 800mm deep refer dwg 213.
Guardrail cast-in bracket. Refer dwg 218 for locations.
Service utilities support brackets refer dwg 212.
1
TYPICAL SECTION
1:50
Note: E.O.S denotes edge of seal
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This drawing is confidential and shall only be used for the purposes of this project.
C | DM | 25.09.08 | Beams and construction joint amended | DE
B | DM | 23.05.08 | Amended levels | DE
A | DE | 16.05.08 | Issued for construction | DE
No. | BY | DATE | DESCRIPTION | APPD
Scales
As shown (A1)
MAUNSELL | AECOM
Maunsell Limited
TRANSIT NEW ZEALAND
SH25 BRIDGE REPLACEMENTS
TARARU BRIDGE
PLAN, ELEVATION AND
TYPICAL SECTION
CONSTRUCTION
60019014_211
C