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Te Puru flood protection scheme design report

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Executive summary

Te Puru is located on the west coast of the Coromandel Peninsula, eight kilometres 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. Te Puru 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 Te Puru community to develop a flood mitigation strategy to address the Te Puru Stream flood hazards. A flood protection scheme has been completed at Te Puru, the details of which are provided in this Design Report.

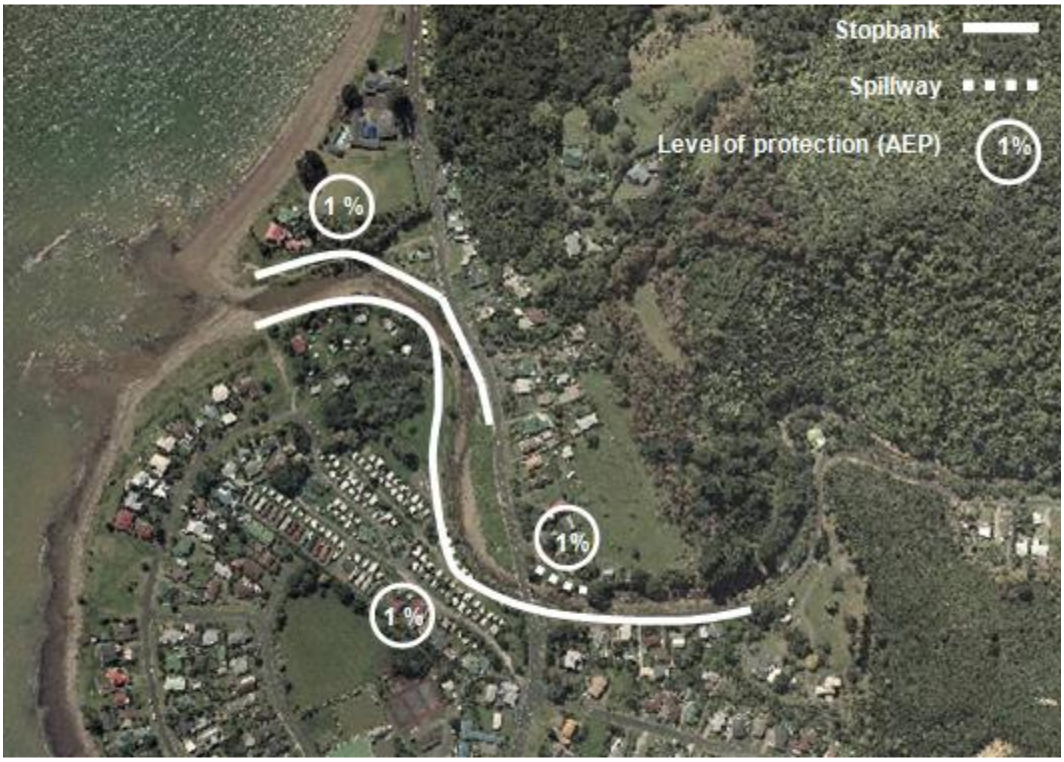
Te Puru is located at the base of the Te Puru Stream catchment on a coastal alluvial fan. The presence of parts of Te Puru on the low-lying land adjacent to Te Puru Stream means that many properties were subject to flood hazard from the stream. The Te Puru Stream catchment is susceptible to short duration 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.

A catchment assessment was undertaken for the Te Puru 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 Te Puru. The initial investigations demonstrated 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.

WRC worked with the community via the Te Puru Working Group to develop the flood mitigation strategy for Te Puru and then consulted with the community on what was proposed. A flood protection scheme was developed that included catchment management works, channel improvements, the SH25 Bridge upgrade and flood defences. The flood defences were designed to provide protection to the 1% Annual Exceedance Probability (AEP) event with freeboard. Due to space restrictions between residential dwellings and the Te Puru Stream the flood defences were designed to be flood walls with clay bulking on the landward side of the flood wall. This arrangement had a smaller footprint than traditional stopbanks, and with the clay bulking the defences have additional structural integrity and reduced chance of failure should they be overtopped.

The SH25 Bridge was upgraded and then the flood protection scheme was constructed to tie into the upgraded bridge. The following figure demonstrates the flood protection scheme that was constructed.



Flood defences in the Te Puru community

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

The main channel of the Te Puru 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 Te araru 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 Te Puru community should be reviewed in accordance with the Coromandel Zone Management Plan. In addition if there are any significant changes in land use in the Te Puru Stream catchment the scheme would need to be reviewed.

1 Introduction

1.1 Background

Te Puru is located on the west coast of the Coromandel Peninsula, eight kilometres 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 that 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. Te Puru 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 TCDC worked with the Te Puru community to develop a flood mitigation strategy to address the Te Puru Stream flood hazard. A flood mitigation scheme has been constructed at Te Puru, 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 Te Puru to reduce the flood hazard from the Te Puru 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

Te Puru is located on the west coast of the Coromandel Peninsula, eight kilometres north of Thames on State Highway 25 (refer to Figure 1).

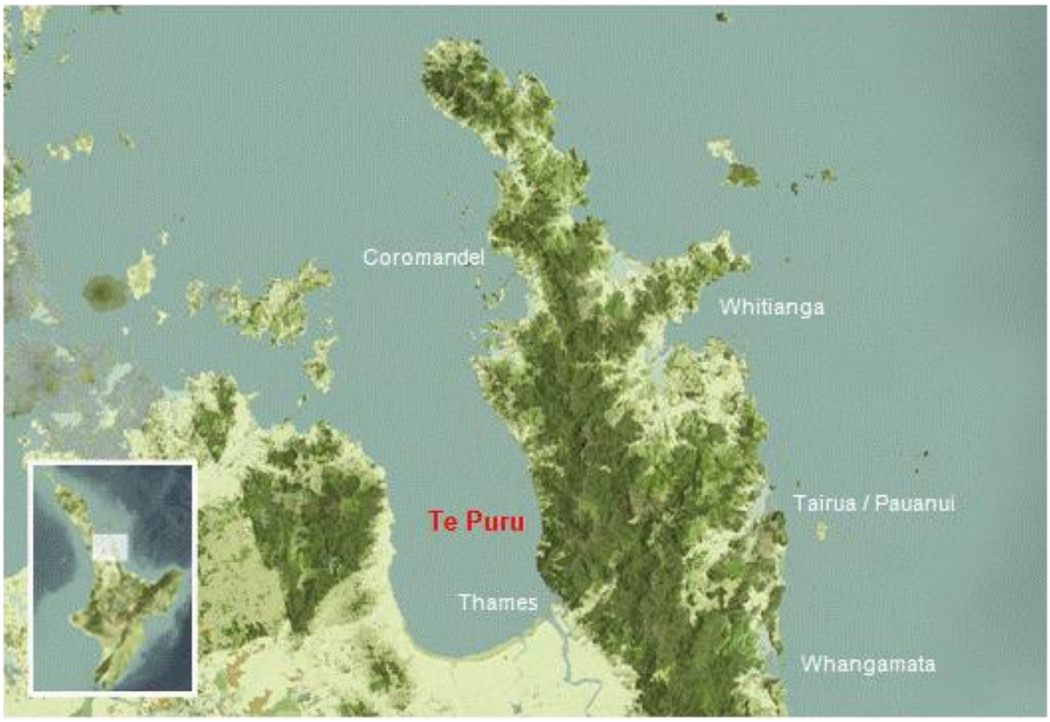


Figure 1 Thames-Coromandel District

The Te Puru Stream has a 24km^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 also susceptible to short duration but high intensity rainfall events that cause flash flooding and debris flows in the Te Puru Stream with little or no warning.

Figure 2 Te Puru Stream catchment

2.2 Te Puru Stream

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

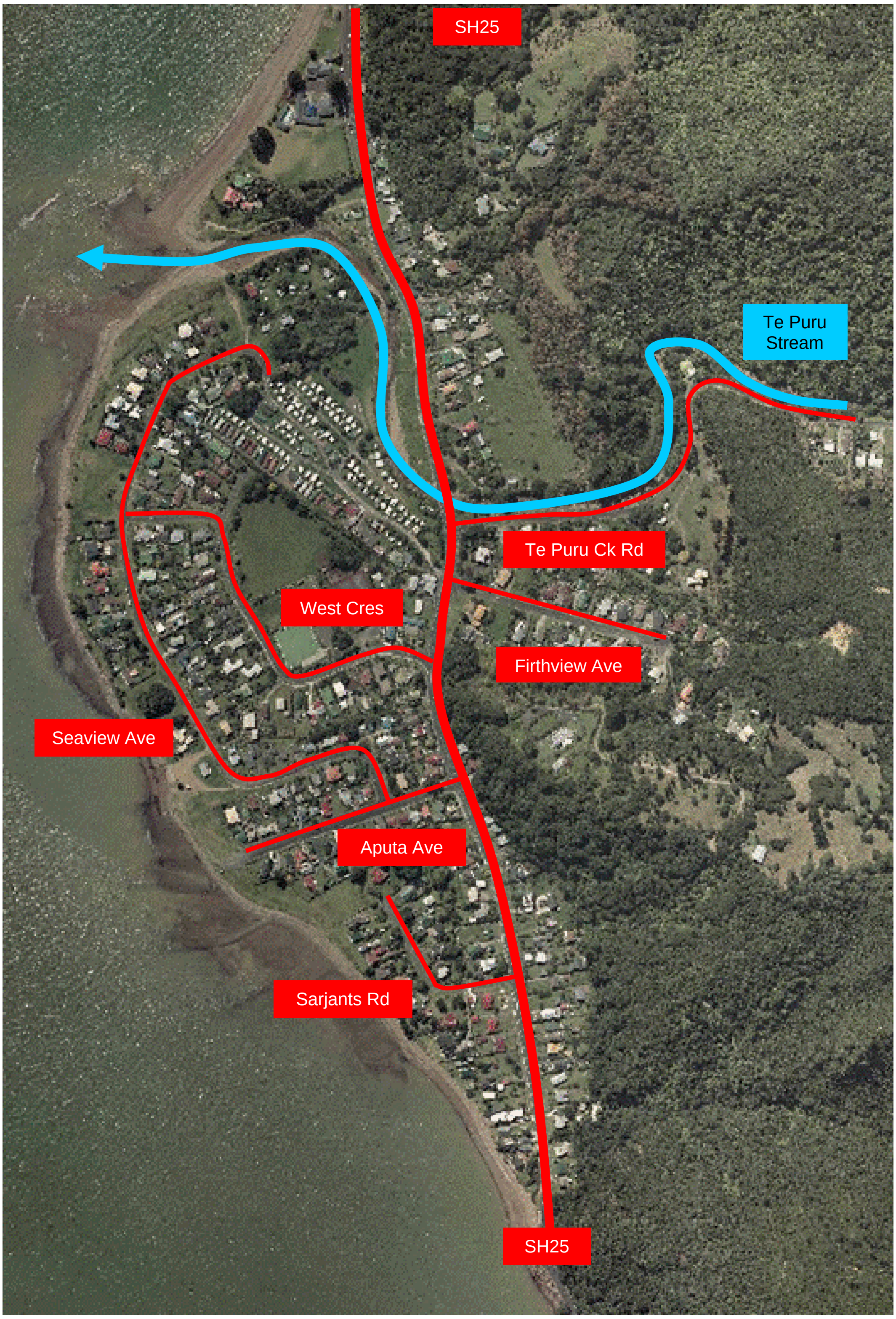


Figure 3 Te Puru community

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

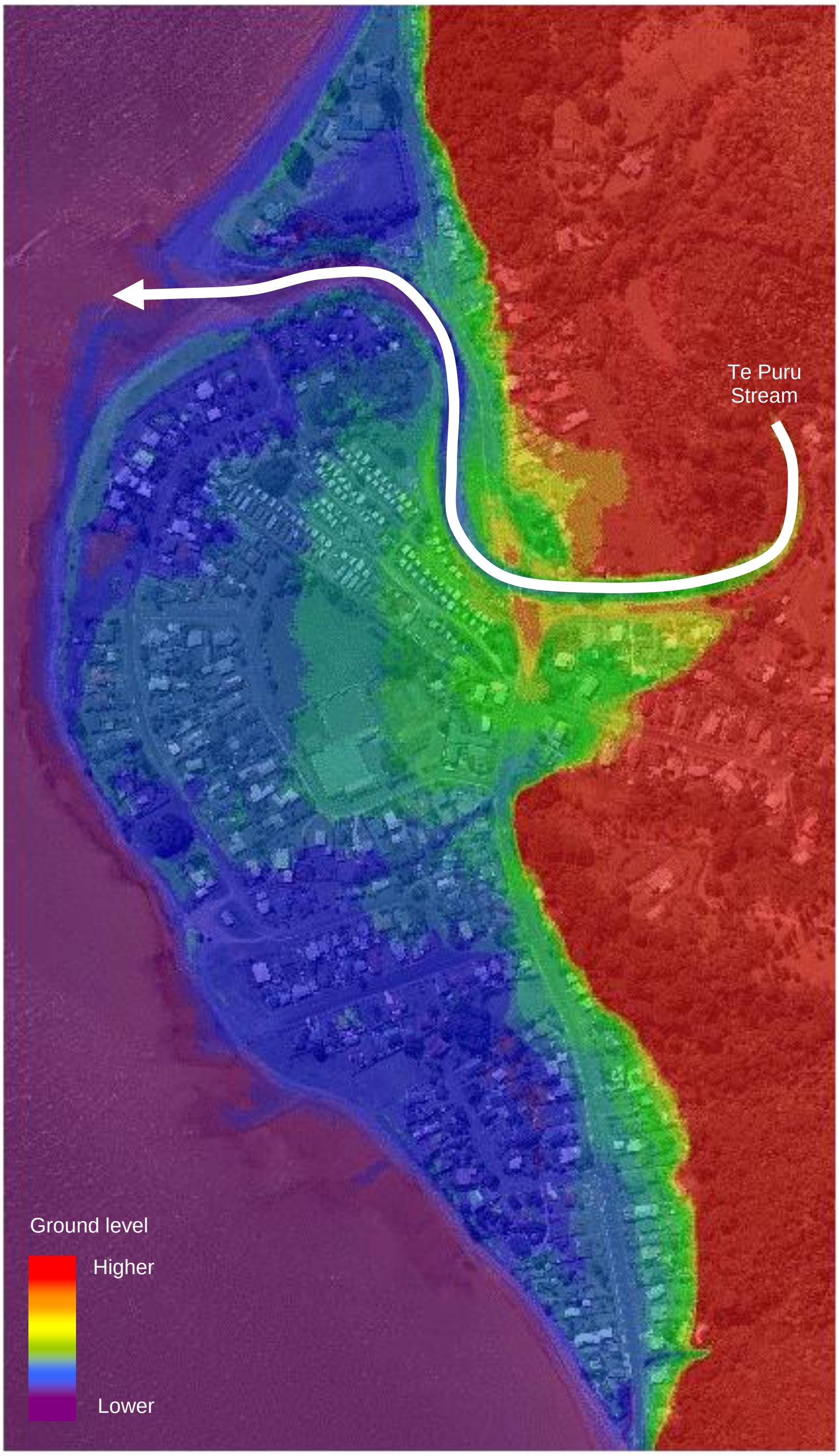


Figure 4 Ground levels at Te Puru

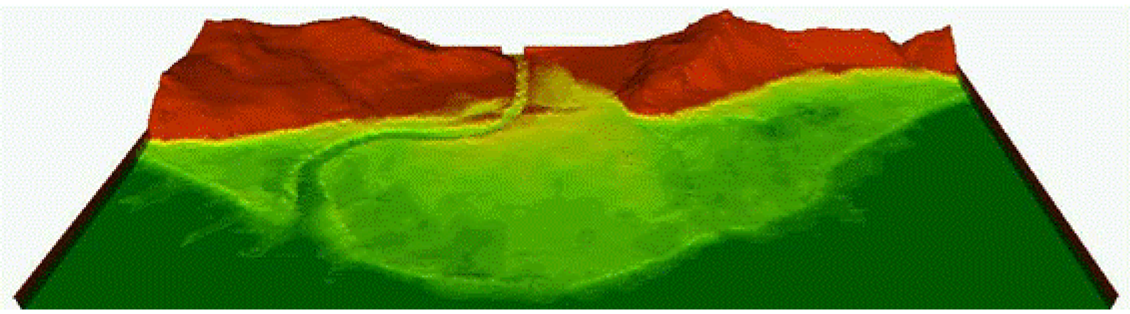


Figure 5 Ground levels at Te Puru (looking inland from the Firth of Thames)

2.3 Flooding issues

The Te Puru community is located at the base of the Te Puru Stream catchment on a coastal alluvial fan. The community consists of mainly residential development on both banks of the Te Puru Stream, with a holiday park located on the left bank downstream of the State Highway 25 (SH25) Bridge. SH25 runs through the Te Puru community and crosses the Te Puru Stream using a dual lane single span bridge.

The presence of parts of the Te Puru community on low-lying land adjacent to Te Puru Stream means that these properties are subject to flood hazard from the stream. The Te Puru 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.

Prior to the scheme being constructed, during significant flood events, overland flow occurred on the left and right bank upstream of the SH25 Bridge, as illustrated in the schematic below. The overland flow over the left bank could cause extensive flooding over a large proportion of the community.

Figure 6 Predominant flooding mechanism at Te Puru

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

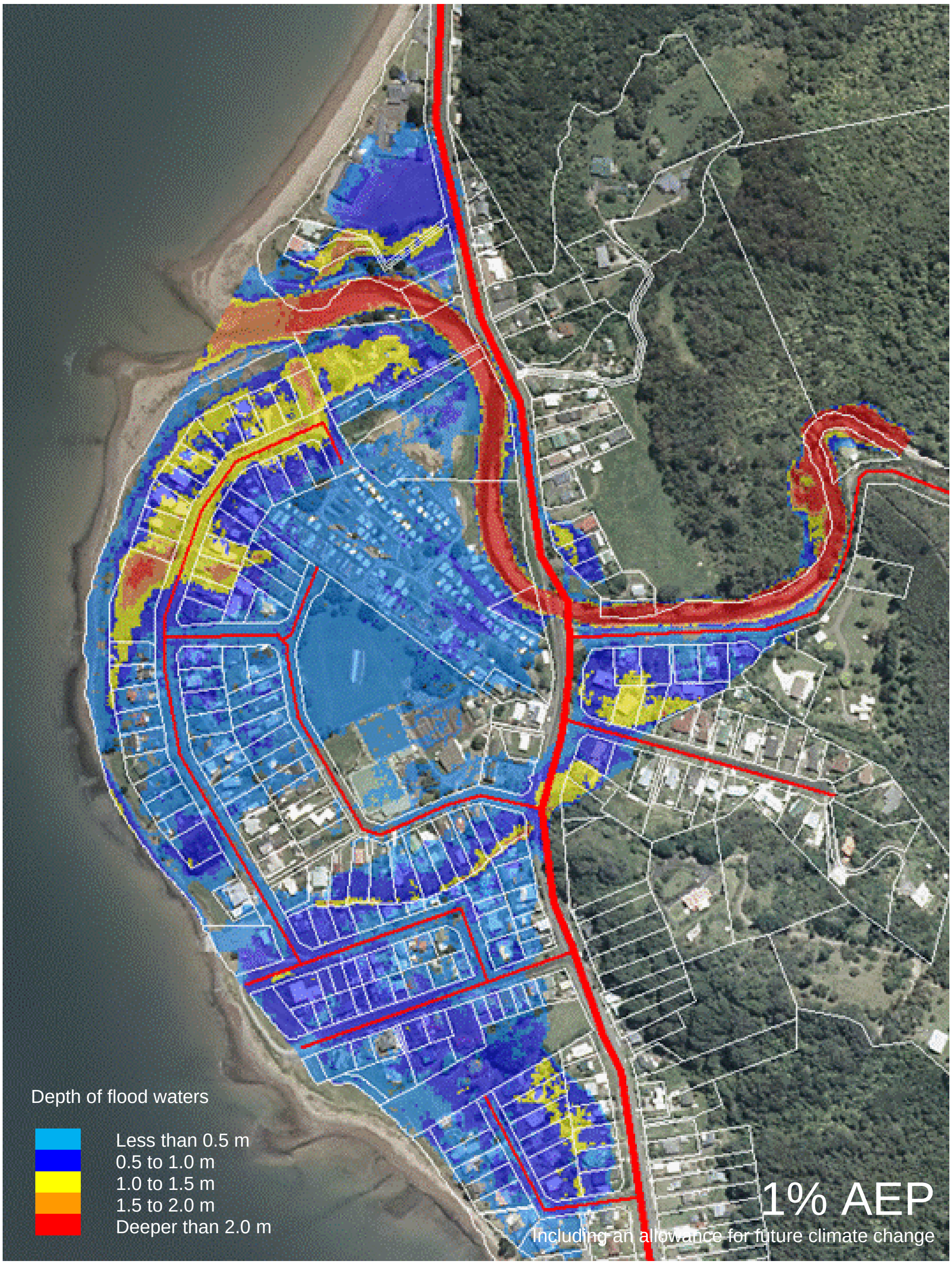


Figure 7 Predicted flood extents for 1% AEP event (with climate change)

The significance of the flood hazard to the Te Puru 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). Te Puru suffered significant damage during this event.

Damage to properties within the Te Puru community was focused on those properties immediately adjacent to the Te Puru Stream and those that were within the secondary flow paths and ponding areas. Figure 8 below illustrates the property damage that occurred within the Te Puru community following the 'Weather Bomb'.

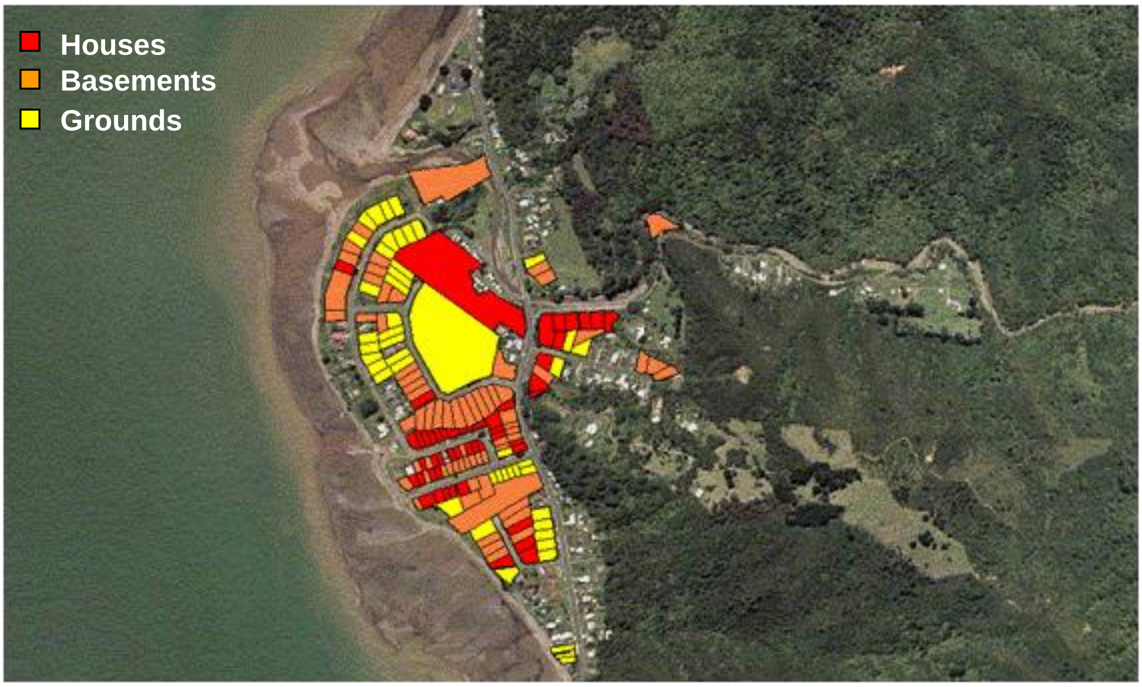


Figure 8 Property damage within the Te Puru community during the 'Weather Bomb'

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 Te Puru.

Risk assessment based on the extent of flooding including depth and velocity of floods was undertaken by URS Consultants for all five communities on the Thames Coast (including Te Puru) with the aim of measuring the level of risk to life and economic feasibility of flood mitigation options. The assessment revealed that Te Puru had the highest risk to life arising from flooding among the five communities investigated and the risk is higher than internationally acceptable standards. Hence both WRC and TCDC committed to investigating and implementing 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 Te Puru Stream catchment. This information is presented in WRC's Technical Report 2004/13 (Ryan GJ, 2004, WRC DM#909430) 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 Te Puru

Community	Previously completed technical investigations
Te Puru	Channel Improvements - HCB Report 117 (Jan 1982) Channel Improvements - HCB Report 194 (Nov 1985) Flood Hazard Mgmt - EW Report 1993/1 (Feb 1993)

Table 3 Summary of completed flood mitigation works at Te Puru

Community	Previously completed works
Te Puru	Channel improvement works were completed during the 1980's by the HCB (on behalf of the TCDC). These works included widening the channel and installing erosion protection works (rock rip rap). Since these works were completed there has been ongoing problems with the effectiveness of erosion control adjacent to Te Puru Creek Road. Pre-2004 these works were maintained by TCDC. WRC took over maintenance responsibility from 1 July 2004.

Longsection information for Te Puru Stream (pre-scheme) has been detailed in a WRC document number WRC DM# 910292. 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 Te Puru:

- Upstream of the SH25 Bridge   10% AEP (10 year ARI) event
- Downstream of the SH25 Bridge   20% AEP (5 year ARI) event

3.2 Catchment characteristics

The Te Puru Stream catchment is located on the steep western slopes of the Coromandel Ranges. The catchment is covered with regenerating native forests and dense scrub. The catchment area and characteristics used in the model are described below.

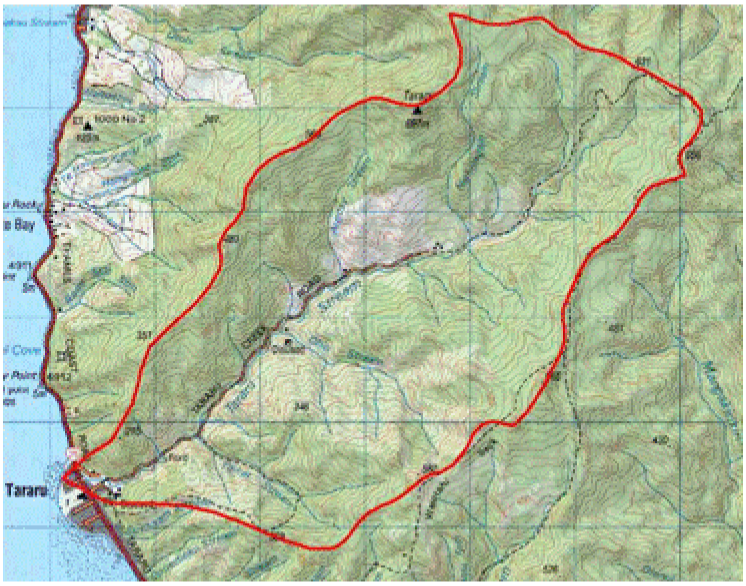


Figure 9 Te Puru Stream catchment boundary

Table 4 Te Puru Stream catchment summary

Catchment area	24 km^2
% urban	Low
% indigenous forest/ scrub	High
Channel slope	5%
Time of concentration	1 hour 15 minutes

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 Te Puru Stream catchment predicted rainfall intensities (existing)

	Rainfall summary 1 hour 15 minute duration event					
Annual Exceedance Probability (AEP) event	50%	20%	10%	5%	2%	1%
Predicted rainfall intensity (mm/hr)	28	34	40	47	58	71

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 (assuming a 20% increase in rainfall intensity allowing for climate change).

Table 6 Te Puru Stream catchment predicted rainfall intensities (future)

	Rainfall summary 1 hour 15 minute duration event					
AEP event	50%	20%	10%	5%	2%	1%
Predicted rainfall intensity 2030 (mm/hr)	30	37	44	52	64	78
Predicted rainfall intensity 2080 (mm/hr)	35	43	51	60	75	91

3.4 Flow estimates

The peak inflow for Te Puru 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.

Table 7 Te Puru Stream peak flow estimates

	Peak flows estimates					
AEP event	50%	20%	10%	5%	2%	1%
Existing peak flow - 2006 (m^3/s)	128	157	211	248	287	315
Future peak flow - 2030 (m^3/s)	140	172	233	274	317	348
Future peak flow - 2080 (m^3/s)	162	199	270	317	368	405

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 Te Puru Stream for existing and future predicted climate change scenarios.

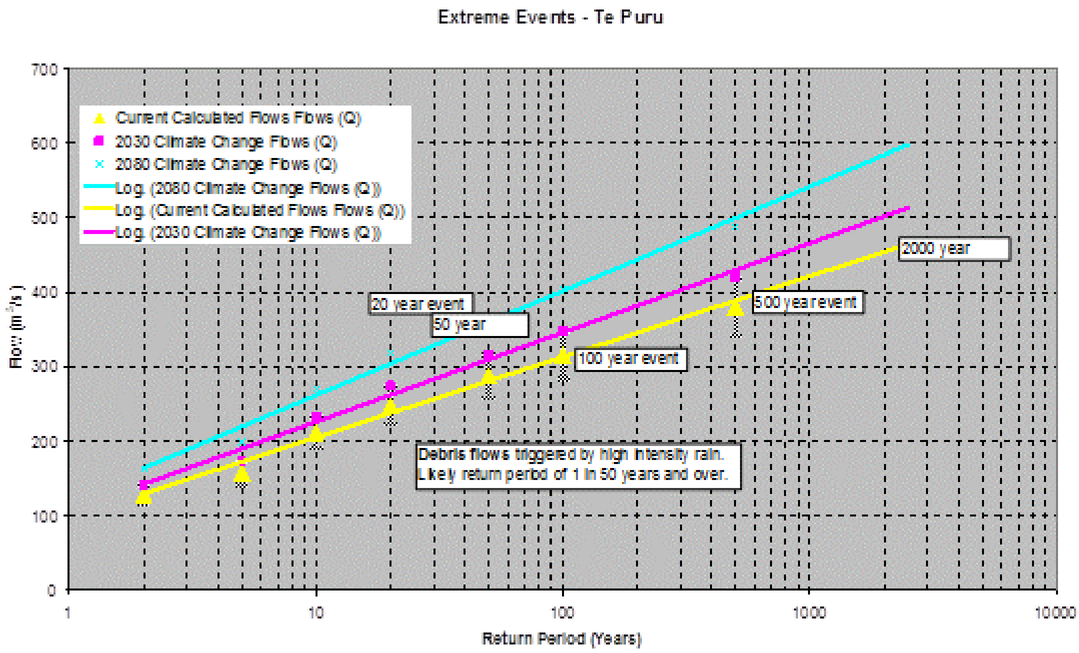


Figure 10 Te Puru Stream hydrological summary

From this assessment, the existing 1% AEP event flood flow for Te Puru Stream is estimated to be 315m^3/s and the future 1% AEP event flow is estimated to be approximately 378m^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.

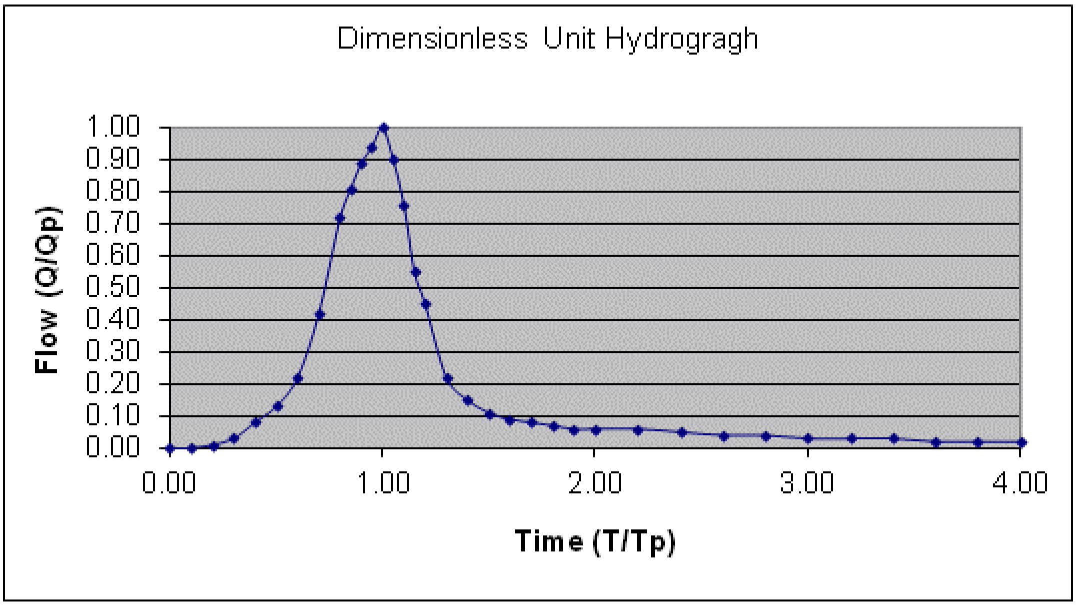


Figure 11 Dimensionless Unit Hydrograph
This was used to produce a unit hydrograph for the Te Puru catchment. Where Tp used is the time of concentration and Qp is the peak flow.

4 Hydraulic model development

4.1 Introduction

Two types of hydraulic models have been developed for Te Puru.

The first was used to develop a flood hazard map for the community and to provide an assessment of where the particularly flood prone areas of community town are. For this purpose the stream and surrounding area was modelled using an unsteady state, two-dimensional computational hydraulic model using the MIKE-21 software. This model provides detailed information in regard to extent, depth and velocity of flooding.

The second hydraulic model was used to develop a detailed design model sufficient to inform the design of components of the flood protection scheme, such as stop banks and flood walls. A one dimensional computational hydraulic model was built to represent the Te Puru Stream using MIKE-11 software. 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 4.3.4 below. The MIKE-11 model provides detailed information regarding flow, flow depth and velocity within the modelled stream channel and associated stream berm.

The MIKE-21 model was also used to estimate super elevation at the bends in the channel, as MIKE-11 models are not able to assess super elevation. The super elevation information was used to develop the design levels.

This section outlines the development of both of the hydraulic models.

4.2 MIKE-21 model

4.2.1 Model inputs

Datum

The MIKE-21 model was developed using the LiDAR datum.

Ground contour

A digital terrain model (DTM) based on ground survey (LiDAR) was used in the hydraulic model to represent the ground contours of the study area. The DTM was based on a 2m by 2m grid of the whole stream and flood plain with an accuracy of +/-0.15m.

Upper boundary condition

The upper boundary of the hydraulic model consists of an inflow hydrograph to represent the peak flows for the contributing sub-catchments to the Te Puru Stream for the 1% AEP event. The development of the inflow hydrograph is discussed in Section 3 above. The following summarises the inflow data for the catchment for the existing and predicted future 1% AEP events (taking into account predicted climate change):

Existing 1% AEP design flow: $315m^3/s$
Future 1% AEP design flow: $378m^3/s$

Lower boundary conditions

The lower boundary of the Te Puru 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 RL1.4m above mean sea level (Tararu 1952 datum). This equates to RL1.6m in terms of the local Te Puru datum and RL2.3m in terms of the LiDAR datum.

Sea level is predicted to rise by 0.50m by the year 2080 according to MfE guidelines. Hence for the climate change scenario, the lower boundary condition used in the model was RL 1.9m above mean sea level (Tararu 1952 datum), or RL2.1m (local datum), or 2.8m (LiDAR datum).

Resistance

The variation in resistance across the flood plains has been taken into account. In MIKE-21 a separate resistance file has been created. In this file, resistance for different areas is assigned. MIKE-21 uses Manning's M to represent roughness, which is the inverse of Manning's n value. In the hydraulic model the resistance was assigned as follows:

Stream/river	= 30
Open spaces/roads	= 20
Built up areas	= 15

Note that the resistance values are assigned with only limited accuracy based on the aerial photographs for the study area. This is considered an appropriate level of detail in hydraulic modeling practice.

4.2.2 Model location

The MIKE-21 hydraulic model used to develop the Flood Hazard Map for Te Puru is located in the WRC system in the following folder:

G:\RCS\Technical Services\Projects\RHEM\TCDC Hydraulic Modelling Stage 1\Hydraulic Models

The MIKE-21 hydraulic model used for design purposes for Te Puru is located in the WRC system in the following folder:

G:\RCS\Technical Services\Projects\Coromandel Zone\Te Puru\Hydraulics\MIKE 21

4.2.3 Model validation

The river flood maps prepared as part of this assessment for the no works scenario were compared with observations made during previous flood events in the Te Puru Stream. This comparison included the review of several Hauraki Catchment Board and Environment Waikato reports, including the following:

- 1981 flood event – HCB Report 109: Flood of April 1981 volume 1
- 1985 flood event – HCB Report 190: Flood of February 1985 volume 1
- 2002 Weather Bomb - Final Technical Report

Figure 12 below compares the modelled extent for the existing 1% AEP flood event versus the surveyed extents of the June 2002 event, which was close to a 1% AEP event. This comparison shows that the modelled flood extent is a reasonable representation of observed flooding in the Te Puru Stream.

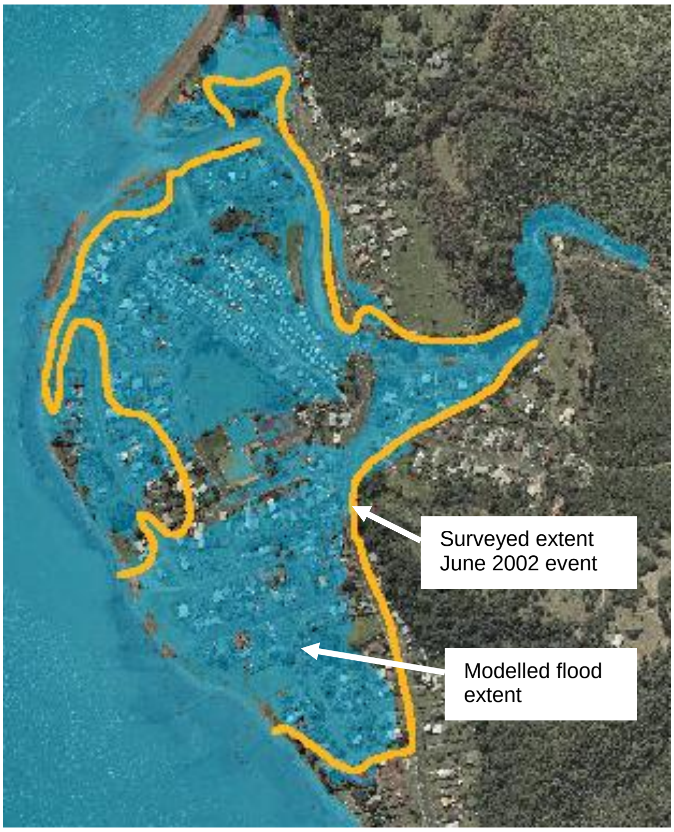


Figure 12 Comparison of modelled and observed flood extents

4.2.4 MIKE-21 model assumptions and limitations

The following outlines the assumptions made when building the MIKE-21 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 flood hazard risk. Alterations to the catchment that may affect the hydrology significantly include, land use changes, deforestation and development. Following significant alterations to the catchment the hydrology should be reviewed and possible adjustments should be made to the flood hazard.

- The modelling work has been undertaken for the current floodplain topography. Aerial survey data (LiDAR) was taken and converted into 2 metre cell Digital Terrain Model (DTM). The DTM incorporates ground levels but excludes features such as fences, trees and buildings. Water is allowed to flow across the DTM to determine the extent and magnitude of the flood hazard risk.
- The flood modelling work is for Te Puru Stream and contributing sub-catchments only. Coastal hazards have not been included as part of the modelling work.

- 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.

4.3 MIKE-11 model

4.3.1 Model inputs

Model reach

The model includes a 700m reach of the Te Puru Stream which extends 210m upstream of SH25 to 490m downstream of SH25 at the Firth of Thames.

Model datum

The datum used in the model is a local datum or Provisional Datum (i.e. approximate mean sea level) taken from Hauraki Catchment Board Plan No 2182. Refer to WRC DM# 2962623 for details. The MIKE-11 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.

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 (refer WRC DM# 2962623 for details). Cross sections were surveyed at nominal 50m intervals. These cross sections were input into the MIKE-11 model to define the channel capacity.

Upper boundary condition

Same as the MIKE-21 model, refer to Section 4.2.1 above.

Lower boundary condition

Same as for the MIKE-21 model, refer to Section 4.2.1 above.

Roughness

A Mannings n of 0.05 was used to define the roughness of the channel for the 1D modeling. This roughness coefficient is considered to be an appropriate Mannings n for the Te Puru Stream based on empirical derivation based on the substrate size in the stream (refer WRC DM# 1391263) and confirmed by Council's experience with the Coromandel streams.

4.3.2 Model location

The MIKE-11 hydraulic model is located on the WRC system in the following folder:

4.3.3 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 Reports 117 and 194. 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 Te Puru Stream.

4.3.4 Bridge upgrade

The SH25 Bridge at Te Puru 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.

The SH25 Bridge upgrade was designed by NZTA and their consultants. Opus Consultants undertook early design work on behalf of NZTA using WRC's model as their basis however the model was revised to design the bridge upgrade (Opus Consultants, 2004, WRC DM#3126273)). Maunsell were then contracted by NZTA to finalise the design and undertake construction of the bridge upgrade. Maunsell advised that they developed their own HEC-RAS model to represent the bridge, but then chose to adopt council's design flood levels for the design of the bridge upgrade as they were more conservative.

Maunsell's Water Assessment is provided in Appendix 1 and a council memo summarising council's design model for the bridge is provided in Appendix 2. NZTA advised that the Waterway Assessment work was undertaken in November 2006 and was used in NZTA's Scheme Report that was prepared in December 2006. NZTA has advised that the report covers the majority of their work on the waterway design (the scour assessment was later updated) and shows the assumptions made.

It should be noted that there was an error in the application of Maunsell's Waterway Assessment. The design levels provided in the Waterway Assessment are in terms of local datum. The roading design was undertaken in LiDAR datum, however the correction from local datum to LiDAR datum (+700mm) wasn't applied when defining the soffit level of the bridge. Hence the bridge was designed with less freeboard than intended. Once this error was detected, NZTA advised that they were unable to raise the bridge due to site constraints. This is discussed further in Section 5.6.

4.3.5 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 floodwalls and 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 proposed flood walls and 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.

4.3.6 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.

4.3.7 Peer review

WRC's MIKE-11 hydraulic model was used by Opus Consultants to prepare the SH25 Bridge upgrade design for NZTA. As part of this process the MIKE-11 model was peer reviewed and suggestions were made to improve the model. WRC adopted Opus' recommendations.

WRC commissioned Hydraulic Modelling Services to undertake review of some of the bridge upgrade options that Opus Consultants on behalf of NZTA developed. As part of this process the model was subject to peer review again.

A peer review was undertaken of the hdyraulic model as part of the resource consent application process for the flood protection scheme. Dr Barnett of Barnett & MacMurray undertook a thorough review of the design hydraulic model and in consultation with Dr Barnett his comments were incorporated into the model as appropriate.

5 Flood protection scheme

5.1 Scheme history

During the 1980s the Hauraki Catchment Board completed channel works within the lower Te Puru Stream to increase the capacity of the channel to 180m^3/s, this equates to between a 10% (10 year ARI) and a 5% AEP (20 year ARI) event. These works included enlargement of the channel and stabilisation of the banks using rock rip rap (refer to Hauraki Catchment Board Reports 117 and 194). Figure 13 provides an example of engineering works undertaken on the Te Puru Stream.

Figure 13 Engineering works undertaken on the Te Puru Stream

Having adopted a design standard equivalent to between the 5% and 10% AEP event, properties in the Te Puru community 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 caused significant damage to property and infrastructure.

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

5.2 Scheme evolution

Following the 'Weather Bomb', the performance of the Te Puru Stream channel was assessed by constructing a one-dimensional hydraulic model (discussed in Section 0) extending from upstream of the SH25 Bridge to the Firth of Thames.

The modelling results indicated the following:

- The bank full capacity of the Te Puru Stream upstream of the SH25 Bridge was approximately 180 m^3/s (between the 10% and 5% AEP event).

- The unrestricted capacity of the SH25 Bridge is around 180m^3/s. Although this did not represent a significant restriction to the bank full flow in the Te Puru Stream, it did place a restriction on increasing the bank full flow by the construction of floodwalls.

- The bank full capacity of the Te Puru Stream downstream of the SH25 Bridge was approximately 150 m^3/s, with overflow during flood flows greater than this limited to the overland flow path downstream of the Te Puru Holiday Park embankment.

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

Waikato Regional Council developed a flood protection scheme for the Te Puru community that included the following components:

- Catchment management works to improve the health of the catchment and reduce instability within the upper catchment and hence potential contribution to debris flow in Te Puru Stream.

- Channel improvements to increase the conveyance of flood flows and to improve channel stability.

- Upgrade of the SH25 Bridge to improve the conveyance of flood flows.

- Flood defences comprising stopbanking to increase the flows that could be conveyed in the floodway and to provide protection to the community from out of channel flow.

The flood defences were to provide protection to the community for the 1% AEP event plus freeboard. The proximity of residential development to the stream channel was a key limitation developing options for the defences. Flood walls were selected due to their reduced footprint when compared to traditional earth stopbanks. The flood wall design included clay bulking on the landward side of the flood walls to provide additional structural stability and to reduce the risk of failure if overtopped. The flood protection scheme was designed to complement the upgrade of the SH25 Bridge.

5.3 River and catchment works

As part of the Peninsula Project, river and catchment management works were proposed within the Te Puru 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 Te Puru 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

5.4.1 Background

As part of previous channel improvement works, Te Puru Stream was enlarged by the Hauraki Catchment Board to pass a flow of 180m^3/s. These works included erosion protection works.

Further channel improvements were undertaken as part of the flood protection scheme, including erosion protection, and the stream width was widened to a minimum width of 15m to increase the conveyance of flood flows.

Indicative locations for the channel improvement works that have been undertaken by the Hauraki Catchment Board and more recently by Waikato Regional Council are shown on Figure 14.

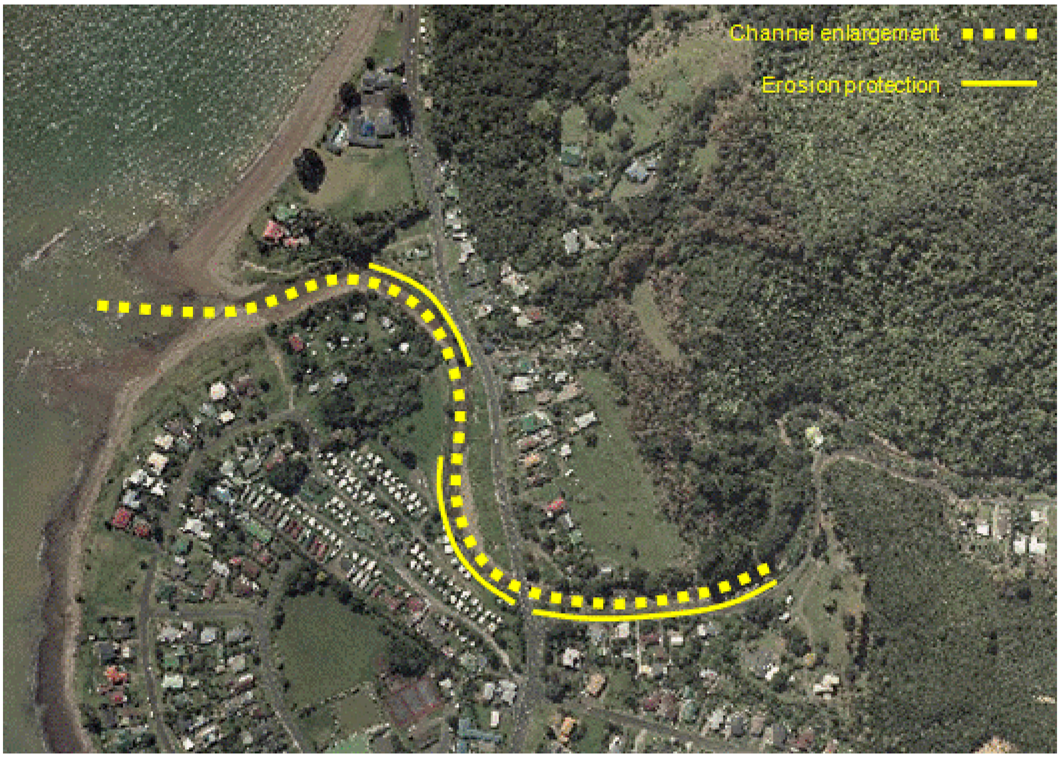


Figure 14 Extent of channel improvements

The channel improvements works that have been undertaken help to improve the stability and capacity of the Te Puru Stream channel and help to maintain the integrity of the flood protection structures.

5.4.2 Design details

Tonkin & Taylor were commissioned to design the channel improvement works for Te Puru Stream. Design details are provided in the Tonkin & Taylor report entitled Te Puru Stream Flood and Erosion Protection Works (Aug 2006, WRC DM# 1103422).

The design criteria used for the erosion protection works was to provide adequate erosion protection where required to prevent erosion of the stream banks in the 1% AEP event, while maintaining a 15m minimum base width channel. Where the flood level exceeded the top of bank, erosion protection was designed to extend to the top of the existing bank.

The stream banks from the mouth of the stream to 300m upstream of the SH25 Bridge were assessed by Tonkin & Taylor. It was identified that there were a number of bank sections where there was existing erosion protection in adequate condition. A 160m section of bank on the true left bank upstream of the SH25 Bridge was found to have inadequate erosion protection. A design was developed in for this length of bank in accordance with the above design criteria. Drawings showing the design are provided in Appendix 3.

5.5 Flood defences

5.5.1 Main scheme

Tonkin & Taylor was commissioned to hep council prepare the design of the flood defences for Te Puru, refer to their report (Tonkin & Taylor, Aug 2006) for details.

A number of options to provide flood protection for the Te Puru community were investigated. The preferred option that was developed provided protection to the community for up to a 1% AEP design standard with 600mm of freeboard, generally through the provision of flood walls, channel improvements and the upgrade of the SH25 Bridge.

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. In general a freeboard of 500mm is used in the Waikato Region. For Te Puru it was decided that a higher level of freeboard would be adopted to provide greater redundancy in the system. A significant portion of the community is subject to flood hazard if the flood scheme fails, hence incorporating a higher freeboard for this community.

The preferred option improves the existing performance of the lower Te Puru Stream floodway to contain the 1% AEP flood event (315m^3/s) by implementing the following works:

- Construction of a timber flood wall with clay bulking on the left bank of the Te Puru Stream (upstream of the SH25 Bridge) to the 1% AEP flood level plus 600mm freeboard to eliminate the previous overland flow paths through properties. The length of defences at this location is approximately 200m.

- Construction of a spillway on the right bank upstream of the SH25 Bridge to the 1% AEP flood level to increase the level of protection to properties located along the overland flow path to the north 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.

- Construction of a combination of timber floodwall, timber flood wall with clay bulking and traditional earth stopbank along both banks of the Te Puru 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. The length of defences on the true left bank is approximately 440 metres and 175 metres on the true right bank

- Placement of rock rip rap to improve the stability of the channel and protect the other works associated with this proposal, upstream and downstream of the SH25 Bridge on the left bank, and a small portion of stream reach on the right bank downstream of the SH25 Bridge.

- 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.

- 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 15. Design details are provided in Appendix 4 and as-built survey information for the flood defences is provided in Appendix 7.

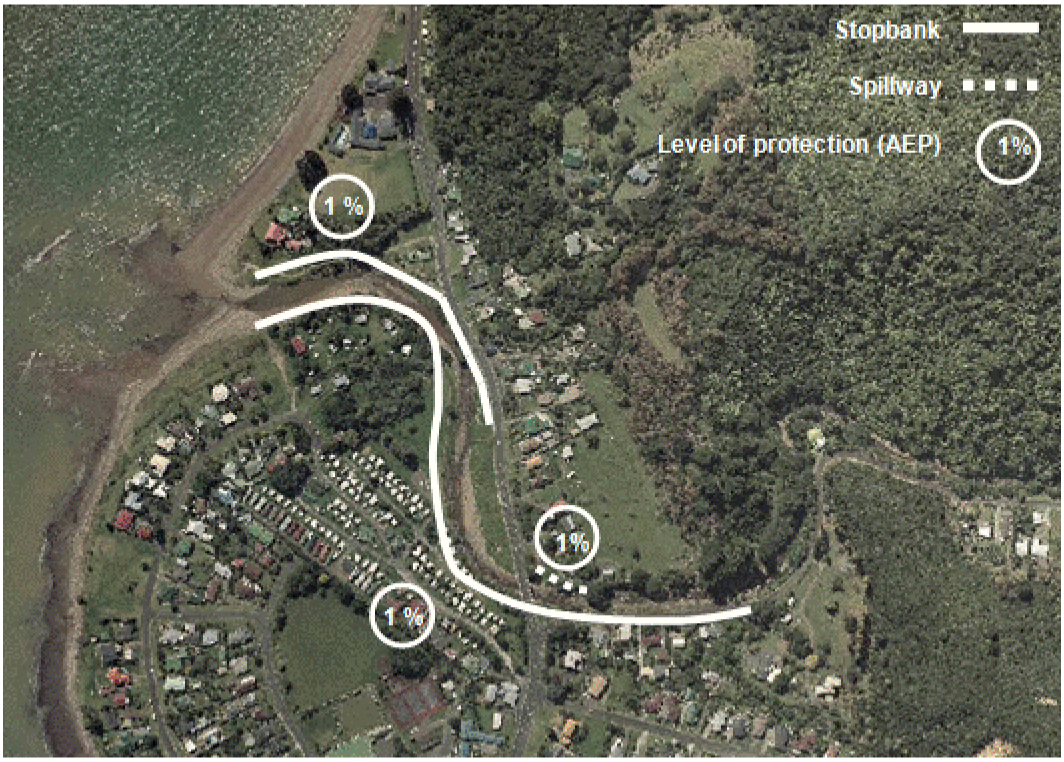


Figure 15 Flood defences in the Te Puru community

The stopbank/ floodwall design was developed by constructing a MIKE-21 hydraulic model to represent the lower reaches of the Te Puru Stream, with stop banks on both sides of the stream, to keep the flows in channel, and then running the model for the existing 1% AEP event flood and the future 1% AEP event flood (i.e. with climate change). The top of the stopbank/floodwall was defined as 600mm above the existing 1% AEP flood level, or 300mm above the future 1% AEP flood level, depending on which was the highest.

Various configurations of stopbank were considered to provide flood protection. Council's initial preference was to build a full clay bank structure with a 3 metre top width and 3:1 batters on both sides. Due to space limitations, this footprint had a significant impact on the adjacent properties in terms of encroachment and access. An alternative option was developed that comprised a timber wall with clay bulking behind it on the landward side of the flood wall. This arrangement provides a robust structure and virtually halves the width of the footprint. All the configurations were put to the adjacent residents during initial consultation and flood wall plus clay bulking option was progressed as the preferred option.

5.5.2 Flood wall extension

During the detailed design phase of the SH25 Bridge, it was determined that sections of SH25 were vulnerable to flooding from Te Puru Stream

Prior to the bridge upgrade, the configuration of the northern approach to the bridge included a dip in the road that enabled overland flows from the right bank overland flowpath to cross the SH and drain back into the stream downstream of the bridge. To the north of the dip the level of the carriageway rose, to effectively form a lip that would stop the water from draining further north toward residential dwellings. When the northern approach was designed for the bridge upgrade, the dip in the road moved further north, and the lip wasn't provided to the same extent as pre-upgrade. Figure 16 below illustrates the pre and post upgrade levels of the carriageway for the northern approach and the design flood levels along this reach.

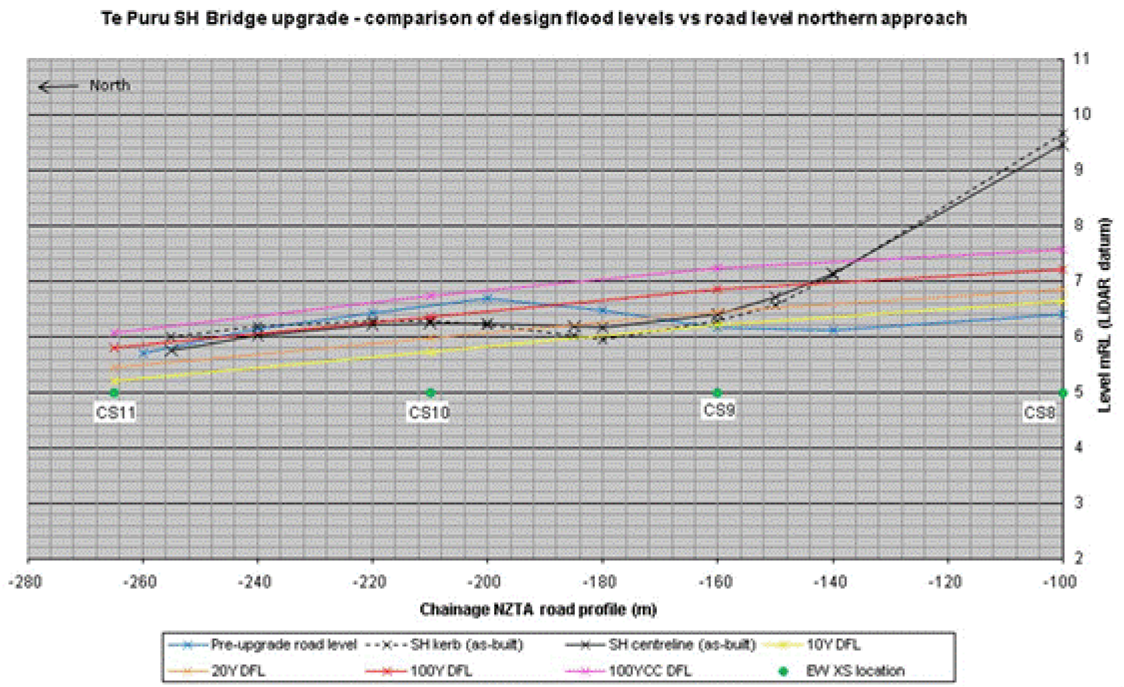


Figure 16 Design flood levels and carriageway levels (northern approach to bridge)

This assessment demonstrated that this section of the SH25 was vulnerable to flooding from greater than the 10% AEP event. The concern for WRC was that if the carriageway flooded, that flood waters would be able to get in behind the flood defences on the right bank at this location, which are designed to protect three residential dwellings and a school. Once flood waters get behind the flood defences they would need to be pumped out.

To remedy the situation, WRC designed an extension to the flood defences to protect the SH25 and the associated flood defences in this vicinity. The flood defences along this section of SH were constructed to the 1% AEP flood level with an allowance for climate change with no freeboard. Refer to Appendix 4 for design levels for the flood wall extension. This means this section of wall has less freeboard than the remainder of the scheme. This was a compromise between providing protection to the properties to the north at an affordable price and within the constraints of the available space between the edge of the footpath and the stream.

The flood wall extension was 130m long and on average 400mm high, up to a maximum of 900mm high. The flood wall was constructed immediately adjacent to the footpath, on the stream side. The flood wall construction is the same as what was constructed for the main flood defences, however because it is of a reduced height the foundation requirements are less. There is no clay bulking behind the flood wall. Design details are included in Appendix 4 and in WRC DM#1937518.

The flood wall extension impacts on the performance of the spillway, the operation of the overland flowpath is discussed further in Section 5.5.3 below.

5.5.3 Spillway

The design for the Te Puru flood protection scheme includes a right bank spillway upstream of the SH25 Bridge on the true right bank. This spillway is an important feature of the flood protection scheme as it provides a relief valve, hence protecting the left bank from overtopping. Once the left bank spills a significant portion of the town is likely to be affected by flooding.

Prior to the scheme being constructed, the land immediately upstream of the SH25 Bridge on the right bank was acting as a spillway in severe flood events. This overflow drained north to the east of SH25, then crossed the SH25 approximately 120m north of the old bridge, and then water then flowed back into the stream. Figure 17 below shows the existing ground levels pre-scheme (extracted from LiDAR survey data) and illustrates the pre-scheme overland flow path and associated low-lying land.

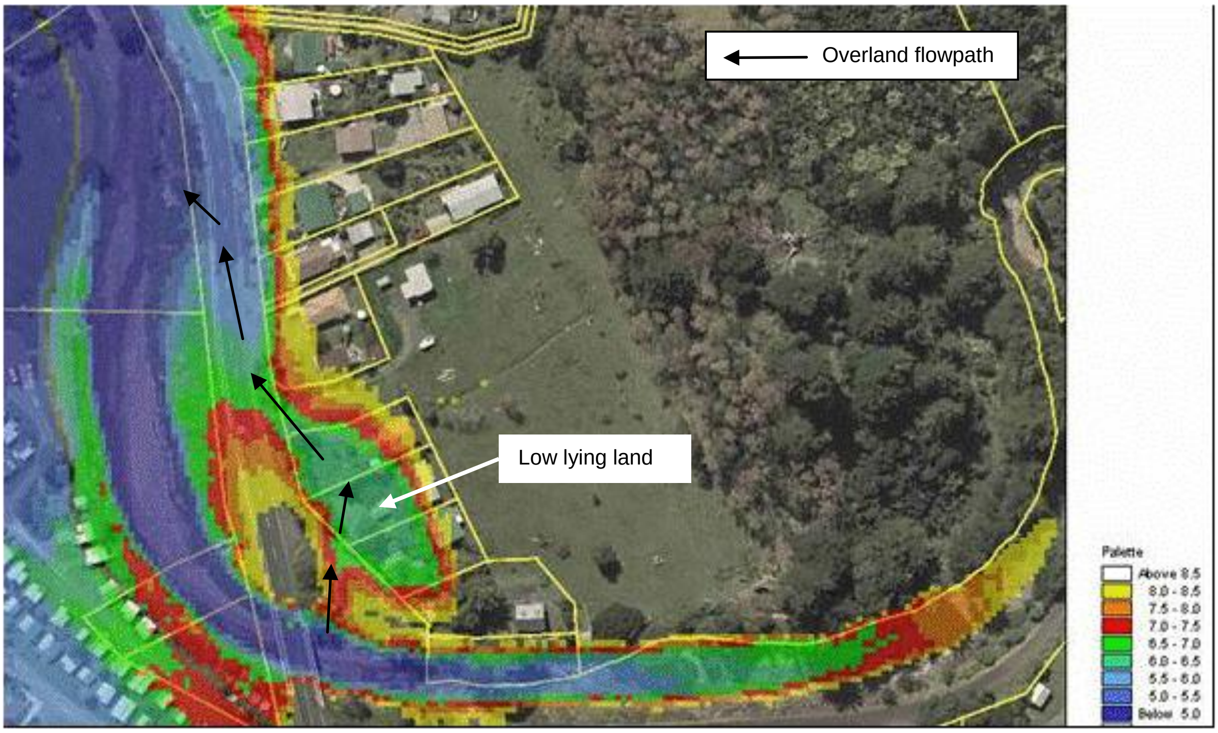


Figure 17 Existing ground levels in the vicinity of the proposed spillway (RL local datum)

The topography in the vicinity of the right bank spillway changed considerably as part of the SH25 Bridge upgrade works undertaken by NZTA. The result is that the capacity of the overland flowpath is reduced from what it was pre-scheme.

NZTA endeavoured to provide the greatest capacity practicable taking into account the site constrains. A 1200mm diameter culvert was constructed by NZTA as part of the bridge upgrade works to convey flows direct from the overland flowpath to Te Puru Stream. The capacity of this culvert is $5m^3/s$. The capacity of the overland flowpath provided was assessed by NZTA to be $10m^3/s$ with 100-200mm freeboard to the lowest house located adjacent to the overland flowpath, and $19m^3/s$ with no freeboard to the lowest house, in addition to the $5m^3/s$ capacity of the culvert. Refer to WRC DM#1921894, email correspondence from NZTA confirming the capacity of the overland flowpath and Appendix 5 which shows the arrangement of the pipework and driveways in the secondary overland flowpath as provided by NZTA. On these plans the alignment of the 1200mm diameter culvert is shown from MH1 to MH4 to MH5 to SWOUT1. This was the greatest capacity that could be provided by NZTA considering the site constraints.

WRC constructed a spillway on the right bank, upstream of the SH25 Bridge, designed with a sill height set at the 1% AEP flood level plus 300mm freeboard to control the activation level of the right bank overland flowpath. Refer to Appendix 4 for design levels for the spillway and WRC DM#1937518. The purpose of this spillway was to improve the level of protection to those properties located to the north of the stream, particularly considering the reduced capacity of the overland flowpath.

Despite the reduced capacity of the overland flowpath, the raised level of the spillway means that overall properties to the north have more protection than they did pre-scheme. When the spillway activates (in greater than design events) flows will drain away via the 1200mm dia culvert, and the overland flowpath that was provided by NZTA to the carriageway. Floodwaters will pond in the carriageway until flows can drain away by the road drainage.

5.5.4 Floodgates

Three new floodgates have been installed as part of the flood protection scheme and SH25 Bridge upgrade, the locations of which are shown on the as-built surveys in Appendix 7. Details are provided below:

Asset name	Size	Comment
Te Puru right floodgate 1	900mm	Downstream of drain at 501 Thames Coast Road (SH25)
Te Puru right floodgate 2	2 x 375mm	Downstream of SH25 local drainage
Te Puru right floodgate 3	1200mm	Downstream of secondary overland flow path large diameter culvert NZTA installed for right bank spillway activation.

5.6 SH25 Bridge upgrade

5.6.1 Pre-scheme SH25 Bridge

The pre-scheme SH25 Bridge was constructed in 1951. It had three spans of 9.1m, 12.2m and 9.1m. The original abutments were vertical but had rock batters added at some stage which gave the appearance of sloping abutments.

Key levels for the pre-scheme bridge included (in local datum):

- Deck level of 8.95m RL
- Soffit level 8.20m RL
- Approximate bed level 4.25m RL
- Design flood level of 7.30m RL as shown on the original bridge drawings (HCB 117, Jan 1982).

The stream turns through a 90 degree right hand bend downstream of the bridge location. The bridge is located just downstream of the start of the bend. The reach immediately upstream had erosion protection measures on both banks that contract the channel width relative to the bridge section. The erosion protection works on the left bank downstream of the bridge encroached on the channel width.

It was estimated that the pre-scheme bridge had capacity for 180m^3/s (between a 20% and 10% AEP event) which was the bank full flow for the Te Puru Stream. Greater than bank full flow historically resulted in higher water levels upstream of the bridge causing flooding over roads and through private property.

Council’s flood defences would result in elevated flood water levels relative to pre-scheme ground levels and infrastructure. An enlarged bridge waterway was required to reduce the afflux and to increase conveyances for flows greater than the bank full flow and to enable councils flood defences to achieve their full benefits.

5.6.2 Bridge design

It was proposed that the bridge would be upgraded to the following criteria:

- The total waterway should be able to pass the 1% AEP flood without significant damage to the road and waterway structure(s), and
- The freeboard, measured from the predicted flood stage to the underside of the superstructure, shall be 1.2m.

Consideration must be given to the impact of the bridge and its approaches on the waterway and surrounding environment. In particular, the proposed bridge must be closely integrated with the proposed flood defence works due to the interaction of one with the other.

It was proposed that the upgraded bridge would have a single span of 30m between vertical abutments and be on the same horizontal alignment as the old bridge. Key levels include:

- The soffit level 10.30m RL;
- Design flood level of 8.50m RL (excluding superelevation); and
- Approximate bed level 4.25m RL.

Refer to Appendix 6 for design drawings and to WRC DM# 1387260 for the full set of drawings. A full set of as-built drawings are provided in WRC DM# 3131559.

5.6.3 Reduced freeboard

As discussed in Section 4.3.4, there was an error in the application of the design levels in Maunsell's Waterway Assessment. The Water Assessment reported levels in terms of local datum, whereas the roading design was prepared in LiDAR datum. The correction from local to LiDAR datum (+700mm) wasn't applied when setting the soffit level of the bridge, hence the bridge soffit is lower than it was intended and doesn't achieve the design criteria of 1.2m freeboard.

The bridge soffit was designed and constructed to be at RL10.3m LiDAR which is 9.6m local datum. The flood level at this location is 8.5m local datum, hence the freeboard is 1.1m, which allowing for 0.2m of super-elevation means the bridge has 900mm freeboard. NZTA advised that they were not able to construct the bridge any higher due to site constraints.

Due to this limitation in providing the usual 1.2m freeboard for the Te Puru 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 5.5.3 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 Te Puru. 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 Coromandel Zone Management Plan (River and Catchment Services et al, 2011) outlines the agreed levels of service for the Coromandel. The agreed levels of service provided for the Coromandel zone were initially developed when the Peninsula Project was established in 2004. The current service levels were confirmed through an extensive consultation process initially undertaken in 2003/04, and subsequently updated by the LTP processes in 2006 and 2009.

In the Coromandel Zone Management Plan the Thames Coast, including Coromandel Town, is identified as a high priority area for flood protection schemes and for upper catchment protection through animal pest control (feral goats and possums). Additional works could focus on hill side erosion and stabilising erosion prone pastoral lands. The Thames Coast has a direct relationship to the Firth of Thames.

The flood protection scheme on Te Puru Stream in Coromandel 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 Te Puru is the existing 1% AEP event (without climate change) plus 500mm freeboard. The general location of the flood protection assets is shown in Figure 18 below. Refer to Appendix 3 and 4 for design details for the flood protection works at Te Puru. As-built survey data is provided in Appendix 7.

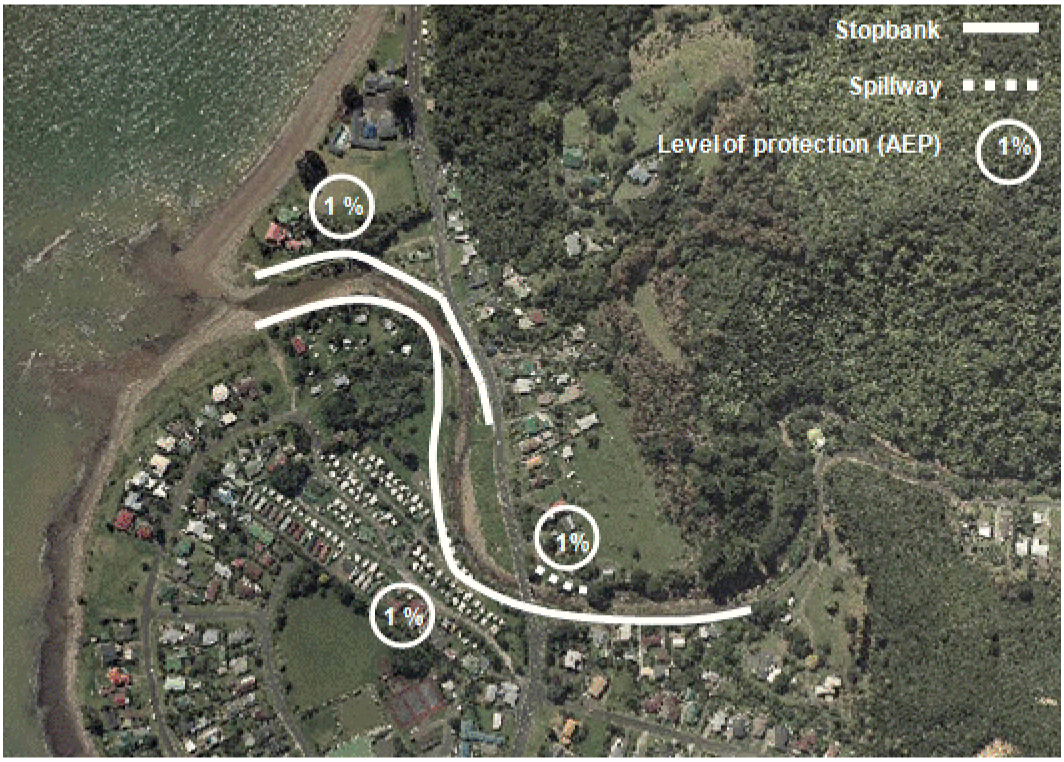


Figure 18 Flood defences in Te Puru

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 Te Puru Stream is discussed in Section 7.

7 Operation and maintenance

The main channel of the Te Puru Stream is monitored and periodically maintained by Waikato Regional Council to remove accumulated sediment and debris, refer to Figure 19 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 19 Extent of channel maintenance

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

- Removal of accumulated gravel, sand and debris from a 600 m section of the Te Puru Stream (refer to diagram for proposed extent – dark blue line).

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

- Removal of accumulated sand, silt and debris from a 170 m section of the Te Puru Stream (refer to diagram for proposed extent – light blue line).

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

Constructed flood protection works at Te Puru (a combination of flood wall, flood wall with clay bulking and sections of 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 ten years. Stopbanks are topped up where necessary.

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

As discussed in Section 5.5.4, three floodgates have been installed at Te Puru as part of the flood protection scheme and SH25 Bridge upgrade. These floodgates will need to be inspected at regular intervals.

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 8.

Table 8 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 20).

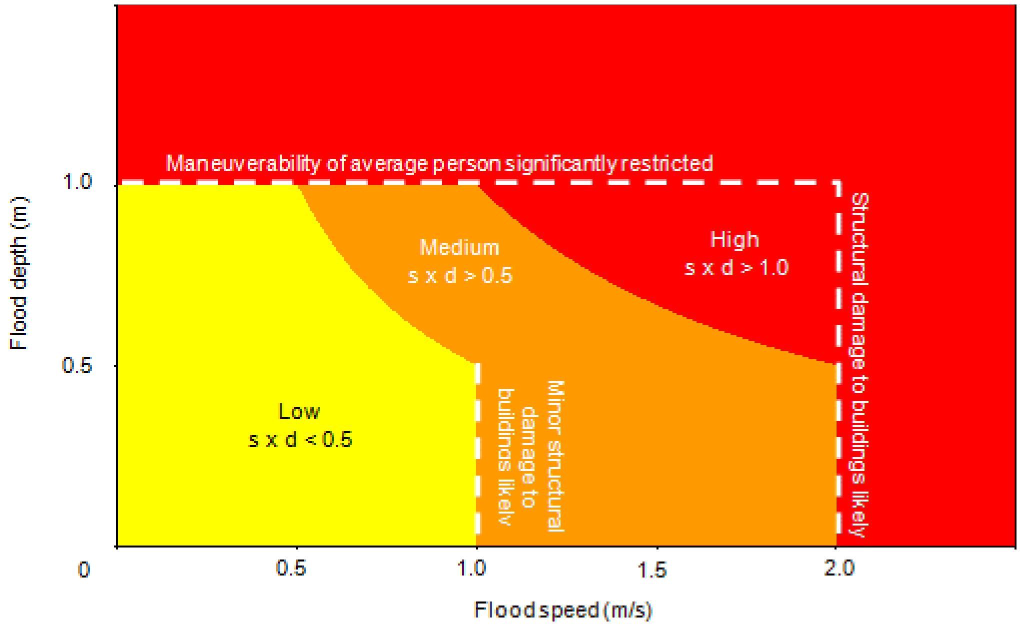


Figure 20 River flood hazard classification matrix

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 Te Puru due to the Te Puru Stream. Figure 21 shows the flood hazard map for Te Puru with the land that is protected by the scheme shaded in blue to reflect its 'Defended' status.

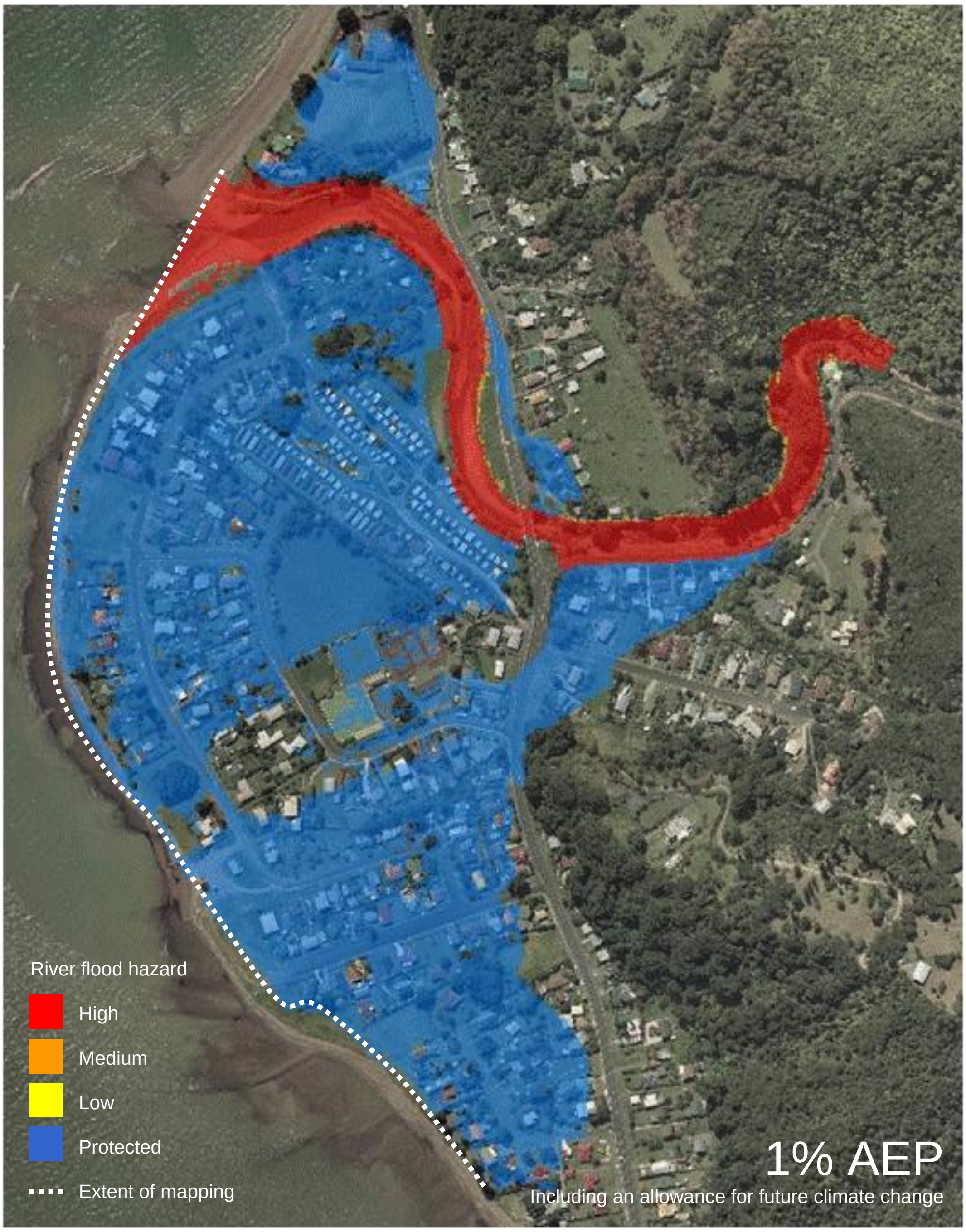


Figure 21 River flood hazard map for Te Puru

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 Te Puru 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 Te Puru 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 Te Puru 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 Te Puru Stream catchment at the time of the design process. Any significant change to this condition will affect the river flood hazard that affects the Te Puru 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 Coromandel Zone Management Plan outlines agreed levels of service for the flood protection schemes on the Coromandel, 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 design heights, achieving performance grade 3 or better.
- 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.
- Undertaking flood protection works within consent conditions.
- 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).
- Conducting all flood protection work in accordance with Council health and safety policies.

The following procedures will measure whether performance targets are achieved:

- Annual performance and condition inspections.
- Yearly performance measures reports to subcommittee and Catchment Services Committee.
- Assessing ongoing changes to catchments, and undertaking design flood level reviews once every 5 years as required.
- 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 Te Puru 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 NZTA's bridge design assessment

1.0 Introduction

This section of the report sets out the available information and work undertaken for waterway design aspects of the Te Puru Stream bridge replacement project. Figures in Appendix X are referred to throughout this section.

2.0 Background

2.1 Existing bridge

The existing bridge was constructed in 1951 some 50m downstream of the previous bridge. It has three spans of 9.1m, 12.2m and 9.1m. The original abutments were vertical but have had rock batters added at some stage which gives the appearance of sloping abutments. Key levels include: the deck level[1] of 8.95m RL; soffit level [2] 8.20m RL; approximate bed level 4.25m RL; and a design flood level of 7.30m RL as shown on the original bridge drawings (HCB 117, Jan 1982).

The stream turns through a 90 degree right hand bend downstream of the bridge. The bridge is located just downstream of the start of the bend. The reach immediately upstream has erosion protection measures on both banks that contract the channel width relative to the bridge section. The erosion protection works on the left bank downstream of the bridge also encroach on the channel width.

2.2 Problem statement

The existing bridge does not result in significant afflux [3] for the bankfull flow of 180 cumecs, however, flows greater than bankfull flow have historically resulted in higher water levels upstream of the bridge causing flooding over roads and through private property.

Flood walls and stopbanks proposed by Environment Waikato (EW), whilst protecting properties adjacent to the stream and in the natural floodplain, will result in elevated flood water levels[4] relative to existing ground levels and infrastructure. An enlarged bridge waterway is required to reduce the afflux and increase conveyance[5] for flows greater than the bankfull flow and to enable EW's proposed flood defence works to achieve their full benefits when they are implemented.

2.3 Objectives

The waterway-related objectives for the bridge replacement project are to:

1. provide an adequate waterway for the design flood,
2. provide adequate overland flow paths for safe handling of events that exceed the design flood,
3. provide adequate scour counter measures, and
4. minimise debris problems including sediment deposition and floating debris.

[1] All levels given are in terms of a provisional mean sea level at Te Puru. The difference between this datum and Tararu MSL has not been established.

[2] Soffit level varies due to the span form. The value given is the lowest level shown on HCB drawing 2182 sheet 9 of 9.

[3] Afflux or backwater is the rise above normal stage at a section upstream of the bridge. It is induced by a bridge or other structure that obstructs or constricts the free flow of water in a channel.

[4] Flood water levels are elevated compared to pre-construction flood water levels for a given discharge, provided it is sufficient to result in out-of-bank flow.

[5] Conveyance is a measure of the ability of a channel to transport flow.

2.4 Design criteria

Waterway requirements for new bridges are set out in the Transit New Zealand Bridge Manual (June 2003). The Bridge Manual stipulates that waterway design shall be carried out in accordance with the Waterway Design manual produced by AUSTROADS (1994). A number of exceptions are listed in section 2.3 of the Bridge Manual where derogations were deemed to be required to suit New Zealand conditions and practice. Key design criteria adopted are listed below.

Serviceability limit state[6] criteria are:

- level of serviceability for traffic (SLS I) – the bridge shall remain operationally functional following flood events up to the 1 in 100 AEP event
- damage avoidance (SLS II) – both the superstructure and non-structural elements shall remain undamaged following events up to the 1 in 25 AEP event

The ultimate limit state[7] criterion is that the bridge must withstand the effects of floods up to the 1 in 2500 AEP event, including overtopping.

Other criteria include:

- the total waterway should be able to pass the 1 in 100 AEP flood without significant damage to the road and waterway structure(s), and
- the freeboard[8], measured from the predicted flood stage to the underside of the superstructure, shall be 1.2m for SLS I.

Consideration must be given to the impact of the bridge and its approaches on the waterway and surrounding environment. In particular, the proposed bridge must be closely integrated with the existing flood defence works due to the interaction of one with the other.

2.5 Proposed bridge

The proposed bridge would have a single span of 30m between vertical abutments and be on the same horizontal alignment as the existing bridge. Key levels include:

- the soffit level 10.30m RL;
- design flood level of 8.50m RL (excluding superelevation); and approximate bed level 4.25m RL.

3.0 Catchment and stream description

3.1 Catchment

The Te Puru Stream has a catchment area[9] of 24 km^2 and is located approximately 11 km north of Thames. The catchment is predominantly steep with 98% being covered in native bush and scrub.

The catchment geology is mapped as Beesons Island volcanics of Tertiary age. Hydrothermal alteration has affected the rocks, which are predominantly andesites, to varying degrees. The initial rock type influences the degree of alteration and the strength of the resulting material, which affects

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6 The state at which a structure becomes unfit for its intended use.

7 The state at which the strength or ductility capacity of the structure is exceeded, or when it cannot maintain equilibrium and become unstable.

8 In accordance with Table 2.2 of the Bridge Manual.

9 Area given is based on HCB report 117. HCB report 123 gives a digitised area of 26.3 km^2. HCB report 190 gives an area of 24.4 km^2.

slope stability. The massive rocks are most resistant to alteration, while the initially weaker tuffs and sediments are more susceptible. A more detailed description of the local geology is given in other sections of this report.

3.2 Stream description

The distance between the watershed boundary and the sea is about 9 km. The average stream slope over that distance is about 3.7% (HCB 117, Jan 1982). The final 700m stream reach flows across the coastal alluvial fan through Te Puru to the sea[10]. The bridge is approximately 490m upstream of the mouth.

Figure 1.1 shows the plan form of the existing stream in the reach of interest. The existing bridge is skewed to the stream at an angle of 25 degrees as shown on Figure 1.2. The stream originally followed a course to the south of Puru Creek Rd, reportedly on the line of a drain that runs along the back of properties adjacent to the road (HCB 117, Jan 1982)[11].

The existing stream has a gradient of 0.0109 m/m (1 in 91) from Ch 0m down to Ch 650m. Downstream of Ch 650m the gradient flattens as the stream approaches the sea. A bar forms at the mouth but is removed by the river discharge as it increases.

The stream cross section varies across the fan but is typically trapezoidal with batters formed using riprap, except where the stream was realigned through high ground where the batters are formed in existing deposits. The base width varies throughout but is about 13-15m in the reach upstream and downstream of the bridge. The channel widens in the lower reaches towards the sea.

4.0 Historical flooding

A brief summary of historical flooding events follows to put the river behaviour and existing river modifications into context

4.1 1979 flood

A flood in March 1979 reportedly produced the largest flood in over 15 years throughout much of the region (HCB 117, Jan 1982). Few details are available of its impact in Te Puru but it was compared to floods in the late 1950s and early 1960s. Significant damage and flo oding occurred resulting in the HCB considering floo d control possibilities .

4.2 1981 flood

The flood of 12-13 April 1981 had a peak discharge of 130 cumecs, estimated using the slope-area method (HCB 109, Sept 1981). The discharge was thought to be equivalent to a 5-10 year flood at that time.

There were 88 landslides identified in the catchment (3.3/km2) following the flood (HCB 123, June 1982). The majority of landslides occurred on 26-35 degree slopes under forest with some under scrub. Two very large earthslips, each with a bare ground area approximately 4 hectares, were mapped at the head of the catchm ent. An estimated 100,000-150,000 m3 of debris from one of the large slips was left in storage in the watercourse after the storm. Some of this was washed down in freshes in November 1981.

The damage was far greater than the 1979 flood. At its peak an estimated 30 cumecs flowed over Puru Creek Rd and 50 cumecs flowed through the campground and properties along the left bank

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[10] Chainage is measured along the channel centreline starting at cross section 1.

[11] Also shown on PWD drawing 20261 sheet 4 of 7.

downstream of the bridge. Lateral erosion occurred on the left bank upstream of the bridge and on both banks downstream of the bridge.

Channel works implemented in 1982 were designed to provide a capacity of 180 cumecs, equivalent to the 15-20 year flood at the time. The design approach was to make the channel cross section more uniform while maintaining the existing stream gradient (HCB 117, Jan 1982).

4.3 1985 flood

The flood of 16-17 February 1985 had a peak discharge of 170 cumecs, estimated using the slope-area method (HCB 190, Oct 1985). The discharge was thought to be equivalent to a 10-20 year flood at that time.

Flood levels were surveyed and are shown on Dwg 2182 sheet 9 of 9 and Dwg 2609 sheet 1 of 1. Significant superelevation effects occurred (up to 450mm) along the stream reach upstream of the bridge.

There was limited damage during this event due to failure of gabion baskets on Puru Creek Rd. At its peak an estimated 20 cumecs flowed over the Puru Creek Rd and 150 cumecs passed beneath the bridge. Some lateral erosion and destabilisation of the channel batters occurred as expected (HCB 194, Nov 1985). Minor remedial works were subsequently proposed.

4.4 2002 flood

The flood of 20-21 June 2002 had an estimated peak discharge of 345 cumecs (EW, June 2004). The discharge was thought to be greater than a 100 year flood at that time. The storm event that generated the flood is generally referred to as the 'weather bomb'.

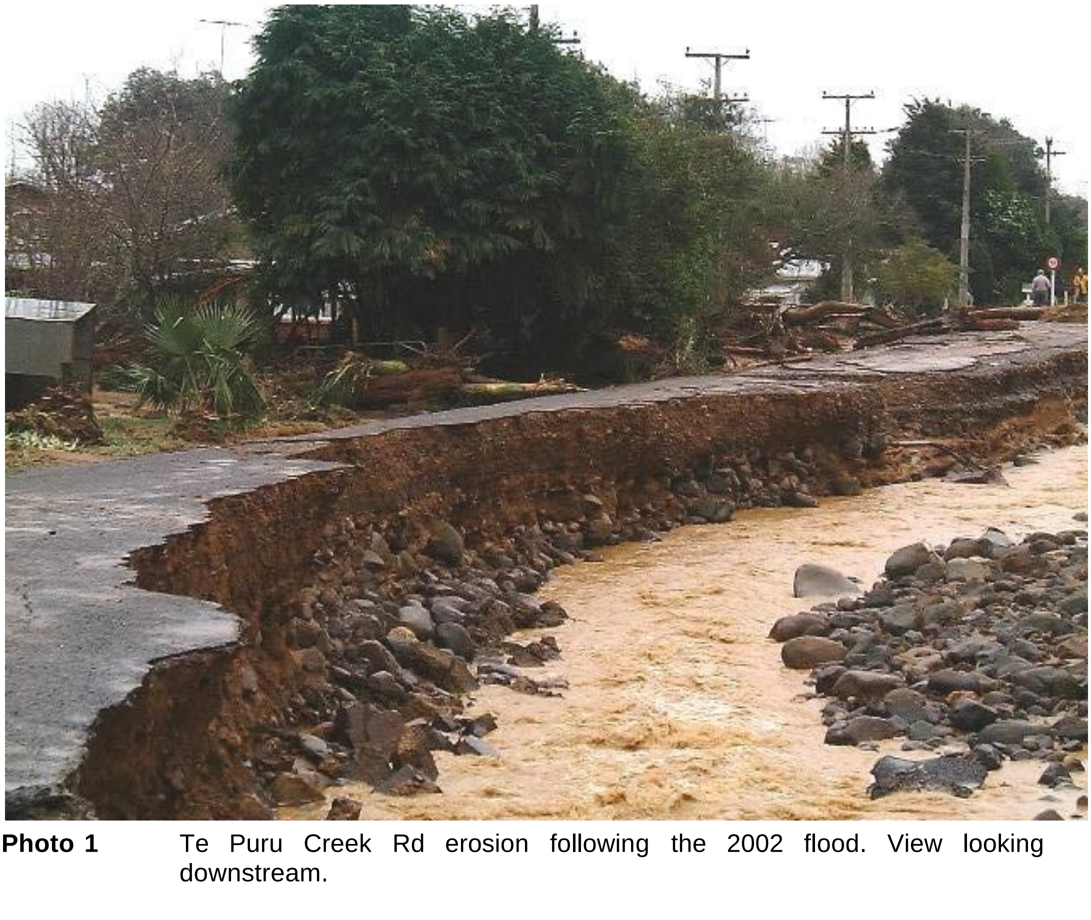

Photo 1 Te Puru Creek Rd erosion following the 2002 flood. View looking downstream.

5.0 Flood estimates

Table 2 shows estimated peak flood discharges for a variety of AEP events (Hydraulic Modelling Services, June 2006).

Table 2 Flood estimates

AEP[12] (1 in Y)	Discharge (m^3/s)
2	128
5	157
10	186
20	249
50	270
100	315

The estimates for the ungauged catchment were based (in part) on Flood Frequency in New Zealand (McKerchar and Pearson, 1989) as prescribed in the Bridge Manual for rural catchments greater than 10 km^2. Synthetic flood hydrographs for the 1 in 20, 1in 100 and 1 in 2000 AEP events were derived by Opus (October 2004) by transferring a dimensionless hydrograph from the nearby gauged Kauaeranga River, adopting the peak estimates given in the table and using a time to peak from a small catchment in the Bay of Plenty/East Cape region.

6.0 Design considerations

6.1 Bridge hydraulics

6.1.1 Existing capacity

The existing bankfull capacity is approximately 180 cumecs (EW, Oct 2003 and Opus, October 2004). The bridge waterway can pass 180 cumecs without any freeboard allowance (EW, Aug 2003). Comparison of these values with the design criteria set out earlier, and the flood estimates given in Table 2, clearly shows that modifications to the bridge waterway are required to enable the 1 in 100 AEP flood to be passed with the recommended freeboard allowance of 1.2m.

6.1.2 Modifications proposed

The modifications proposed at this stage are limited to a single span bridge with a higher soffit level. River realignment and in-channel modifications are not proposed. Figure 1.2 shows the proposed new bridge deck outline and approximate extent of the sheetpile guide walls. Figure 1.3 shows the channel cross section upstream with the proposed bridge waterway projected onto it. Note that the existing abutments are vertical but have had rock batters added at some stage which gives the appearance of sloping abutments. Figure 1.4 shows the existing channel cross section downstream of the bridge for reference purposes only.

Discussions have been started with EW regarding their plans for flood defences , a target channel profile and in particular their plans for the existing erosion protection works upstream and downstream of the bridge which currently encroach on the waterway area. EW has applied for consents for various works. The report by Tonkin and Taylor sets out the flood defence options investigated for EW (Tonkin and Taylor, August 2006). It is envisaged that the extent and alignment of the guide walls, as well as the abutment form, will be determined in the detailed design phase as details of EW's preferences are made available.

6.1.3 Hydraulic modelling

EW has undertaken extensive one and two dimensional computational hydraulic modelling for the stream and has had the work reviewed externally by Opus (October 2004). The models have been used to estimate the flood stage at various locations in the stream for two scenarios and for a variety of discharges and downstream boundary conditions. MIKE11 was used to model the existing channel system, and a proposed channel system which included flood works upstream and downstream of the bridge location (assuming the bridge is upgraded). Bridges were not included in either model. A rating was developed externally to the model using the momentum equation (because a 2 span bridge was assumed) and guidance provided in standard hydraulic references .

[12] Annual Exceedance Probability is the probability of exceedance of a given discharge within a period of one year.

The 1D MIKE11 models and documentation were made available to Maunsell and have been reviewed during preparation of this report. The models confirm that modifications to the bridge waterway are required and that the coincident tide levels in the Firth of Thames do not affect floodwater levels at the bridge. The backwater effect is limited to the reach downstream of Ch 500m. They models also confirm that the proposed flood defences in the reach downstream of the bridge (e.g. stopbanks on the left bank past the motor camp) affect the rating of the bridge.

A key point is that no at -site observations exist to support a calibration of either in -bank or over-bank floods. This is not unusual in un -gauged streams where the floods are flashy and where over-bank flow occurs in numerous places making application of the slope -area method fairly imprecise. It is further complicated du e to flood debris and because the channel geometry is subject to change due to sediment movement and ongoing maintenance. There are no known comparable local gauged catchments to enable assessment of suitable roughness value for the channel.

The uncalibr ated status of the models is highlighted to stress firstly, that the 'correct' flood level for a given flood discharge cannot be reliably determined (it is subjective to a degree), and secondly that collection of calibration data for waterway design is not practical in the time available for implementation of the bridge upgrade project. The uncertainty remaining due to lack of calibration requires judgement, the use of sensitivity analyses during design, and conservatism where practicable. The following des cribes the data used, assumptions made and results of the modelling.

The model starts at cross section 1 and finishes 700m downstream at the sea (cross section 15). Figure 1.1 shows the first 350m of the modelled reach along with the cross section locations and chainage markers. The cross sections include proposed flood works. The bed and bank levels are understood to be based on the FW Millington survey of October 2004. The modelled cross sections will need reconciling with the location and level of the proposed flood defences during the detailed design phase.

EW adopted a Manning's n roughness coefficient of 0.060 for all in-bank and over -bank sections throughout the model following advice from Opus . This is a suitably conservative value for design of the flood defences but could be considered overly conservative for dimensioning the bridge waterway. For comparison purposes in 1985 the HCB adopted an n value of 0.050 (Drawing 2182 sheet 9 of 9). Sensitivity testing of the value will be undertaken in the detailed design phase.

The boundary at the downstream end of the model was a fixed water level of 2.5m RL, which is understood to be higher than MHWS. An explicit allowance was not made for future sea level rise due to climate change or for storm surge as the backwater effect due to tide levels does not influence water levels at the bridge under any circumstances. An allowance for increases in storm severity (e.g. 20% increase in peak discharge values) was included in some model runs but these were disre garded for the purposes of this report . Transit practice is to assume that it will be accommodated within the 1.2m freeboard allowance as it progressively occurs over the design life of the bridge.

Figure 1.5 shows the water surface profile along the channel for the design discharge. The adopted flood stage upstream of the bridge for the 1 in 100 AEP flood is 8.50m RL.

6.1.4 Afflux

Stream crossings generally impose some degree of encroachment of the river or floodplain which can have an effect on the water level in the vicinity and upstream of the bridge. There are standard empirical methods for estimating afflux for stream crossings such as the AUSTROADS methodology (1994) which applies the principle of conservation of energy between the point of maximum bac kwater upstream of the bridge and a point downstream at which normal stage has been re -established. It uses empirical coefficients to estimate total afflux due to the bridge opening ratio, the abutment shape, the presence of piers, the skew of the bridge to the channel, and the eccentricity of the channel with respect to the flood plain.

The AUSTROADS methodology has not been applied and a separate allowance for afflux has not been made. The afflux would likely be small as the design flood will be largely in-bank in the reach upstream and downstream of the bridge.

6.1.5 Bend loss

There would intuitively be a head loss associated with the bend at the bridge, compared to a straight channel. There has been no complete, systematic study of head losses in bends (USA CE, 1991). The guidance available suggests that the increased head loss over and above that attributable to an equivalent straight channel is very small where the radius is three times or more than the top width of the channel. In this instance the proposed centreline radius is 120m and the top width is 26m which meets the criterion. A separate allowance for the head loss has not been made.

6.1.6 Superelevation

Superelevation has been estimated to be 0. 17m using the USACE methodology (1991). Figure 1. 6 shows the relationship used and the input values. Note that the 0. 17m value is the rise relative to the water level at the centreline.

6.1.7 Freeboard

A freeboard of 1.2m has been adopted in accordance with Table 2.2 of the Bridge Manual which is appropriate given the hig h debris load in the stream and the uncertainty in the hydraulic calculations due to lack of calibration. Adopting a lesser freeboard would increase the risk of scour, debris blockage, road overflow and potential structural damage to the bridge.

6.1.8 Soffit level

Based on the calculations undertaken for this report the soffit level should be 9.87m RL which is the adopted flood stage at Ch 200m of 8.50m RL plus 0.17m for the superelevation and 1.2m for the freeboard. Given the uncalibrated status of the models it is recommended that the soffit level of 10.3m RL proposed by EW and Opus (July 2006) be adopted without change.

6.2 Scour assessment

The Bridge Manual requires that scour is estimated using the methods included in the Bridge Scour manual (Melville and Coleman, 2000). Calculation of general scour, contraction scour and local scour will be undertaken in the detailed design phase along with design of counter measures.

Given that the stream is generally aggrading, and that contraction at the bridge section is modest, the dominant scour mechanism will be turbulence and helicoidal currents due to the bend. An interim scour depth of 2m below existing channel invert (scour to say 2.2m RL) has been adopted for the purposes of this report. This value is based on judgement informed by examination of the bed material on site and available drillhole logs.

6.3 Debris

Flood events in the catchment are characterised by high flow, short duration, events that carry a significant amount of debris sourced from the middle and upper parts of the catchment. High volumes of debris enter the system due to mass movements on the steep slopes and channel scour. Steep shallow soils exacerbate the problem even with a predominantly bush clad catchment (HCB 190, Oct 1985). The debris typically consists of young and old timber, boulders, cobbles, gravels and fine material.

Multiple span bridges should be avoided if practicable in this sort of environment due to the high risk of floating debris causing blockages at piers. For a single span bridge the existing channel alignment and the freeboard proposed should not present significant problems for the passage of floating debris. The bridge upgrade proposed will not reduce the maintenance burden associated with sediment deposits in the stream. The existing maintenance regime will need to continue.

6.4 Overland flow paths

Overland flow paths are required for events that exceed the design flood event and to enable discharge to be safely handled should the bridge capacity be restricted for some reason (e. g. sediment deposits and floating debris). It is proposed that a floodway be formed and protected from development for this purpose. The proposed floodway would pass flow from a lowered length of the right bank upstream of the bridge northward along the landward side of SH25. A low point in the highway vertical alignment will be required to ensure that the spilled flow is channelled to an appropriate discharge point back into the stream.

6.5 Interface with flood protection works

Channel improvement works were completed for flood protection purposes during the 1980's by the HCB. These works included widening the channel and installing erosion protection works (riprap) and are currently maintained by EW. Future flood protection works are likely to comprise stopba nks upstream and downstream of the bridge. As mentioned previously options for the defences have been developed by Tonkin and Taylor for EW. Discussions with EW regarding their plans will continue in the detailed design phase to ensure that the defences ar e integrated with the bridge due to the interaction of one with another.

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FIGURE 1.1
TE PURU STREAM BRIDGE UPGRADE
CROSS SECTION LOCATION PLAN

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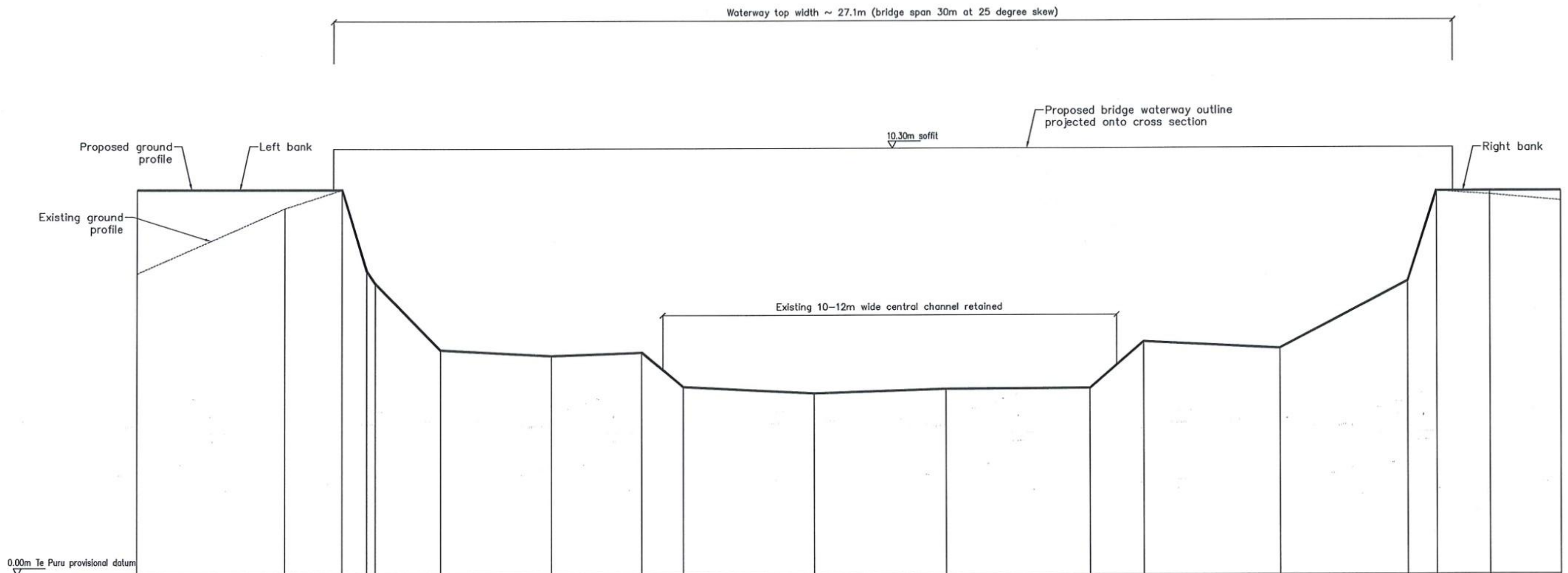
FIGURE 1.2
TE PURU STREAM BRIDGE UPGRADE
BEND GEOMETRY

MAUNSELL | AECOM

NOTES:
1. Refer to Figure 1.1 for notes.



Station (m)	0.00	3.6	5.0	5.6	5.8	7.4	10.1	12.3	13.3	16.5	19.7	23.2	24.5	27.8	30.9	31.6	32.9	34.6
Existing elevation (m RL)	7.29	8.86	9.31	7.35	7.06	5.44	5.30	5.37	4.54	4.38	4.48	4.50	5.62	5.45	7.07	9.24	9.15	9.0
Proposed elevation (m RL)	9.31																9.24	9.24

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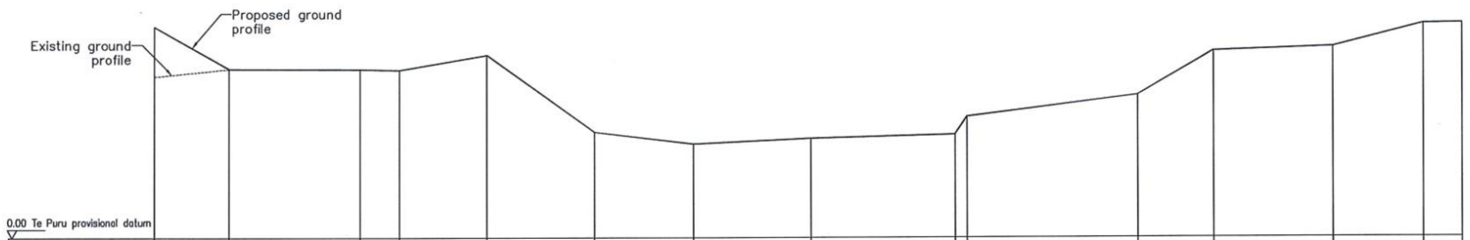
FIGURE 1.3
TE PURU STREAM BRIDGE UPGRADE
CROSS SECTION UPSTREAM

MAUNSELL | AECOM

NOTES:
1. Refer to Figure 1.1 for notes.



Station (m)	0.00	3.1	8.5	10.1	13.7	18.1	22.2	27.0	32.9	33.4	40.4	43.5	48.4	52.1	53.7
Existing elevation (m RL)	6.61	6.88	6.87	6.83	7.44	4.30	3.82	4.03	4.19	4.92	5.79	7.58	7.75	8.67	8.69
Proposed elevation (m RL)	8.60														

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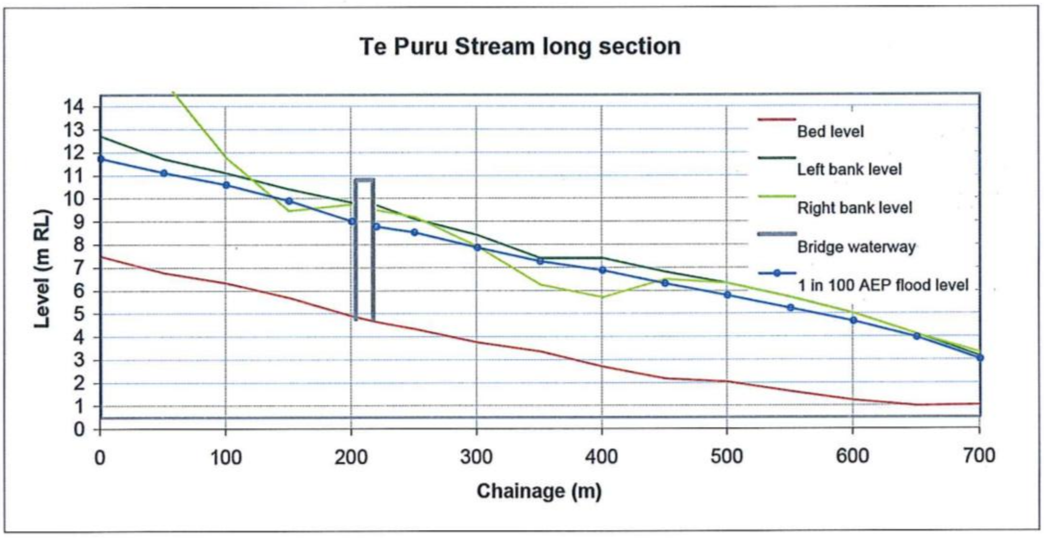
Nov 06

FIGURE 1.4
TE PURU STREAM BRIDGE UPGRADE
CROSS SECTION DOWNSTREAM

Figure 1.5 Te Puru Stream long section

EW's MIKE11 model - 315 m^3/s, post flood works and bridge replacement

			Existing channel		With proposed flood works		
Cross section number	Chainage (m)	Bed level (m RL)	Left bank level (m RL)	Right bank level (m RL)	Left bank level (m RL)	Right bank level (m RL)	1 in 100 AEP flood level (m RL)
1	0	6.99	10.78	17.32	12.20	21.85	11.23
2	50	6.26	9.66	14.38	11.20	14.61	10.61
3	100	5.82	9.15	11.03	10.60	11.25	10.09
4	150	5.18	7.47	8.70	9.90	8.96	9.39
U/S bridge	200	4.38	8.33	8.91	9.31	9.24	8.50
5	210	4.25	9.18	9.11			
D/S bridge	220	4.13	7.95	8.90	9.20	8.98	8.27
6	250	3.82	6.72	8.69	8.60	8.69	8.02
7	300	3.24	6.80	7.41	7.90	7.41	7.35
8	350	2.85	6.65	5.74	6.90	5.74	6.76
9	400	2.18	4.31	5.15	6.90	5.19	6.36
10	450	1.66	4.09	5.84	6.30	5.99	5.79
11	500	1.52	3.54	5.03	5.80	5.80	5.27
12	550	1.11	3.59	3.69	5.20	5.20	4.71
13	600	0.72	3.41	3.25	4.50	4.50	4.16
14	650	0.48	2.94	2.99	3.60	3.60	3.45
15	700	0.52	2.66	2.49	2.63	2.80	2.50



Notes

1. All levels shown are in terms of Provisional Mean Sea Level at Te Puru (Mean sea level assumed to = 0.00 mRL).
   The same datum was adopted for the 1980's flood defence works. Refer to HCB drawing 2182, sheet 9 of 9, dated Oct 1985.
2. Existing bank and bed levels are based on the FW Millington survey of Oct 2004.
3. The proposed bank and flood levels were extracted from Environment Waikato's MIKE 11 models developed in 2005.
   Flood wall levels extracted from: Te Puru Stream - Floodworks (Bridge Fixed) - Bridge.xns11, dated 30/11/05
   Flood levels extracted from: TE PURU STREAM - FLOODWORKS - NO BRIDGE (RATING).RES11, dated 1/12/05
4. The model used included the proposed flood defences. The degree of bank raising required is indicated by the difference between existing and proposed levels given above.
5. A two span bridge was assumed in the modelling. Bridge afflux was estimated separately from the model but has not been included in the flood level shown for Ch 200m because the current proposal is for a single span bridge.
6. The proposed bridge waterway soffit is 10.30m RL, including allowances for superelevation and freeboard.

Figure 1.6 Superelevation estimate

USACE, Hydraulic Design of Flood Control Channels, EM1110-2-1601, 1991

Eqn $\Delta y = C\ V^2 W / g\ r$

Coefficient, C	0.5	
Mean velocity, V	3.90	m/s
Channel width at CL depth, W	26.0	m
Centreline radius, r	120.0	m
Rise, Δ y	0.17	m

Notes

1. The rise calculated is relative to the water level at the centreline.
2. The coefficient is drawn from Table 2-4 of the original reference.
   The value shown is for subcritical concentric flow in a trapezoidal channel.

Appendix 2 WRC's bridge model

Memo

File No:	Z21 S200
Date:	5 December 2005
To:	Mark Roper Opus Consultants Paeroa PO Box 91 Paeroa mark.roper@opus.co.nz
From:	Nick Martin
Subject:	**Design soffit level and span length for replacement bridge at Te Puru**

BY E-MAIL & POST

Introduction

As has previously been done for the Tararu Stream, a series of one-dimensional hydraulic models have now been set up using the MIKE11 modelling software package in order to aid the design of the replacement bridge crossing the Te Puru Stream at Te Puru.

A full description of the methodology used in the models will be included in the upcoming technical report for this study. However, a brief overview is contained below.

Once again, the key requirement at this stage of the project is the design soffit level, as requested. The level and the various aspects considered in the derivation of this figure will also be discussed below.

Methodology

A basic MIKE11 model for the area had previously been set up by Environment Waikato and later reviewed and rerun by Opus Consultants (refer to your report for Transit New Zealand, ref: 263500.91, September 2004). A number of small adjustments were made to reflect the comments made in that report, namely the use of the momentum equation to derive a rating for flows through the bridge (rather than using the FHWA WSPRO module within MIKE11), and a global Manning's n number of 0.06.

It is also important to note that new cross sections have since been obtained for this reach and have been included in the new models. These sections were surveyed in October 2004 for Environment Waikato by F.W. Millington Ltd (their ref: 2474).

Using these sections as a basis, new 'post floodworks' sections were derived to approximate the future scenario in which the bridge will be required to operate. At this stage it was assumed that this will involve floodwalls or stopbanks (at approximately the 1 in 100 year level plus a freeboard of 500 millimetres) in the following locations:

- The entire left bank from Ch. 0 (210 metres upstream of the bridge) onwards; &
- The right bank from Ch. 500 (near SH 25 at the downstream end) onwards.

The approximate locations of the assumed floodworks are shown in Figure 1. Note that this diagram is for illustrative purposes only.

Figure 1: Assumed approximate locations of floodworks at Te Puru

As was done for the Tararu Stream case, the model's sensitivity to changes in downstream water level ('tailwater') was tested. However, for the Te Puru Stream case, variations in tailwater had essentially no effect on levels at the bridge. Hence, the downstream level was set at a constant 2.5 metres, as per previous modelling.

Environment Waikato had previously used MIKE11's inbuilt bridge modelling modules to model flows through the bridge. However, in the Opus Consultants report for Transit New Zealand (263500.91, September 2004) this method was highlighted as not being suitable for this application. Indeed, this method was predicting losses of around 2 metres for peak flow, which is clearly incorrect.

As a result of this issue being identified, a more accurate method was developed by Tom Parsons at your Wellington offices. This method produces a rating (flow versus height) for the bridge by using the momentum equation to calculate pier losses through the bridge for a range of flows (a step hydrograph is used to simulate each flowrate in turn). This rating can then be placed into the model at the bridge (as an artificial 'weir' module/structure in the MIKE11 network) during the design simulations.

In this way, a rating was initially derived for the bridge. Once this was obtained, the design simulation was run. The simulation used a design 1 in 100 year hydrograph, the shape of which was based on flow records from the nearby Kauaeranga River, and with a 315 m^3/s peak flow, an update which was also suggested in your September 2004 report. This was considered to be the basic design model.

However, before final soffit levels could be determined it was necessary to also consider superelevation effects at the bridge. Superelevation is defined as the observed difference in stream level (between centreline and outside surface) as water flows around a bend as a result of centrifugal forces. Flows on the outside of a bend will be higher, and these effects need to be considered when determining appropriate soffit levels, especially for bridges on bends such as the Te Puru Bridge (note that the bend for this bridge is not nearly as severe as that at Tararu). The maximum superelevation level (normally during the peak flow) should be added to the modelled peak flow level to account for the elevated levels on the outer edge of the steam as flows pass beneath the bridge.

An additional 100 millimetres was also added to account for an additional friction allowance, owing to uncertainties in the friction calculations through the bridge (this may be reviewed by your own hydraulics engineers in the future).

Finally, a suitable freeboard level was added to allow floating debris in the stream to pass beneath the bridge without causing an obstruction. This is especially important in a steep, heavily wooded catchment such as this, where large volumes of debris are likely, and where the bridge is on a sharp bend. 1.2 metres was previously assumed to be an adequate freeboard level for the Te Puru Bridge and has been included in the calculations here.

Note that, in order to gauge the future impact of climate change on the system, an additional design model was run that included a 20% increase in flows. This is in line with the accepted current practice for estimating the effects of climate change. These results are also given below.

An indication of the calculated peak scour depths for the design case have also been included below and should be considered during the bridge design phase.

Results

The results of the modelling investigations are contained in Table 1 below. Note that future climate change may add around 400 millimetres to the soffit level requirement.

The design soffit level, as requested, should therefore be taken as 10.3 metres (MSL datum).

Table 1: Results of Hydraulic Modelling Investigation for Design Soffit Level at Te Puru Bridge

	Design Modelled Level [metres]	**Superelevation Allowance [metres]**	**Additional Friction Allowance [metres]**	**Freeboard Allowance [metres]**	**DESIGN SOFFIT LEVEL [metres]**
1 in 100 year	8.78	0.25	0.1	1.20	**10.3**
1 in 100 year + 20% flows	*9.10*	*0.31*	*0.1*	*1.20*	*10.7*

For the peak scour depth calculations three calculation methods were used (Blench, Maza Alvarez & Echavarria Alfaro, and Holmes) for general scour (y_{ms}) and the average taken. The average peak scour depth was calculated as being 4.5 metres. For a typical peak flow depth beneath the bridge of 4.4 metres this translates to around 0.1 metres of scour. Hence, general scour can be considered minor.

However, as the bridge is located on a bend in the stream, the bend scour was then calculated on top of this. Using two calculation methods (Maynord and Neill) the average bend scour was calculated as being approximately 8.4 metres (that is, potentially around 4 metres of scour at the bend). While this may seem excessive, it is not thought to be unrealistic. It is recommended that the depth of the scour beneath the bed level at the bridge is assumed to be between 3 and 5 metres.

Discussion

It is noted that the previous recommended soffit level of 10.1 metres has been exceeded by 0.2 metres as a result of this investigation. Additional requirements were introduced by the inclusion of the superelevation (0.25 metres) and additional friction allowances (0.10 metres), although the modelled level was slightly lower (8.78 metres compared to the previous 8.9 metres). This change in the modelled level is presumably a result of using the new surveyed cross sections and assumed stopbank/floodwall locations.

As stated above, the inclusion of the friction allowance may be reviewed in the near future by yourselves. However, it is highly recommended that the superelevation allowance is maintained in the bridge’s design.

Conclusion

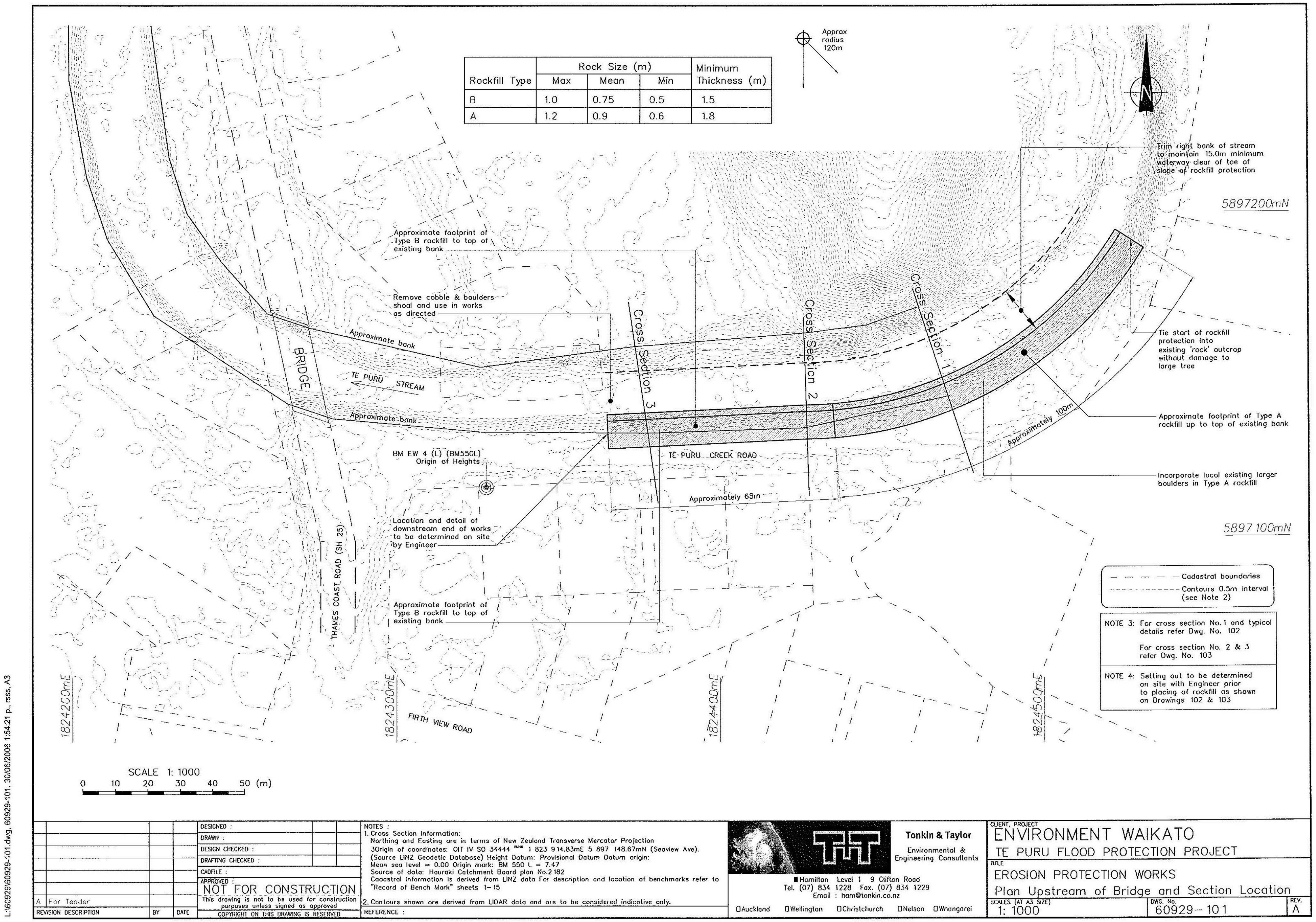
Environment Waikato recommend that the minimum soffit level for the upgraded SH25 bridge crossing the Te Puru Stream at Te Puru be set at 10.3 metres.

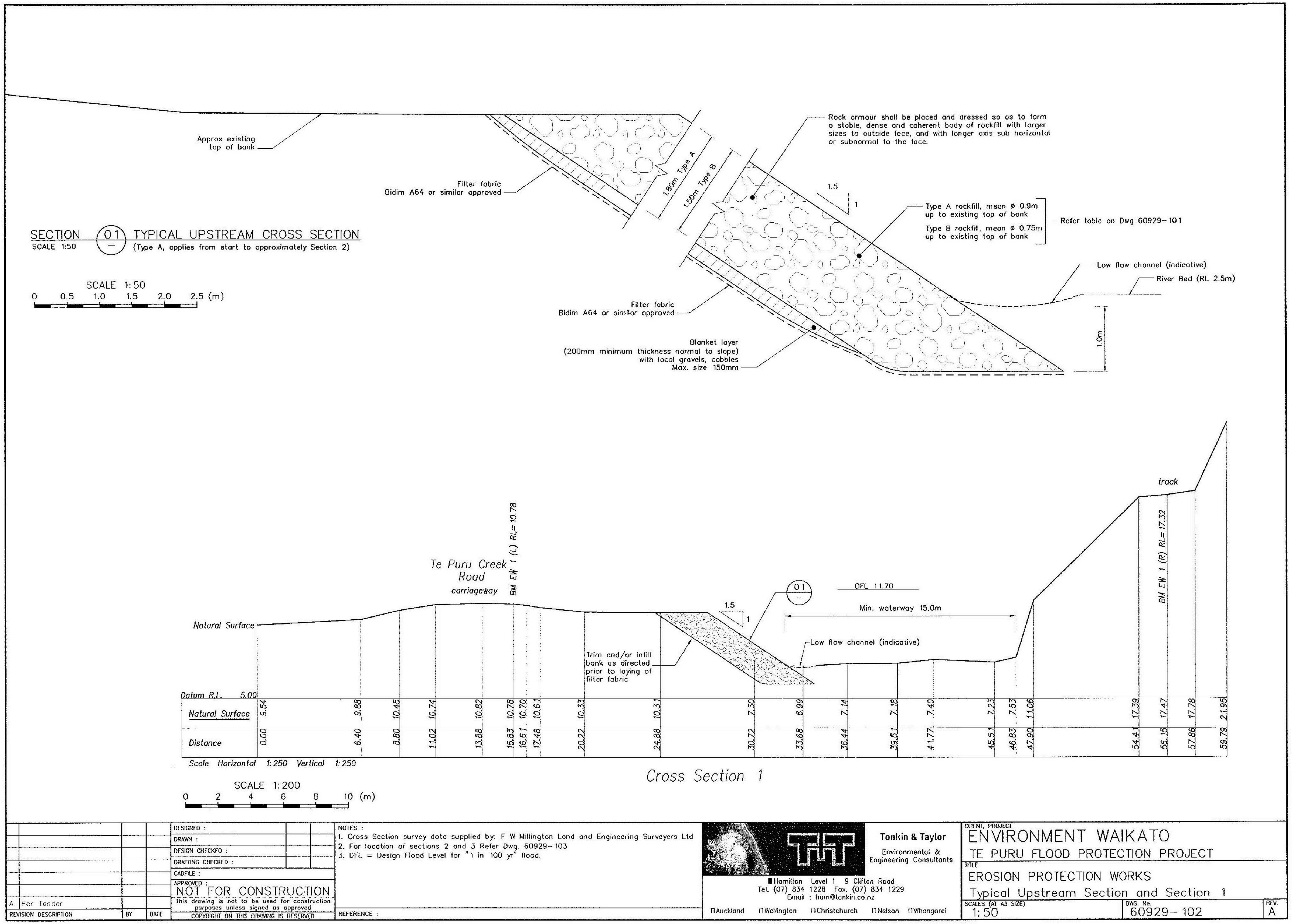
Should further information or investigations be required please do not hesitate to contact me.

Yours sincerely

Nick Martin
Environmental Engineer
River and Catchment Services

Appendix 3 Erosion protection design details





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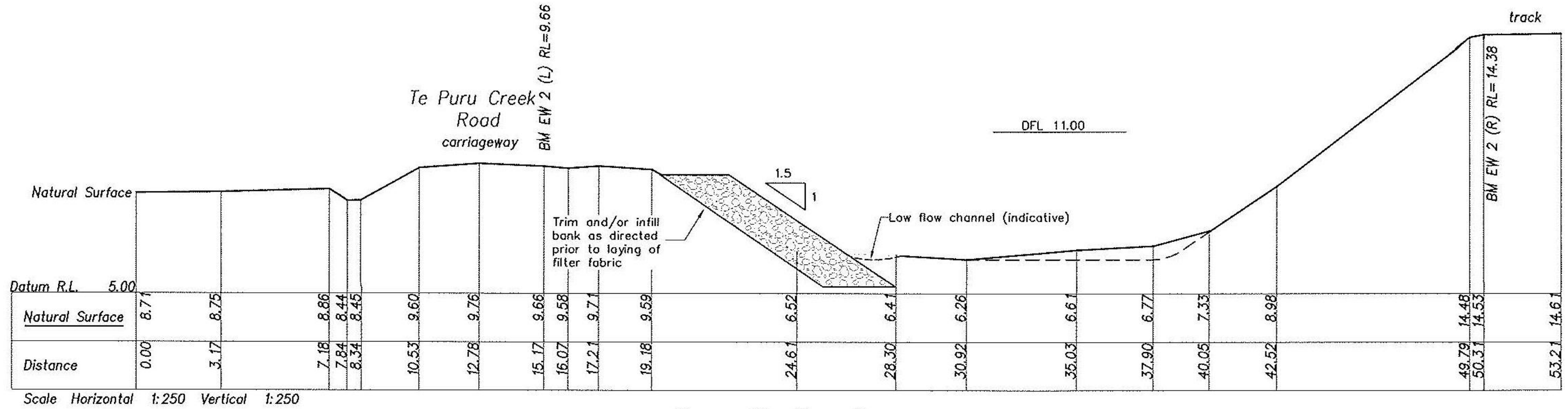

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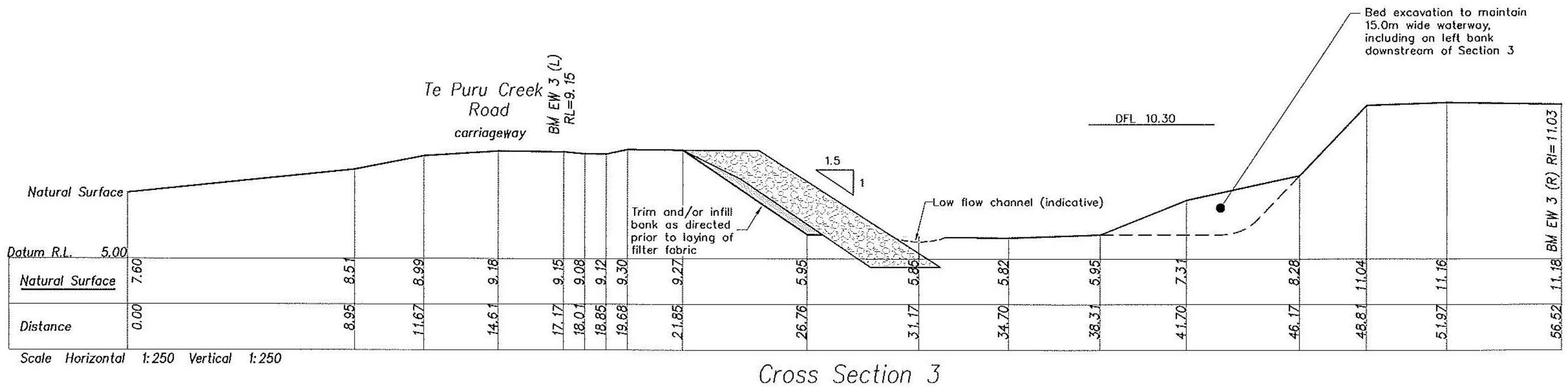

Cross Section 3

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DESIGNED :
DRAWN :
DESIGN CHECKED :
DRAFTING CHECKED :
CADFILE :
APPROVED :

NOT FOR CONSTRUCTION
This drawing is not to be used for construction purposes unless signed as approved

NOTES :
1. Cross Section survey data supplied by: F W Millington Land and Engineering Surveyers Ltd
2. For Datum information Refer Dwg. 60929-101
3. For typical details of Type A rockfill refer Dwg. 60929-102

REFERENCE :

Tonkin & Taylor
Environmental & Engineering Consultants
■Hamilton Level 1 9 Clifton Road
Tel. (07) 834 1228 Fax. (07) 834 1229
Email : ham@tonkin.co.nz
□Auckland □Wellington □Christchurch □Nelson □Whangarei

CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION PROJECT
TITLE
EROSION PROTECTION WORKS
Section 2 & Section 3
SCALES (AT A3 SIZE) 1: 200
DWG. No. 60929-103
REV. A

Appendix 4 Flood protection scheme design details

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ENVIRIONMENT WAIKATO
Te Puru Flood Protection
Construction Issue

DRAWING	Rev	Title
• 60929.001-100	B	Location Plan & Drawing Index & General Notes
• 60929.001-200	B	Site Layout Plan
• 60929.001-300	A	Flood Protection Works Layout Plan - LB Chainage 0.00 - 300m
• 60929.001-301	B	Flood Protection Works Layout Plan - LB Chainage 300-467m
• 60929.001-302	B	Flood Protection Works Layout Plan - LB Chainage 477-677m
• 60929.001-303	A	Flood Protection Works Layout Plan - Campground Layout Plan
• 60929.001-400	B	Flood Protection Works Longsection - LB Chainage 0.0-300m
• 60929.001-401	B	Flood Protection Works Longsection - LB Chainage 300-465.70m
• 60929.001-402	B	Flood Protection Works Longsection - LB Chainage 505.31-675.80m
• 60929.001-403	B	Flood Protection Works Longsection - RB Chainage 0.0-200.81m
• 60929.001-500	B	Flood Protection Works Cross Sections - LB Chainage 0.0-348.12m
• 60929.001-501	B	Flood Protection Works Cross Sections - LB Chainage 523.34-676.24m
• 60929.001-502	A	Flood Protection Works Cross Sections - RB Chainage 0.0-201.00m
• 60929.001-600	B	Flood Wall Details - Sheet 1 of 3
• 60929.001-601	B	Flood Wall Details - Sheet 2 of 3
• 60929.001-602	B	Flood Wall Details - Sheet 3 of 3
• 60929.001-603	A	Flood Protection Works Details - Lot Access Details
• 60929.001-604	B	Flood Protection Works Details - Rip Rap Details
• 60929.001-700	B	Retaining Wall Details
• 60929.001-800	A	Miscellaneous Details

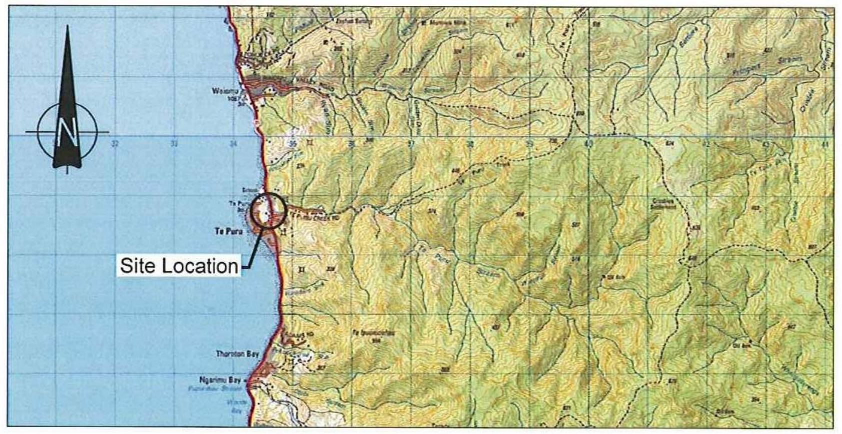
• Denotes drawing this issue: 20/11/2009

GENERAL

1. All Drawings shall be read in conjunction with the Specification.
2. Dimensions shall not be obtained by scaling from Drawings.
3. All discrepancies shall be referred to the Engineer for resolution before proceeding with the work.
4. The stability of structures during construction is the responsibility of the Contractor.
5. All materials and workmanship shall be in accordance with the current Codes of Practice except where varied by the Specification and/or Drawings.
6. General Abbreviations as follows:

NTS	Not to Scale
SOP	Set Out Point
UNO	Unless Noted Otherwise
RL	Reduced Level
HDG	Hot dip galvanised
PL	Plate
EF	Each face
NF	Near face
FF	Far face
EW	Each way
T	Top
B	Bottom
Reinf.	Reinforcement
CJ	Control joint
Crs.	Centres
Stgd.	Staggered
Stps.	Stirrups
Alt.	Alternate
Strs.	Starters
SS	Stainless steel
CL	Centreline

7. All excavations shall be inspected by the Engineer prior to filling.
8. The Contractor shall be responsible for identifying all services on site prior to the start of works.
9. The Contractor shall set out all works prior to the start of works & confirm all clashes with existing trees, structures, pavement & lot appurtances with the Engineer prior to proceeding with works. The Contractor shall also be aware of the potential presence of burial sites & shall stop works immediately and contact the Engineer if human remains or artifacts are uncovered.
10. The Contractor shall confirm the locations of any site offices or facilities, stockpile areas and access points with the Engineer prior to the start of works.
11. The Contractor shall implement all erosion and sediment control measures necessary to minimise adverse environmental affects of soil disturbing activities in accordance with Environment Waikato publication, "Erosion & Sediment Control Guidelines for Soil Disturbing Activities".



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				DRAWN :	RSSS	Oct.09
				DESIGN CHECKED :	EDW	11/09
				DRAFTING CHECKED :	BMQ	11/09
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B	Minor Revisions	EDW	11/09	APPROVED : EDWilson 23/11/09		
A	For Construction	EDW	10/09	This drawing is not to be used for construction purposes unless signed as approved		
REVISION	DESCRIPTION	BY	DATE	COPYRIGHT ON THIS DRAWING IS RESERVED		

NOTES :

REFERENCE :

Tonkin & Taylor
Environmental & Engineering Consultants

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Email : ham@tonkin.co.nz

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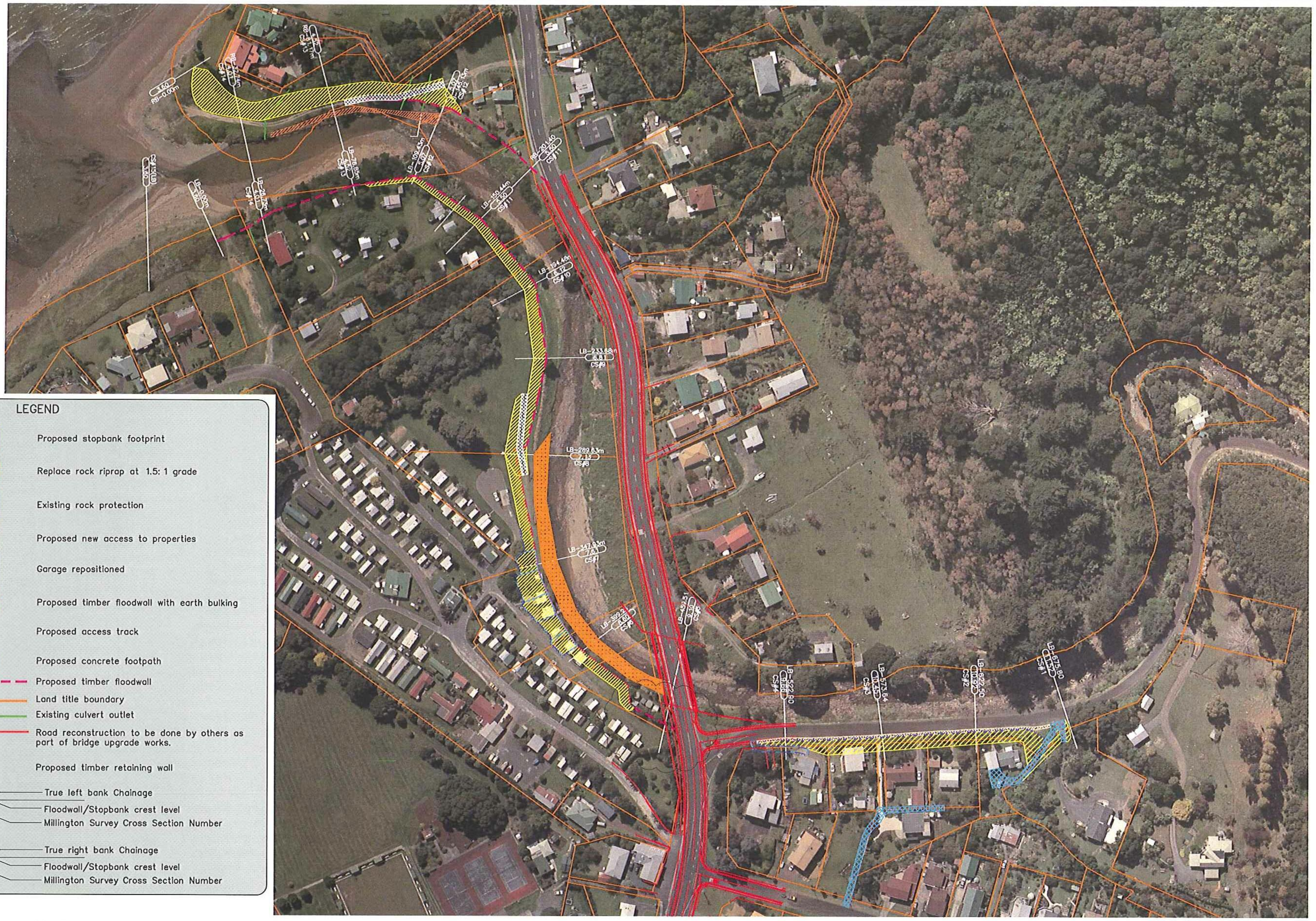
CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS
Location Plan, Drawing Index & General Notes

SCALES (AT A3 SIZE)

DWG. No. 60929.001– 100

REV. B



LEGEND

- Proposed stopbank footprint
- Replace rock riprap at 1.5: 1 grade
- Existing rock protection
- Proposed new access to properties
- Garage repositioned
- Proposed timber floodwall with earth bulking
- Proposed access track
- Proposed concrete footpath
- Proposed timber floodwall
- Land title boundary
- Existing culvert outlet
- Road reconstruction to be done by others as part of bridge upgrade works.
- Proposed timber retaining wall

LB–0.00 — True left bank Chainage
0.00 — Floodwall/Stopbank crest level
CS#1 — Millington Survey Cross Section Number

RB–0.00 — True right bank Chainage
0.00 — Floodwall/Stopbank crest level
CS#1 — Millington Survey Cross Section Number

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A	For Construction	EDW	10/09
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DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BMQ	11/09
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APPROVED : EDWilson 23/11/09		

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NOTES :

1. All dimensions are in millimetres unless noted otherwise.
2. Design Floodwall/Stopbank levels supplied by Environment Waikato.
3. Design 1% AEP Flood levels supplied by Environment Waikato.
4. Cross sections and Land Title Boundaries from F.W.Millington Ltd, Environment Waikato Thames Coast Project – Te Puru Stream Survey Dwg No.2474 Sheets 1 to 8 dated October 2004.

REFERENCE :

Tonkin & Taylor
Environmental & Engineering Consultants
Hamilton Level 1 9 Clifton Road
Tel. (07) 834 7320 Fax. (07) 834 7349
Email : ham@tonkin.co.nz
Auckland Wellington Christchurch Nelson Whangarei

DRAWING STATUS: **CONSTRUCTION ISSUE**

CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS
Site Layout Plan

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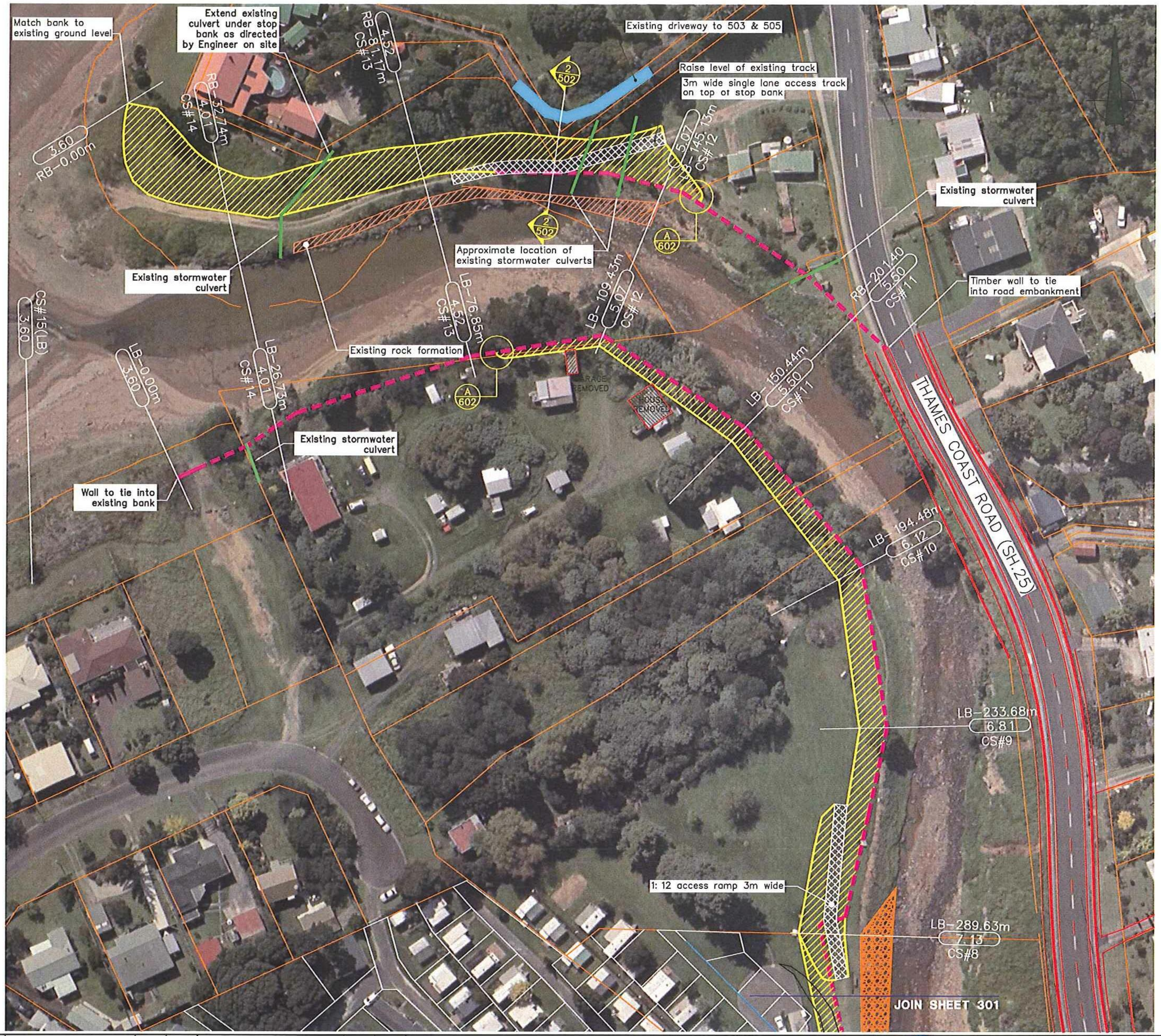

LEGEND

- Proposed stopbank footprint
- Replace rock riprap at 1.5: 1 grade
- Existing rock protection
- Proposed new access to properties
- Garage repositioned
- Proposed timber floodwall with earth bulking
- Proposed access track
- Proposed concrete footpath
- Proposed timber floodwall
- Land title boundary
- Existing culvert outlet
- Road reconstruction to be done by others as part of bridge upgrade works.
- Proposed timber retaining wall

LB-0.00 — True left bank Chainage
0.00 — Floodwall/Stopbank crest level
CS#1 — Millington Survey Cross Section Number

RB-0.00 — True right bank Chainage
0.00 — Floodwall/Stopbank crest level
CS#1 — Millington Survey Cross Section Number

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DESIGN CHECKED : EDW 10/09
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NOTES :
1. All dimensions are in metres unless noted otherwise.
2. Design Floodwall/Stopbank levels supplied by Environment Waikato.
3. Design 1% AEP Flood levels supplied by Environment Waikato.
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Email : ham@tonkin.co.nz
Auckland Wellington Christchurch Nelson Whangarei

CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS LAYOUT PLAN
Left Bank Chainage 0.0m to 300m

SCALES (AT A3 SIZE) 1: 1000
DWG. No. 60929.001–300
REV. A

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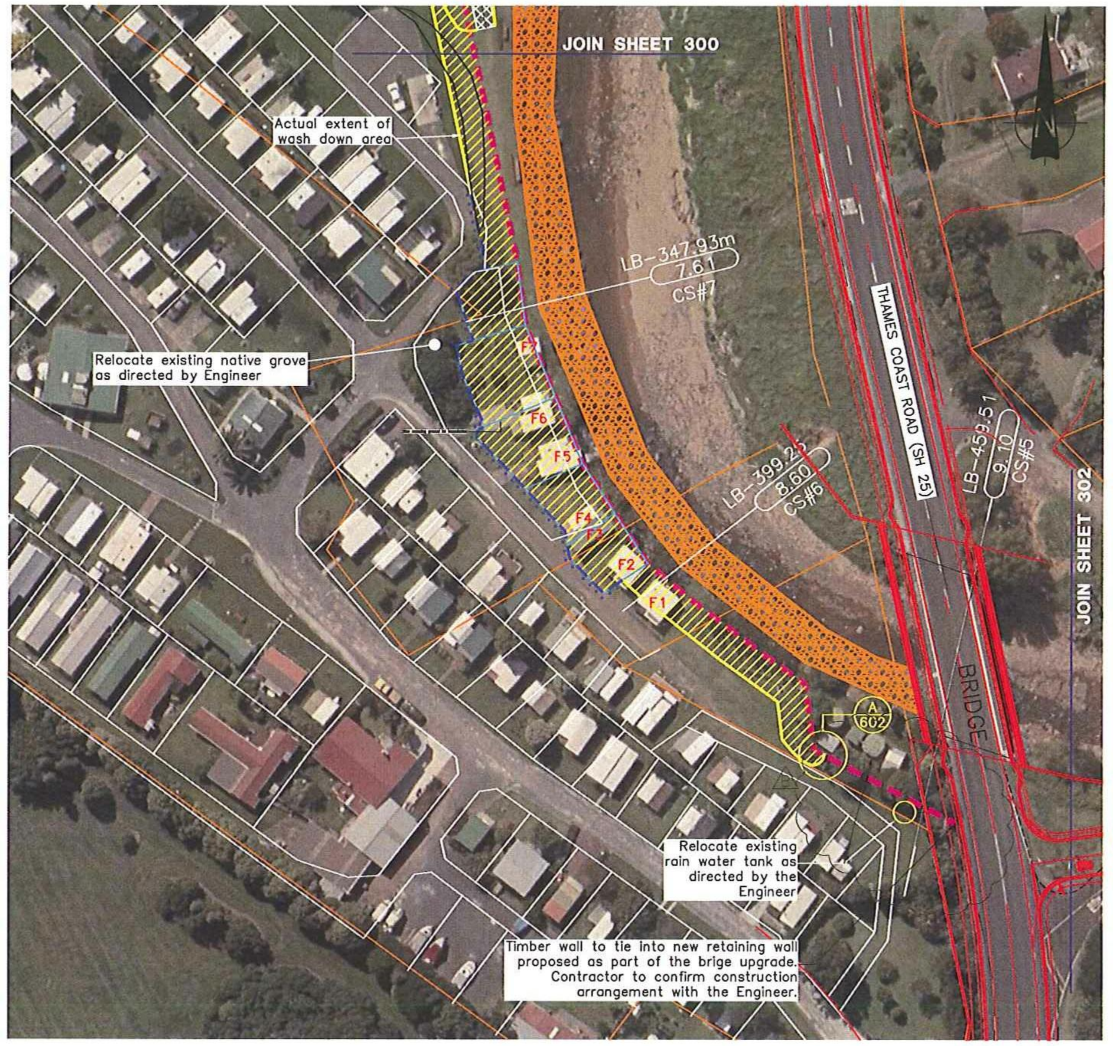

LEGEND

- Proposed stopbank footprint
- Replace rock riprap at 1.5: 1 grade
- Existing rock protection
- Proposed new access to properties
- Garage repositioned
- Proposed timber floodwall with earth bulking
- Proposed access track
- Proposed concrete footpath
- Proposed timber floodwall
- Land title boundary
- Existing culvert outlet
- Road reconstruction to be done by others as part of bridge upgrade works.
- Proposed timber retaining wall
- LB-0.00 — True left bank Chainage; 0.00 — Floodwall/Stopbank crest level; CS#1 — Millington Survey Cross Section Number
- RB-0.00 — True right bank Chainage; 0.00 — Floodwall/Stopbank crest level; CS#1 — Millington Survey Cross Section Number

SCALE 1: 1000

0 10 20 30 40 50 (m)

DRAWING STATUS: CONSTRUCTION ISSUE

REV.	REVISION DESCRIPTION	BY	DATE
B	Minor Revisions	EDW	11/09
A	For Construction	EDW	10/09

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APPROVED : EDWilson		23/11/09

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NOTES :

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□Auckland □Wellington □Christchurch □Nelson □Whangarei

CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS LAYOUT PLAN
Left Bank Chainage 300m to 467m

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- Existing rock protection
- Proposed new access to properties
- Garage repositioned
- Proposed timber floodwall with earth bulking
- Proposed access track
- Proposed concrete footpath
- Proposed timber floodwall
- Land title boundary
- Existing culvert outlet
- Road reconstruction to be done by others as part of bridge upgrade works.
- Proposed timber retaining wall

LB-0.00 — True left bank Chainage
0.00 — Floodwall/Stopbank crest level
CS#1 — Millington Survey Cross Section Number

RB-0.00 — True right bank Chainage
0.00 — Floodwall/Stopbank crest level
CS#1 — Millington Survey Cross Section Number

Site Notes:

1. Driveways to be 3m wide with compacted gravel finish as directed by the Engineer.
2. Crossovers to be 3.0m wide with 120mm thick 20MPa concrete broom finished with 661 mesh central on 30mm thick AP65 basecourse on min subgrade CBR 10 vehicle crossing, layout & grades to be in accordance with TCDC Standard Drawings 600-211A & 600-219

SCALE 1: 1000
0 10 20 30 40 50 (m)

DRAWING STATUS: CONSTRUCTION ISSUE

REV	REVISION DESCRIPTION	BY	DATE
B	Minor Revisions	EDW	11/09
A	For Construction	EDW	10/09

DESIGNED :	BMQ	Oct.09
DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BCMQ	11/09
CADFILE : \\60929.001-300_303.dwg		
APPROVED : EDWilson	23/11/09	

This drawing is not to be used for construction purposes unless signed as approved

NOTES :

1. All dimensions are in metres unless noted otherwise.
2. Design Floodwall/Stopbank levels supplied by Environment Waikato.
3. Design 1% AEP Flood levels supplied by Environment Waikato.
4. Cross sections and Land Title Boundaries from F.W.Millington Ltd, Environment Waikato Thames Coast Project – Te Puru Stream Survey Dwg No.2474 Sheets 1 to 8 dated October 2004.

REFERENCE :

Tonkin & Taylor
Environmental & Engineering Consultants
Hamilton Level 1 9 Clifton Road
Tel. (07) 834 7320 Fax. (07) 834 7349
Email : ham@tonkin.co.nz
Auckland Wellington Christchurch Nelson Whangarei

CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS LAYOUT PLAN
Left Bank Chainage 477m to 677m

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 1000	60929.001-302	B

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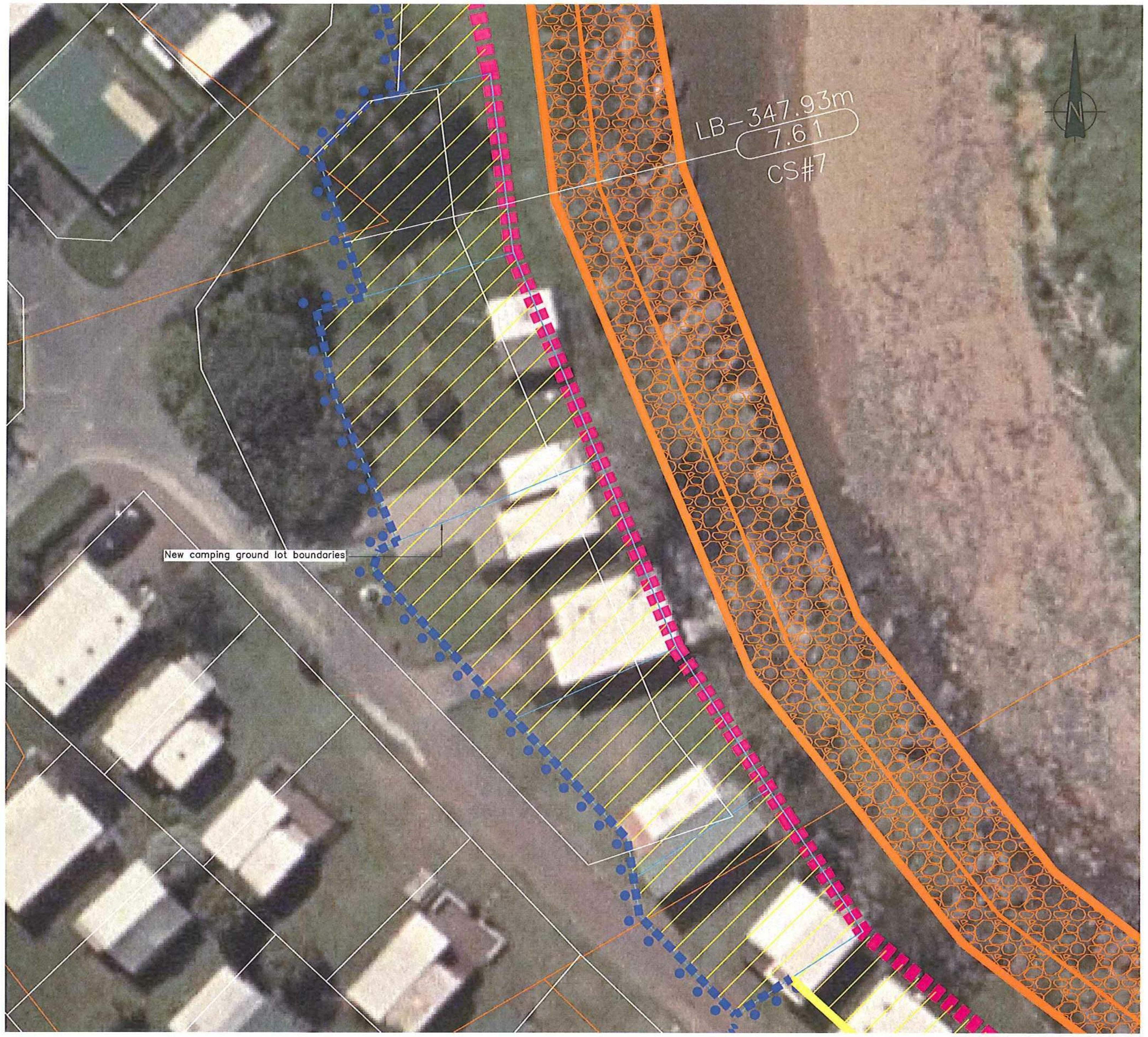

LEGEND

- Proposed stopbank footprint
- Replace rock riprap at 1.5: 1 grade
- Existing rock protection
- Proposed new access to properties
- Garage repositioned
- Proposed timber floodwall with earth bulking
- Proposed access track
- Proposed concrete footpath
- Proposed timber floodwall
- Land title boundary
- Existing culvert outlet
- Road reconstruction to be done by others as part of bridge upgrade works.
- Proposed timber retaining wall
- LB-0.00 — True left bank Chainage; 0.00 — Floodwall/Stopbank crest level; CS#1 — Millington Survey Cross Section Number
- RB-0.00 — True right bank Chainage; 0.00 — Floodwall/Stopbank crest level; CS#1 — Millington Survey Cross Section Number

SCALE 1: 250
0 5 10 15 (m)

DRAWING STATUS: **CONSTRUCTION ISSUE**

A	For Construction	EW	10/09
REVISION	DESCRIPTION	BY	DATE

DESIGNED :	BMQ	Oct.09
DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EW	10/09
DRAFTING CHECKED :	BNQ	10/09
CADFILE : \\60929.001-300_303.dwg		
APPROVED : EDWilliams 20/10/09		

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NOTES :

1. All dimensions are in metres unless noted otherwise.
2. Design Floodwall/Stopbank levels supplied by Environment Waikato.
3. Design 1% AEP Flood levels supplied by Environment Waikato.
4. Cross sections and Land Title Boundaries from F.W.Millington Ltd, Environment Waikato Thames Coast Project – Te Puru Stream Survey Dwg No.2474 Sheets 1 to 8 dated October 2004.

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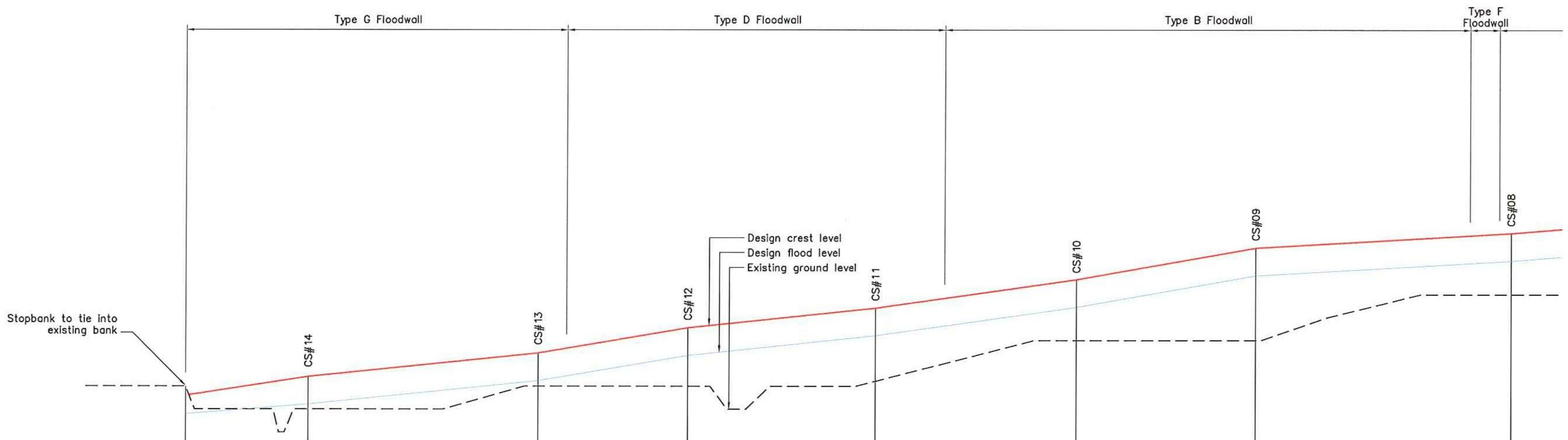
CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS LAYOUT PLAN
Campground Layout Plan

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 250	60929.001-303	A



Datum RL 0.0m

FLOODWALL/STOPBANK HEIGHT (m)	3.60		4.01		4.52				5.07	5.50	6.12		6.81			7.13	
DESIGN FLOOD LEVEL HEIGHT (m)			3.41		3.92				4.47	5.05	5.52		6.21			6.53	
EXISTING GROUND LEVEL (m)	3.79		3.30		3.80				3.80	3.91	4.80		4.80			5.80	
HEIGHT OF FLOODWALL ABOVE EXISTING GROUND (m)	0.00		0.71		0.72				1.27	1.58	1.32		2.00			1.33	
DEPTH OF POSTS BELOW GROUND (m)	1.5m							2.0m									
CHAINAGE (m)	00.00	18.29	26.73	32.70	76.85	83.06	93.44	100.00	109.43	150.44	194.48	200.00	233.68	280.63	287.07	289.63	300.00

B

B

LONGSECTION – LEFT BANK FLOODWALL – CH 0.0m to CH 300.0m
SCALE 1: 100 V
1: 1000 H

SCALE 1: 100
0 1 2 3 4 5 (m)

SCALE 1: 1000
0 10 20 30 40 50 (m)

DESIGN DATA SOURCES

1. Design Floodwall/Stopbank levels supplied by Environment Waikato.
2. Design 1% AEP Flood levels supplied by Environment Waikato.
3. Existing ground levels from LIDAR 2004.

DRAWING STATUS: **CONSTRUCTION ISSUE**

REVISION DESCRIPTION	BY	DATE
B Minor Revisions	EDW	11/09
A For Construction	EDW	10/09

DESIGNED :	BMQ	Oct.09
DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BMQ	11/09
CADFILE : \\60929.001-400_404.dwg		
APPROVED : EDWilson 23/11/09		

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CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS LONGSECTION
Left Bank Chainage 0.0m to 300.0m

SCALES (AT A3 SIZE) 1: 100V 1: 1000H
DWG. No. 60929.001-400
REV. B

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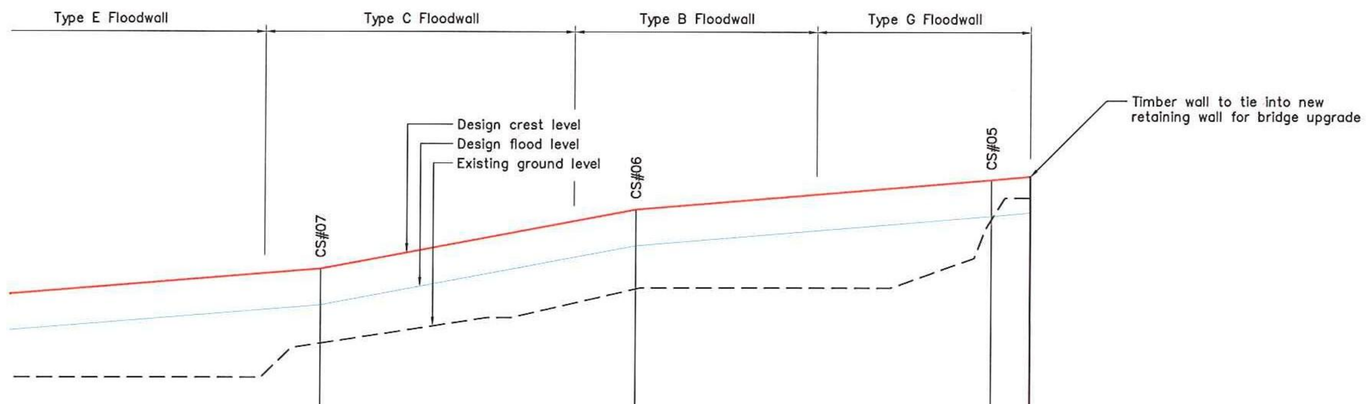

Datum RL 0.0m

FLOODWALL/STOPBANK HEIGHT (m)			7.61			8.60		9.10	9.20
DESIGN FLOOD LEVEL HEIGHT (m)			7.01			7.60		8.02	
EXISTING GROUND LEVEL (m)			6.37			7.28		8.44	
HEIGHT OF FLOODWALL ABOVE EXISTING GROUND (m)			1.24			1.32		0.66	
DEPTH OF POSTS BELOW GROUND (m)				2.0m					1.5m
CHAINAGE (m)	300.00	314.25	348.11	380.25	399.25	400.00	428.31	459.51	465.78

LONGSECTION – LEFT BANK FLOODWALL – CH 300.0m to CH 465.78m
SCALE 1: 100 V
1: 1000 H

SCALE 1: 100
0 1 2 3 4 5 (m)

SCALE 1: 1000
0 10 20 30 40 50 (m)

DESIGN DATA SOURCES

1. Design Floodwall/Stopbank levels supplied by Environment Waikato.
2. Design 1% AEP Flood levels supplied by Environment Waikato.
3. Existing ground levels from LIDAR 2004.

DRAWING STATUS: CONSTRUCTION ISSUE

REV.	REVISION DESCRIPTION	BY	DATE
B	Minor Revisions	EDW	11/09
A	For Construction	EDW	10/09

DESIGNED :	BMQ	Oct.09
DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BMQ	11/09
CADFILE : \\60929.001–400_404.dwg		
APPROVED : EDWilson		23/11/09

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CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS LONGSECTION
Left Bank Chainage 300.0m to 465.7m

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 100V 1: 1000H	60929.001–401	B

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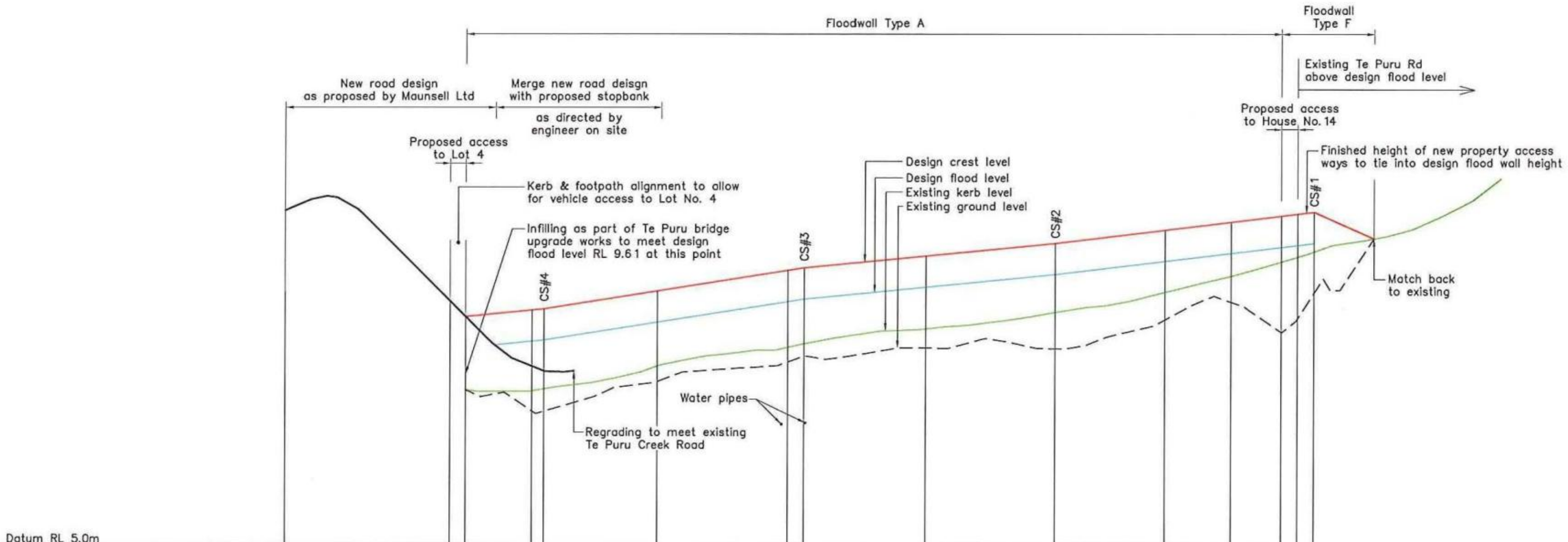

FLOODWALL / STOPBANK HEIGHT (m)	9.51	9.51		9.66			10.45		10.92					11.52
DESIGN FLOOD LEVEL HEIGHT (m)				9.06			9.85		10.32					10.92
EXISTING EDGE OF SEAL / KERB (m)				8.13	8.56		8.99	9.28	9.59	9.98	10.29			
EXISTING GROUND LEVEL (m) (along timber wall alignment)				6.95	7.56		8.33	8.58	8.54	9.20	9.80	9.21	9.47	9.96
HEIGHT OF FLOODWALL ABOVE PATH (m)				1.53	1.44		1.46	1.39	1.33	1.20	1.04			
DEPTH OF POSTS BELOW FOOTPATH			2.0m							1.5m				
CHAINAGE (m)	505.31	508.31	521.00	522.90	545.16	571.00	573.64	597.46	622.50	644.55	660.24	669.90	673.05	675.80

LONGSECTION – LEFT BANK FLOODWALL – CH 505.31m to CH 675.80m
SCALE 1: 100V
1: 1000 H

DESIGN DATA SOURCES

1. Design Floodwall/Stopbank levels supplied by Environment Waikato.
2. Design 1% AEP Flood levels supplied by Environment Waikato.
3. Existing edge of seal/kerb & existing ground levels from F.W. Millington Ltd, Te Puru Stream Flood Protection – Topographical Survey. Drawing No. 2910 Sheets 1 to 10, dated August 2007.
4. Proposed Te Puru Road levels from Maunsell Ltd, Te Puru Bridge/Road Plan and Longsections Drawings 6001 9014/02, 03 and 04. (Adjusted by −0.7 to match local datum).

SCALE 1: 1000
0 10 20 30 40 50 (m)

SCALE 1: 100
0 1 2 3 4 5 (m)

DRAWING STATUS: CONSTRUCTION ISSUE

B	Minor Revisions	EDW	11/09
A	For Construction	EDW	10/09
REVISION DESCRIPTION		BY	DATE

DESIGNED : BMQ Oct.09
DRAWN : RSSS Oct.09
DESIGN CHECKED : EDW 11/09
DRAFTING CHECKED : EMD 11/09
CADFILE : \\60929.001-400_404.dwg
APPROVED EDWilson 23/11/09
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CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION
TITLE
FLOOD PROTECTION WORKS LONGSECTION
Left Bank Chainage – CH 505.31m to 675.80m
SCALES (AT A3 SIZE) 1: 100V 1: 1000H
DWG. No. 60929.001–402
REV. B

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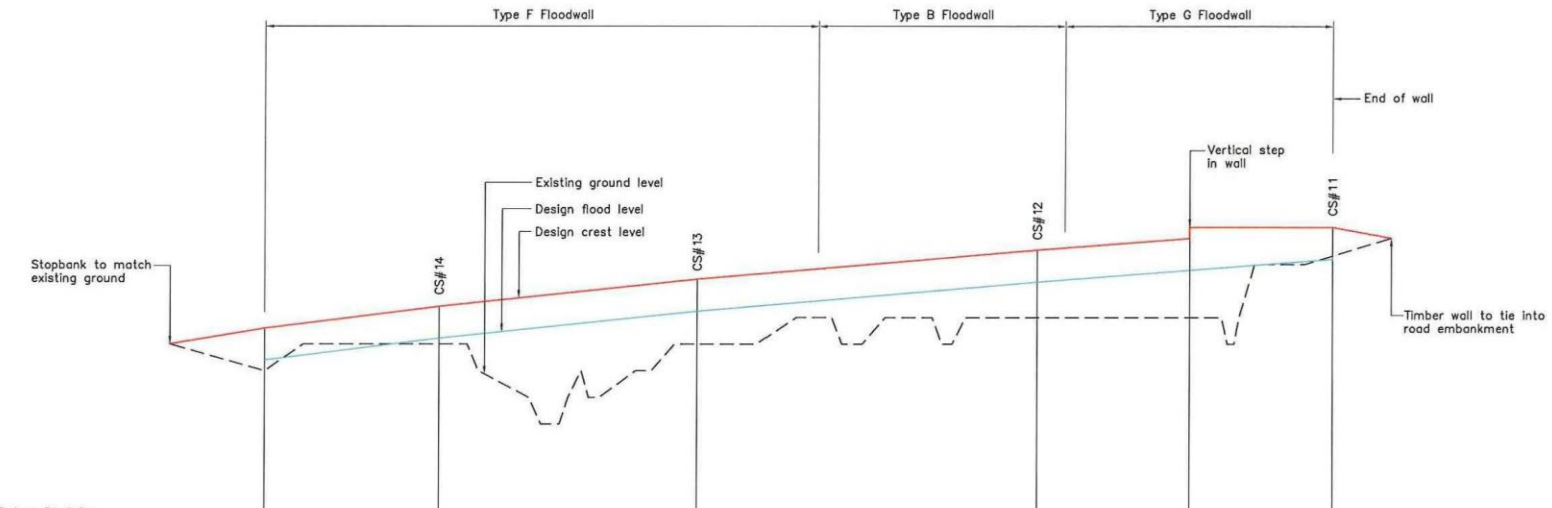

Datum RL 0.0m

CHAINAGE(m)	00.00	32.74	50.00	81.17	100.00	103.85	117.91	145.13	150.00	173.87	185.21	200.81
FLOODWALL/STOPBANK HEIGHT(m)	3.60	4.01		4.52				5.07		5.29 / 5.50		5.50
DESIGN FLOOD LEVEL HEIGHT(m)		3.41		3.92				4.47		4.69 / 4.90		5.05
EXISTING GROUND LEVEL (m)	2.80	3.30		3.30				3.80		3.80 / 3.80		4.96
HEIGHT OF FLOODWALL ABOVE EXISTING GROUND (m)		0.71		1.22				1.27		1.49 / 1.70		0.54
DEPTH OF POSTS BELOW GROUND (m)						2.0m (B)					1.5m (B)	

LONGSECTION – RIGHT BANK FLOODWALL – CH 0.0m to CH 200.81m
SCALE 1: 100 V
1: 1000 H

SCALE 1: 100
0 1 2 3 4 5 (m)

SCALE 1: 1000
0 10 20 30 40 50 (m)

DESIGN DATA SOURCES

1. Design Floodwall/Stopbank levels supplied by Environment Waikato.
2. Design 1% AEP Flood levels supplied by Environment Waikato.
3. Existing ground levels from LIDAR 2004.

DRAWING STATUS: **CONSTRUCTION ISSUE**

REV.	REVISION DESCRIPTION	BY	DATE
B	Minor Revisions	EDW	11/09
A	For Construction	EDW	10/09

DESIGNED :	BMQ	Oct.09
DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BMQ	11/09
CADFILE : \\60929.001-400_404.dwg		
APPROVED : EDWilson	23/11/09	

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NOTES :
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CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS LONGSECTION
Right Bank Chainage 0.0m to 200.81m

SCALES (AT A3 SIZE): 1: 100V 1: 1000H
DWG. No.: 60929.001-403
REV.: B

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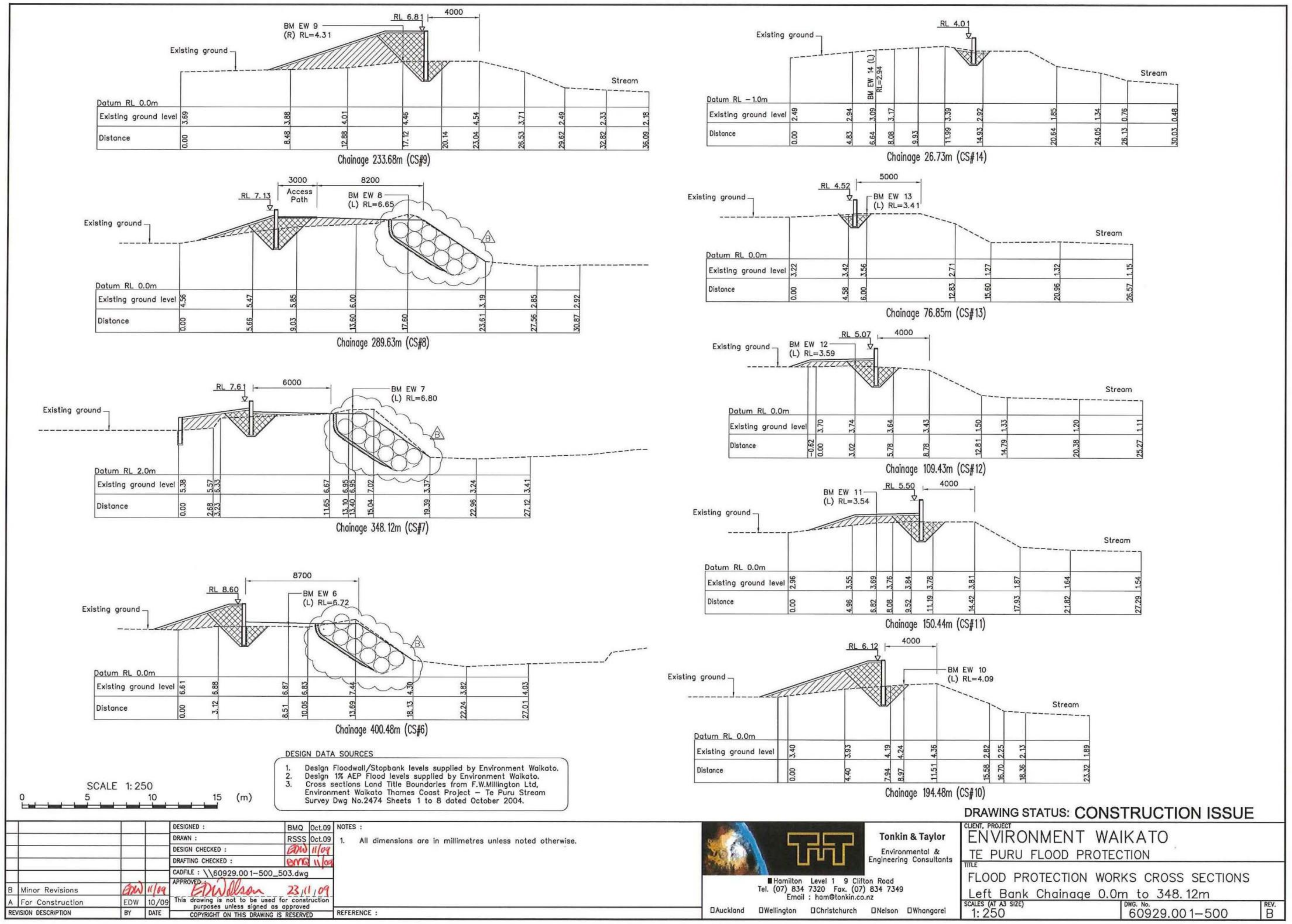
Chainage 233.68m (CS#9)
Chainage 289.63m (CS#8)
Chainage 348.12m (CS#7)
Chainage 400.48m (CS#6)
Chainage 26.73m (CS#14)
Chainage 76.85m (CS#13)
Chainage 109.43m (CS#12)
Chainage 150.44m (CS#11)
Chainage 194.48m (CS#10)
DESIGN DATA SOURCES
1. Design Floodwall/Stopbank levels supplied by Environment Waikato.
2. Design 1% AEP Flood levels supplied by Environment Waikato.
3. Cross sections Land Title Boundaries from F.W.Millington Ltd, Environment Waikato Thames Coast Project – Te Puru Stream Survey Dwg No.2474 Sheets 1 to 8 dated October 2004.
SCALE 1: 250
DRAWING STATUS: CONSTRUCTION ISSUE
NOTES :
1. All dimensions are in millimetres unless noted otherwise.
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ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION
FLOOD PROTECTION WORKS CROSS SECTIONS
Left Bank Chainage 0.0m to 348.12m
1: 250
60929.001-500
B
B Minor Revisions
A For Construction
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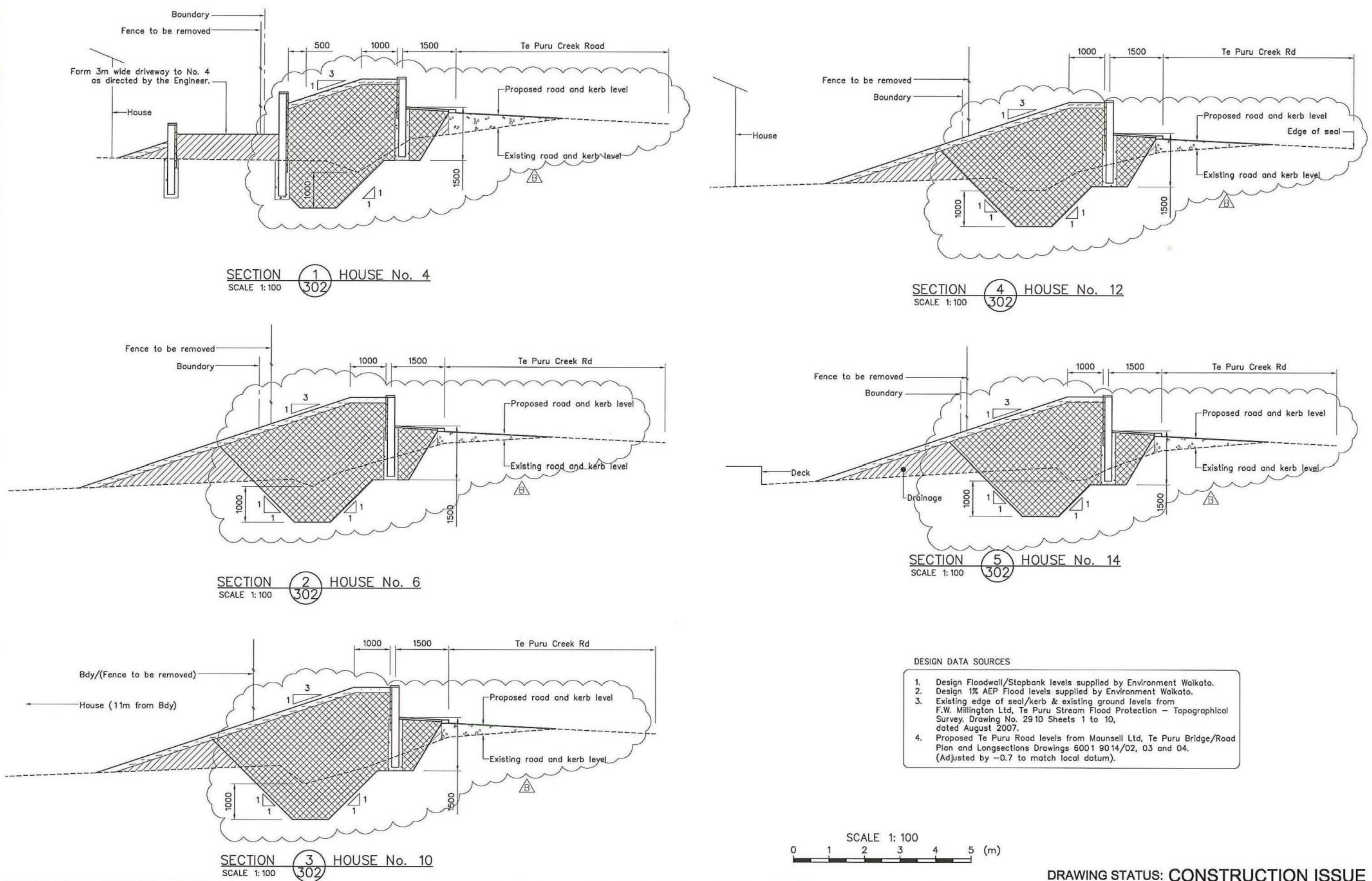

DESIGN DATA SOURCES

1. Design Floodwall/Stopbank levels supplied by Environment Waikato.
2. Design 1% AEP Flood levels supplied by Environment Waikato.
3. Existing edge of seal/kerb & existing ground levels from F.W. Millington Ltd, Te Puru Stream Flood Protection – Topographical Survey. Drawing No. 2910 Sheets 1 to 10, dated August 2007.
4. Proposed Te Puru Road levels from Mounsell Ltd, Te Puru Bridge/Road Plan and Longsections Drawings 6001 9014/02, 03 and 04. (Adjusted by –0.7 to match local datum).

SCALE 1: 100
0 1 2 3 4 5 (m)

DRAWING STATUS: CONSTRUCTION ISSUE

REV.	REVISION DESCRIPTION	BY	DATE
B	Minor Revisions	EDW	11/09
A	For Construction	EDW	10/09

DESIGNED :	BMQ	Oct.09
DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BMQ	11/09
CADFILE : \\60929.001–500_503.dwg		
APPROVED : EDWilson 23/11/09		

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CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS CROSS SECTIONS
Left Bank Chainage Between 505.31m to 675.80m

SCALES (AT A3 SIZE)	DWG. No.	REV.
1: 100	60929.001–501	B

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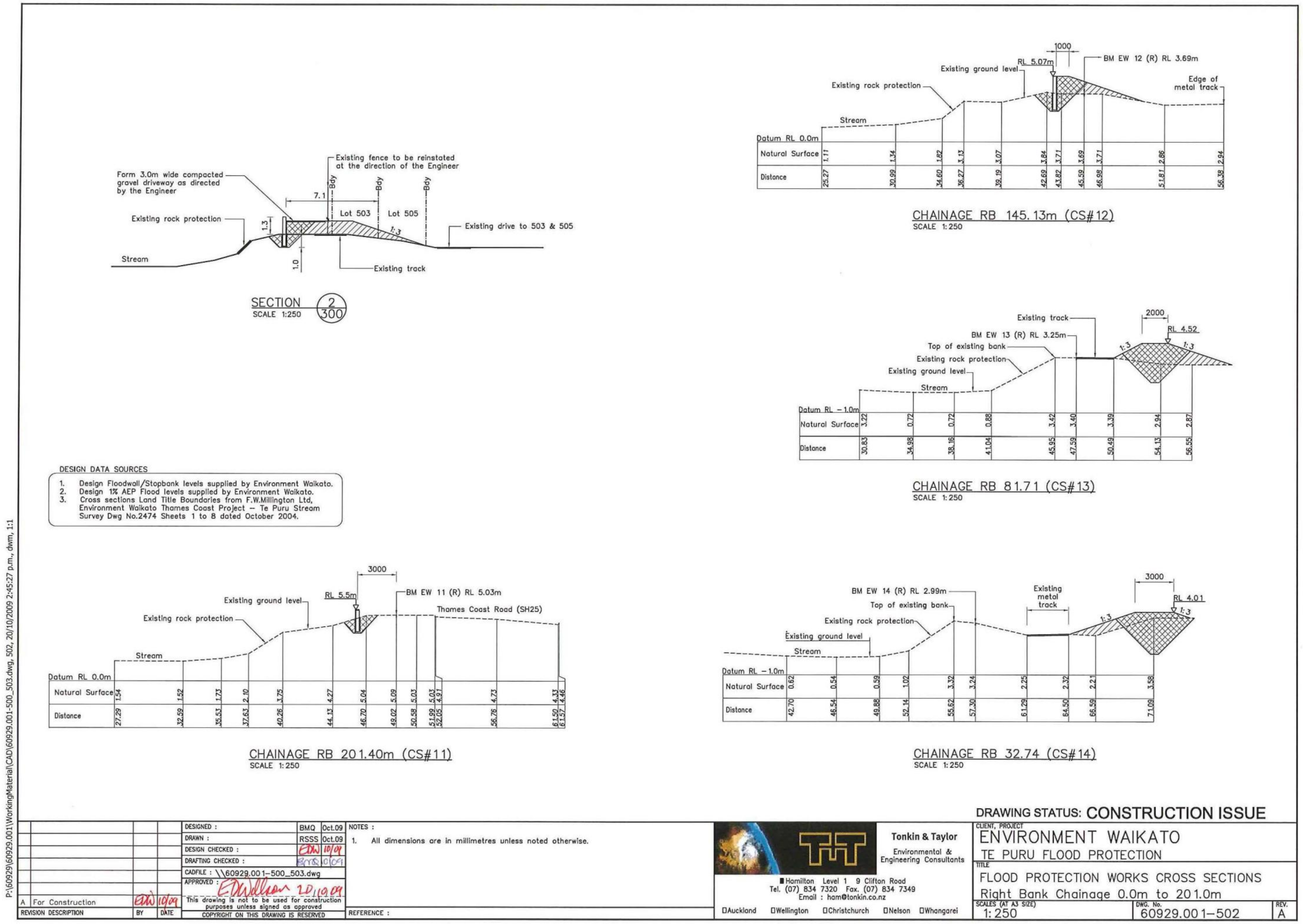
SECTION 2/300
SCALE 1:250
Form 3.0m wide compacted gravel driveway as directed by the Engineer
Existing fence to be reinstated at the direction of the Engineer
Existing rock protection
Existing drive to 503 & 505
Existing track
Stream
Lot 503
Lot 505
Bdy
DESIGN DATA SOURCES
1. Design Floodwall/Stopbank levels supplied by Environment Waikato.
2. Design 1% AEP Flood levels supplied by Environment Waikato.
3. Cross sections Land Title Boundaries from F.W.Millington Ltd, Environment Waikato Thames Coast Project – Te Puru Stream Survey Dwg No.2474 Sheets 1 to 8 dated October 2004.
CHAINAGE RB 201.40m (CS#11)
SCALE 1:250
Existing ground level
RL 5.5m
BM EW 11 (R) RL 5.03m
Thames Coast Road (SH25)
Datum RL 0.0m
Natural Surface
Distance
CHAINAGE RB 145.13m (CS#12)
SCALE 1:250
RL 5.07m
BM EW 12 (R) RL 3.69m
Edge of metal track
CHAINAGE RB 81.71 (CS#13)
SCALE 1:250
BM EW 13 (R) RL 3.25m
Top of existing bank
RL 4.52
Datum RL – 1.0m
CHAINAGE RB 32.74 (CS#14)
SCALE 1:250
BM EW 14 (R) RL 2.99m
Existing metal track
RL 4.01
DRAWING STATUS: CONSTRUCTION ISSUE
DESIGNED : BMQ Oct.09
DRAWN : RSSS Oct.09
DESIGN CHECKED :
DRAFTING CHECKED :
CADFILE : \\60929.001-500_503.dwg
APPROVED :
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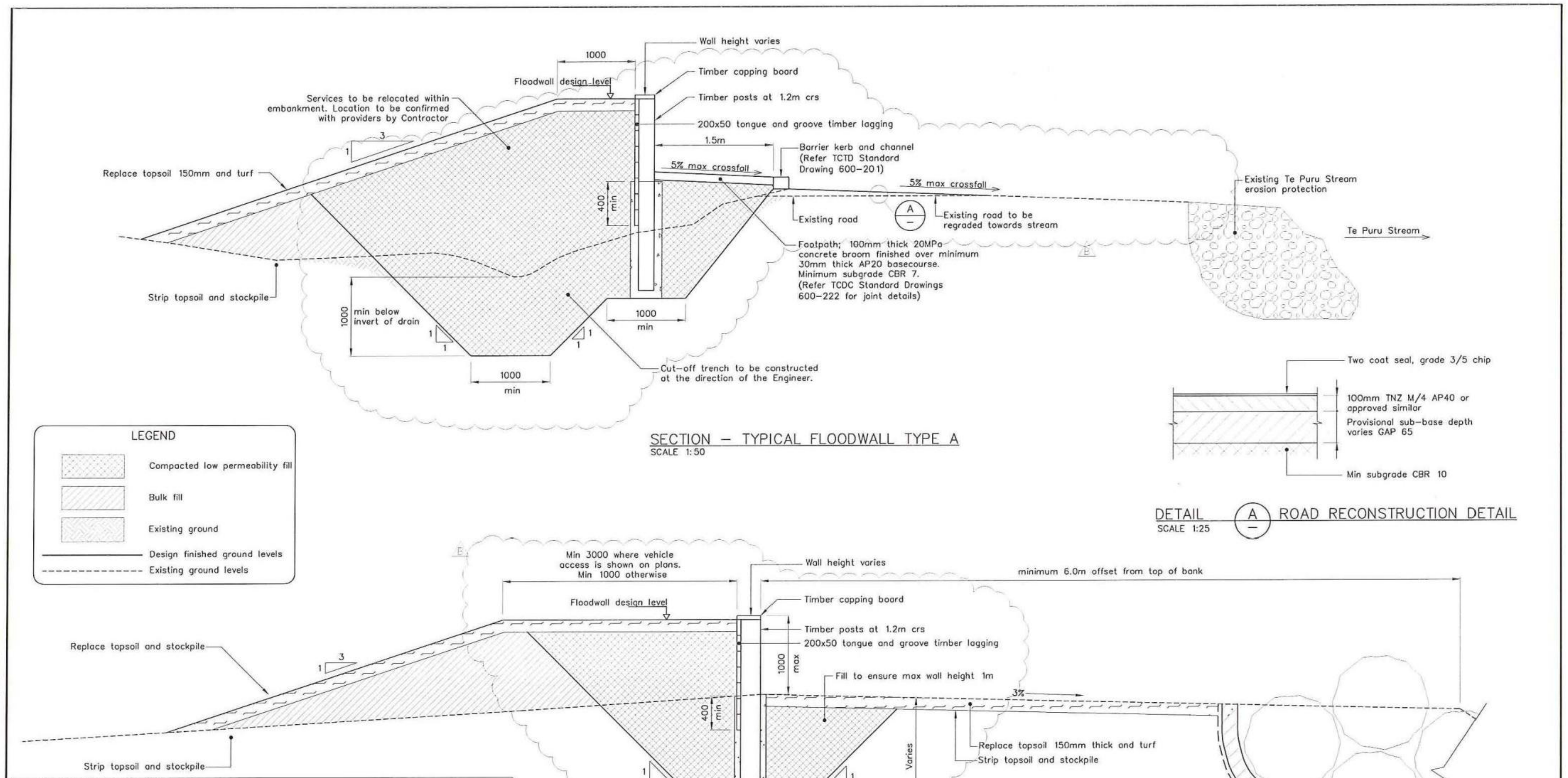
Auckland Wellington Christchurch Nelson Whangarei
CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION
TITLE
FLOOD PROTECTION WORKS CROSS SECTIONS
Right Bank Chainage 0.0m to 201.0m
SCALES (AT A3 SIZE) 1:250
DWG. No. 60929.001-502
REV. A



TIMBER WALL NOTES:

1. The Contractor shall be responsible for identifying and locating all existing services prior to the start of wall construction.
2. The Engineer is to inspect all excavations prior to the placement of any fill.
3. All excavations shall have side slopes of 1: 1 unless approved otherwise by the Engineer. Contractor to ensure the excavated sides slopes are restrained from collapsing.
4. Posts shall be concrete encased in 20MPa concrete min 75mm thick in min ø400mm drilled holes.
5. Timber lagging on walls shall extend minimum 400 below ground level.
   Timber posts shall be H5 high density poles.
   Timber lagging shall be H4 tongue and grooved No1 Framing.
   Timber capping board shall be H4 No1 Framing.
   Timber handrail posts shall be H5 VSG10 (or MSG10).
   Timber handrail rails shall be H4 No1 Framing.
   Timber handrail battens shall be H3 No1 Framing.
6. All cut timber and pole ends shall be flooded 3 times with metallex green or equivalent.
7. Handrail required on all floodwalls & retaining walls where the wall height is greater than 1000mm.
8. Erection of handrails shall take place as directed by the Engineer.
9. All timber fastenings shall be nails min 100 long unless noted otherwise.
10. All bolts, fixings and nails shall be hot dipped galvanised with average galvanised coating mass of 375 g/m^2.

TIMBER FLOODWALL SCHEDULE

Wall height (h)	Footing depth (d)	Post SED ø	Timber cap
< 1.0m	1.5m	200mm	250x50
1.0 – 1.5m	2.0m	250mm	300x50

DRAWING STATUS: CONSTRUCTION ISSUE

B Minor Revisions	EDW	11/09
A For Construction	EDW	10/09
REVISION DESCRIPTION	BY	DATE

DESIGNED :	BMQ	Sep.09
DRAWN :	RSSS	Sep.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BMR	11/09
CADFILE : \\60929.001-600_604.dwg		
APPROVED : EDWilson	26.11.09	

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CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION
TITLE
FLOOD WALL DETAILS
Sheet 1 of 3
SCALES (AT A3 SIZE) 1:50
DWG. No. 60929.001-600
REV. B

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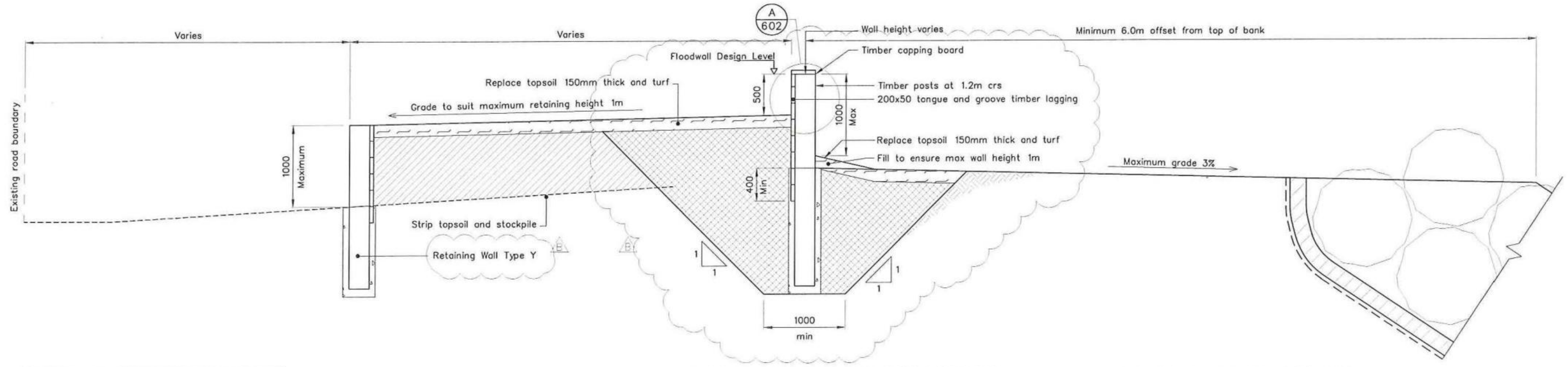


SECTION – TYPICAL FLOODWALL TYPE C
SCALE 1:50

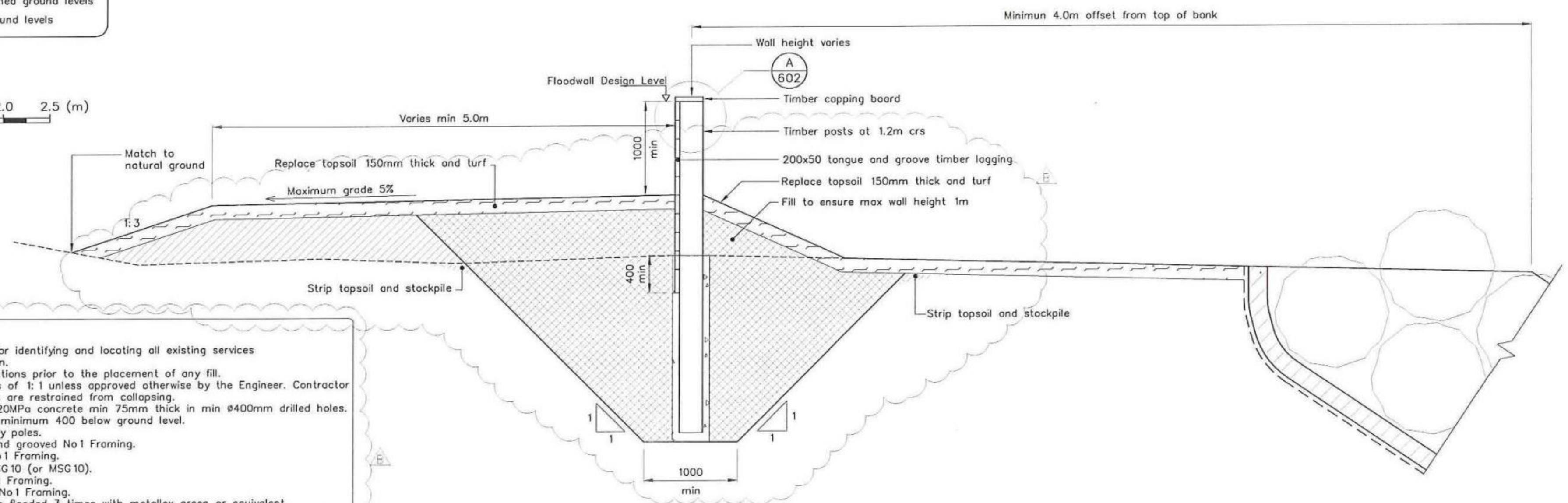
TIMBER FLOODWALL SCHEDULE

Wall height (h)	Footing depth (d)	Post SED ø	Timber cap
< 1.0m	1.5m	200mm	250x50
1.0 – 1.5m	2.0m	250mm	300x50

LEGEND

(hatch)	Compacted low permeability fill
(hatch)	Bulk fill
(hatch)	Existing ground
———	Design finished ground levels
- - - -	Existing ground levels

SCALE 1:50
0 0.5 1.0 1.5 2.0 2.5 (m)



SECTION – TYPICAL FLOODWALL TYPE D
SCALE 1:50

TIMBER WALL NOTES:

1. The Contractor shall be responsible for identifying and locating all existing services prior to the start of wall construction.
2. The Engineer is to inspect all excavations prior to the placement of any fill.
3. All excavations shall have side slopes of 1:1 unless approved otherwise by the Engineer. Contractor to ensure the excavated sides slopes are restrained from collapsing.
4. Posts shall be concrete encased in 20MPa concrete min 75mm thick in min ø400mm drilled holes.
5. Timber lagging on walls shall extend minimum 400 below ground level.
   Timber posts shall be H5 high density poles.
   Timber lagging shall be H4 tongue and grooved No1 Framing.
   Timber capping board shall be H4 No1 Framing.
   Timber handrail posts shall be H5 VSG10 (or MSG10).
   Timber handrail rails shall be H4 No1 Framing.
   Timber handrail battens shall be H3 No1 Framing.
6. All cut timber and pole ends shall be flooded 3 times with metallex green or equivalent.
7. Handrail required on all floodwalls & retaining walls where the wall height is greater than 1000mm.
8. Erection of handrails shall take place as directed by the Engineer.
9. All timber fastenings shall be nails min 100 long unless noted otherwise.
10. All bolts, fixings and nails shall be hot dipped galvanised with average galvanised coating mass of 375 g/m².

DRAWING STATUS: CONSTRUCTION ISSUE

B	Minor Revisions	EDW	11/09
A	For Construction	EDW	10/09
REVISION	DESCRIPTION	BY	DATE

DESIGNED :	BMQ	Sep.09
DRAWN :	RSSS	Sep.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BWQ	11/09
CADFILE : \\60929.001-600_604.dwg		
APPROVED : EDWilson 26 11 09		

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NOTES :
1. All dimensions are in millimetres unless noted otherwise.

REFERENCE :

Tonkin & Taylor
Environmental & Engineering Consultants
Hamilton Level 1 9 Clifton Road
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Email : ham@tonkin.co.nz
Auckland Wellington Christchurch Nelson Whangarei

CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD WALL DETAILS
Sheet 2 of 3

SCALES (AT A3 SIZE) 1:50
DWG. No. 60929.001-601
REV. B

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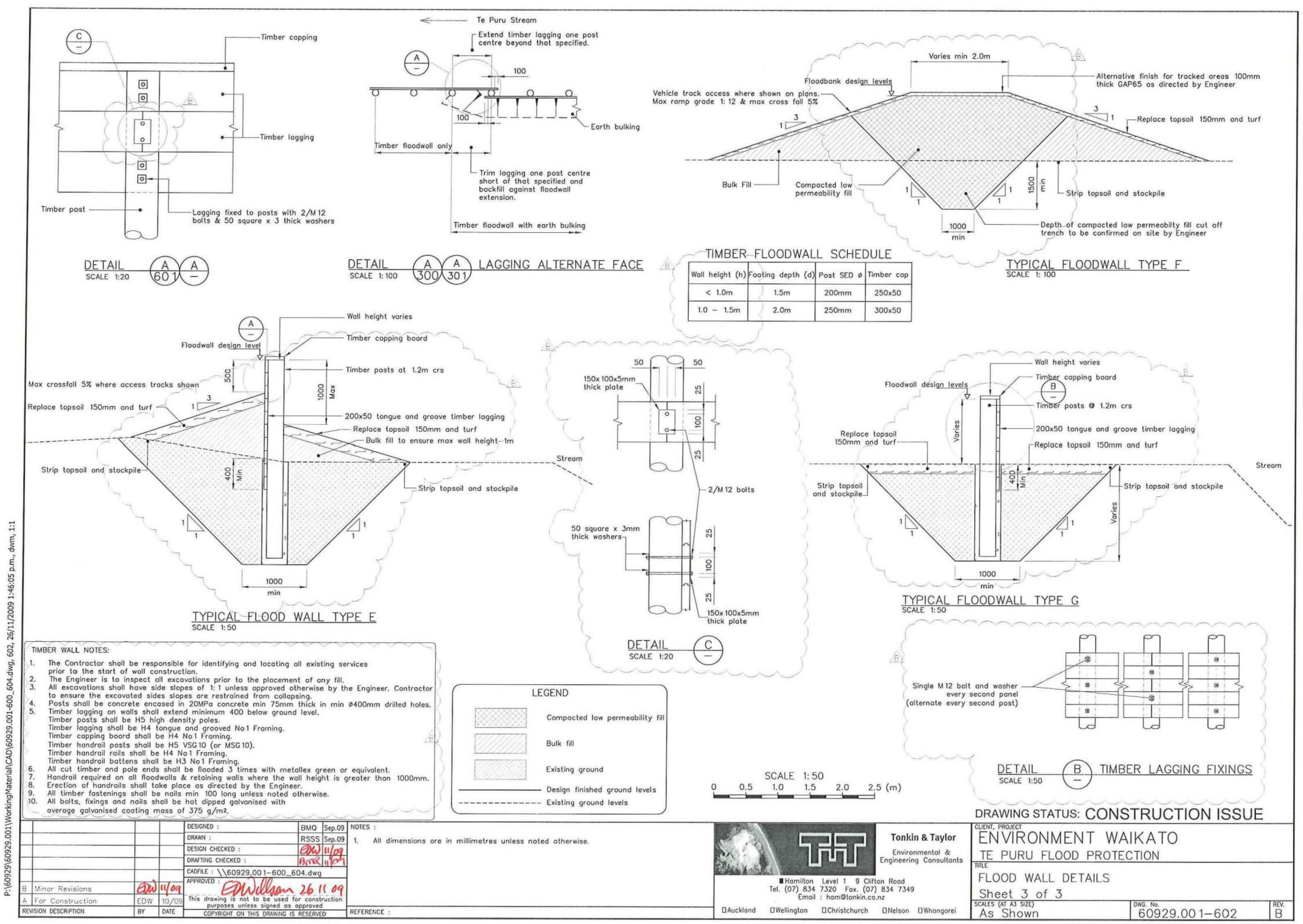
Te Puru Stream
Timber copping
Timber lagging
Timber post
Lagging fixed to posts with 2/M12 bolts & 50 square x 3 thick washers
DETAIL A/601 A
SCALE 1:20
Extend timber lagging one post centre beyond that specified.
Earth bulking
Timber floodwall only
Trim lagging one post centre short of that specified and backfill against floodwall extension.
Timber floodwall with earth bulking
DETAIL A/300 A/301 LAGGING ALTERNATE FACE
SCALE 1:100
TIMBER FLOODWALL SCHEDULE
Wall height (h) | Footing depth (d) | Post SED ø | Timber cop
< 1.0m | 1.5m | 200mm | 250x50
1.0 – 1.5m | 2.0m | 250mm | 300x50
Varies min 2.0m
Floodbank design levels
Vehicle track access where shown on plans. Max ramp grade 1:12 & max cross fall 5%
Alternative finish for tracked areas 100mm thick GAP65 as directed by Engineer
Replace topsoil 150mm and turf
Bulk Fill
Compacted low permeability fill
Strip topsoil and stockpile
Depth of compacted low permeabilty fill cut off trench to be confirmed on site by Engineer
1000 min
TYPICAL FLOODWALL TYPE F
SCALE 1:100
Wall height varies
Timber copping board
Floodwall design level
Timber posts at 1.2m crs
Max crossfall 5% where access tracks shown
Replace topsoil 150mm and turf
200x50 tongue and groove timber lagging
Bulk fill to ensure max wall height 1m
Strip topsoil and stockpile
Stream
TYPICAL FLOOD WALL TYPE E
SCALE 1:50
150x100x5mm thick plate
2/M12 bolts
50 square x 3mm thick washers
DETAIL C
SCALE 1:20
Timber posts @ 1.2m crs
Replace topsoil 150mm and turf
TYPICAL FLOODWALL TYPE G
SCALE 1:50
Single M12 bolt and washer every second panel (alternate every second post)
DETAIL B TIMBER LAGGING FIXINGS
SCALE 1:50
TIMBER WALL NOTES:
1. The Contractor shall be responsible for identifying and locating all existing services prior to the start of wall construction.
2. The Engineer is to inspect all excavations prior to the placement of any fill.
3. All excavations shall have side slopes of 1:1 unless approved otherwise by the Engineer. Contractor to ensure the excavated sides slopes are restrained from collapsing.
4. Posts shall be concrete encased in 20MPa concrete min 75mm thick in min ø400mm drilled holes.
5. Timber lagging on walls shall extend minimum 400 below ground level.
Timber posts shall be H5 high density poles.
Timber lagging shall be H4 tongue and grooved No1 Framing.
Timber capping board shall be H4 No1 Framing.
Timber handrail posts shall be H5 VSG10 (or MSG10).
Timber handrail rails shall be H4 No1 Framing.
Timber handrail battens shall be H3 No1 Framing.
6. All cut timber and pole ends shall be flooded 3 times with metallex green or equivalent.
7. Handrail required on all floodwalls & retaining walls where the wall height is greater than 1000mm.
8. Erection of handrails shall take place as directed by the Engineer.
9. All timber fastenings shall be nails min 100 long unless noted otherwise.
10. All bolts, fixings and nails shall be hot dipped galvanised with average galvanised coating mass of 375 g/m².
LEGEND
Compacted low permeability fill
Bulk fill
Existing ground
Design finished ground levels
Existing ground levels
SCALE 1:50
0 0.5 1.0 1.5 2.0 2.5 (m)
DRAWING STATUS: CONSTRUCTION ISSUE
DESIGNED : BMQ Sep.09
DRAWN : RSSS Sep.09
DESIGN CHECKED : EDW 11/09
DRAFTING CHECKED : BMR 11/09
CADFILE : \\60929.001-600_604.dwg
APPROVED : EDWilliams 26 11 09
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A For Construction EDW 10/09
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Email : ham@tonkin.co.nz
Auckland Wellington Christchurch Nelson Whangarei
CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION
TITLE
FLOOD WALL DETAILS
Sheet 3 of 3
SCALES (AT A3 SIZE) As Shown
DWG. No. 60929.001-602
REV. B
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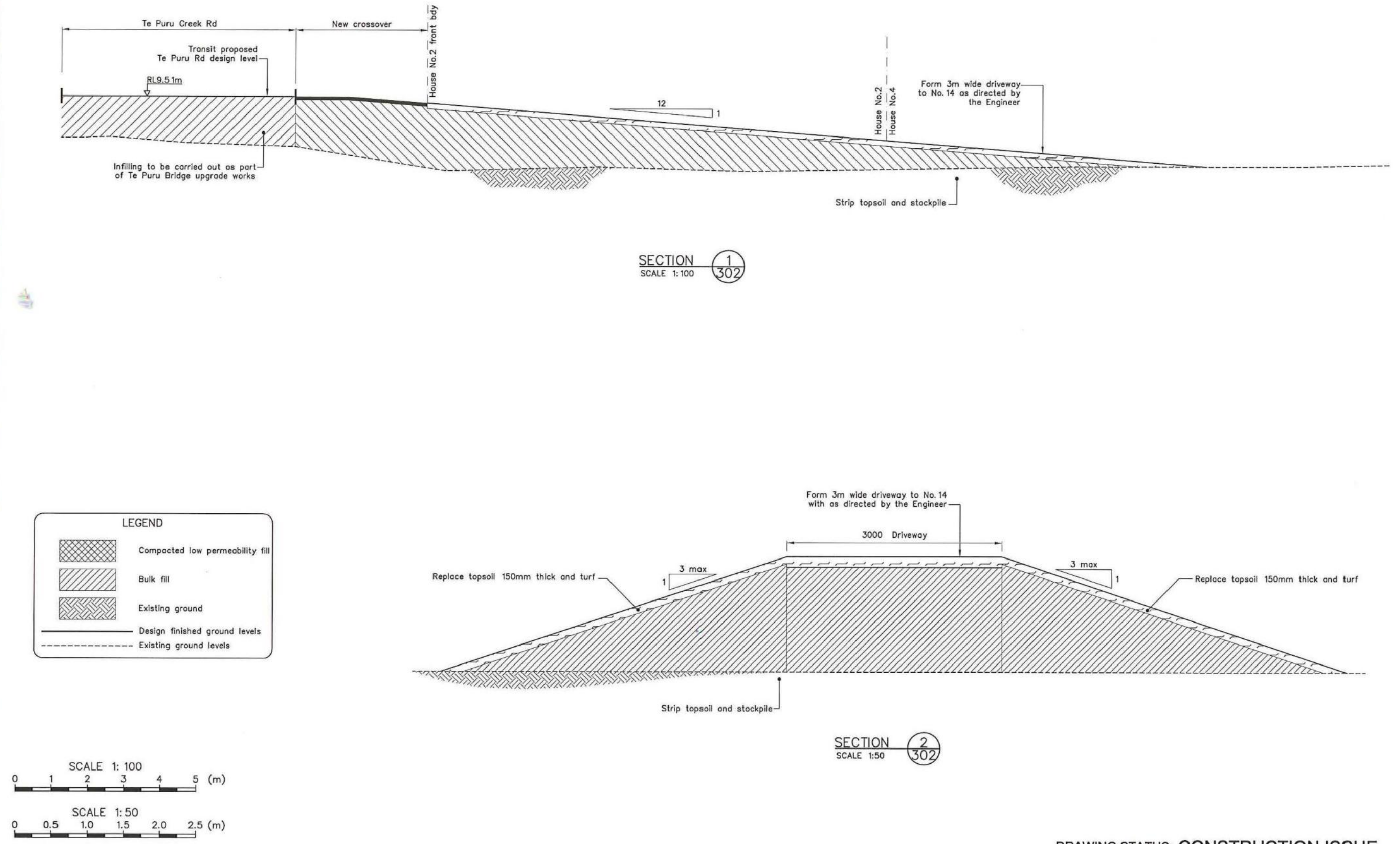

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DRAWING STATUS: **CONSTRUCTION ISSUE**

REVISION DESCRIPTION	BY	DATE
A For Construction	EDW	10/09

DESIGNED :	BMQ	Sep.09
DRAWN :	RSSS	Sep.09
DESIGN CHECKED :	EDW	10/09
DRAFTING CHECKED :	MQ	10/09
CADFILE : \\60929.001-600_604.dwg		
APPROVED : EDWilliams 20,10,09		

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CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS DETAILS
Lot Access Details

SCALES (AT A3 SIZE)	DWG. No.	REV.
As Shown	60929.001-603	A

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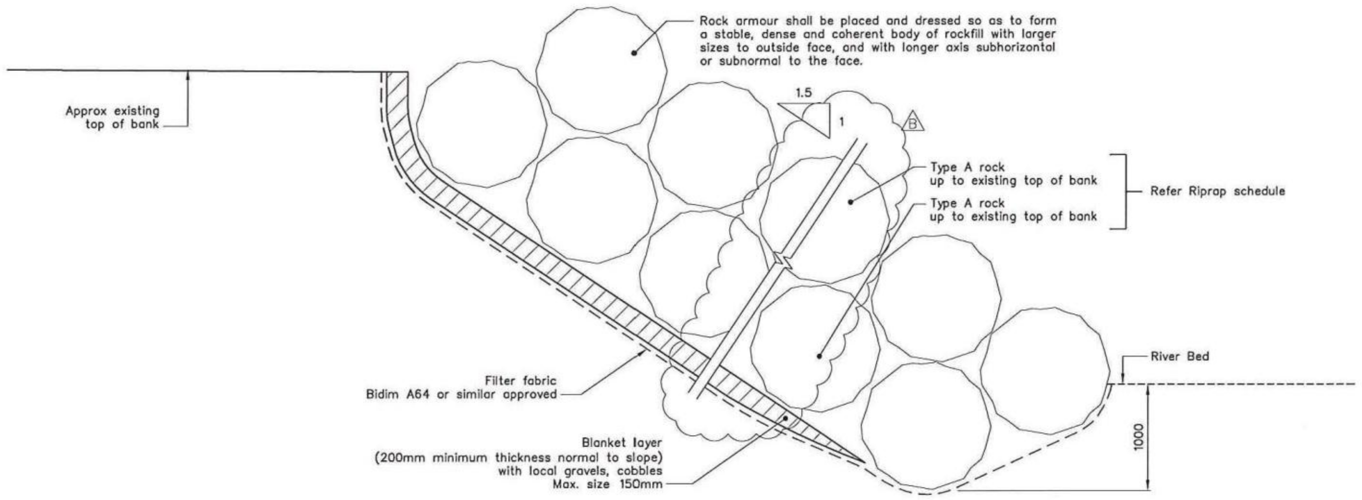

TYPICAL UPSTREAM CROSS SECTION
SCALE 1:50

RIP RAP SCHEDULE

Rockfill Type	Rock Size (mm) Nominal size	Minimum mass (Kg)
A	1200	2000

SCALE 1:50
0 0.5 1.0 1.5 2.0 2.5 (m)

B	Minor Revisions	EDW	11/09	DESIGNED :	BMQ Sep.09
A	For Construction	EDW	10/09	DRAWN :	RSSS Sep.09
REVISION	DESCRIPTION	BY	DATE	DESIGN CHECKED :	EDW 11/09
				DRAFTING CHECKED :	BMQ 11/09
				CADFILE : \\60929.001-600_604.dwg	
				APPROVED : EDWilson 26/11/09	

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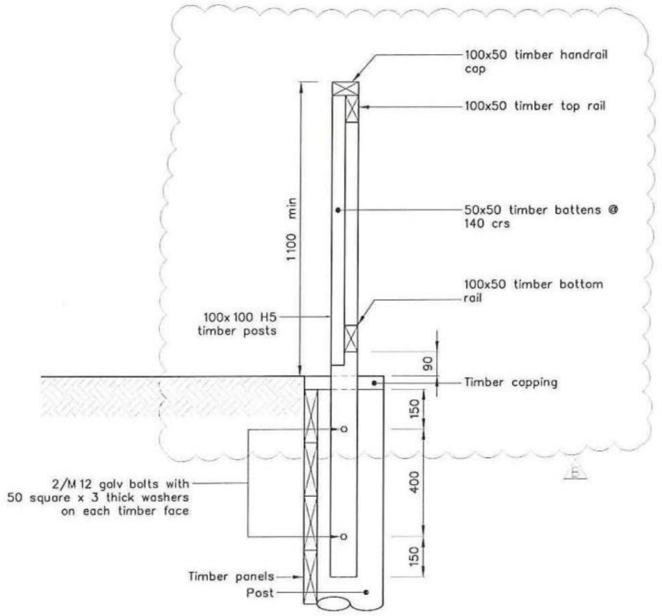
DRAWING STATUS: CONSTRUCTION ISSUE

CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS DETAILS
Rip Rap Details

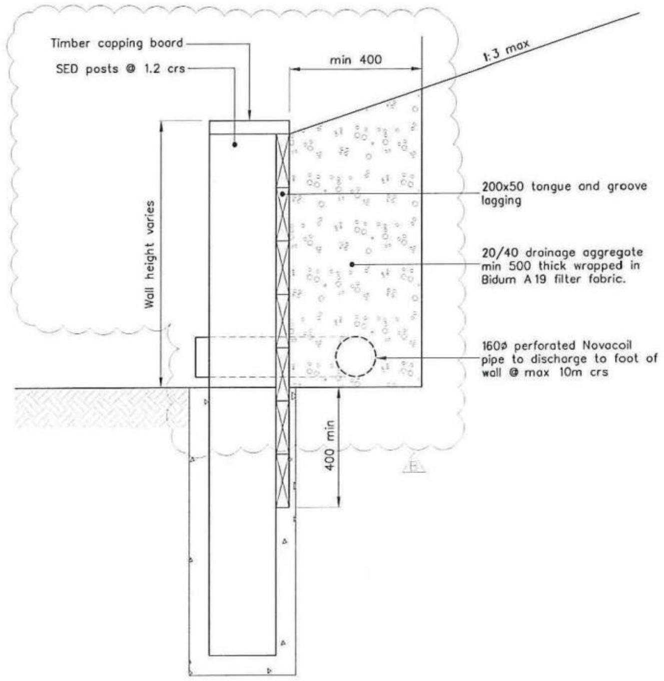
SCALES (AT A3 SIZE) 1:50
DWG. No. 60929.001-604
REV. B



TYPICAL HANDRAIL DETAIL
SCALE 1:20

TIMBER RETAINING WALL SCHEDULE

Max height (h)	Footing depth (d)	Post SED ø	Timber cap
0.6m	1.0m	150mm	150x50
1.0m	1.5m	200mm	250x50
1.5m	2.0m	250mm	300x50



TYPICAL RETAINING WALL TYPE Y
SCALE 1:20

NOTE: Drainage aggregate and Novacoil not required for walls less than 1m high.

TIMBER WALL NOTES:

1. The Contractor shall be responsible for identifying and locating all existing services prior to the start of wall construction.
2. The Engineer is to inspect all excavations prior to the placement of any fill.
3. All excavations shall have side slopes of 1:1 unless approved otherwise by the Engineer. Contractor to ensure the excavated sides slopes are restrained from collapsing.
4. Posts shall be concrete encased in 20MPa concrete min 75mm thick in min ø400mm drilled holes.
5. Timber lagging on walls shall extend minimum 400 below ground level.
   Timber posts shall be H5 high density poles.
   Timber lagging shall be H5 tongue and grooved No 1 Framing.
   Timber copping board shall be H4 No 1 Framing.
   Timber handrail posts shall be H5 VSG 10 (or MSG 10).
   Timber handrail rails shall be H4 No 1 Framing.
   Timber handrail battens shall be H3 No 1 Framing.
6. All cut timber and pole ends shall be flooded 3 times with metallex green or equivalent.
7. Handrail required on all floodwalls & retaining walls where the wall height is greater than 1000mm.
8. Erection of handrails shall take place as directed by the Engineer.
9. All timber fastenings shall be nails min 100 long unless noted otherwise.
10. All bolts, fixings and nails shall be hot dipped galvanised with average galvanised coating mass of 375 g/m².

SCALE 1:20
0 0.2 0.4 0.6 0.8 1.0 (m)

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DRAWING STATUS: CONSTRUCTION ISSUE

REV	REVISION DESCRIPTION	BY	DATE
B	Wall revised	EDW	11/09
A	For Construction	EDW	10/09

DESIGNED :	BMQ	Oct.09
DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EDW	11/09
DRAFTING CHECKED :	BMQ	11/09
CADFILE : \\60929.001-700.dwg		
APPROVED : EDWilson	26 11 09	

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NOTES :
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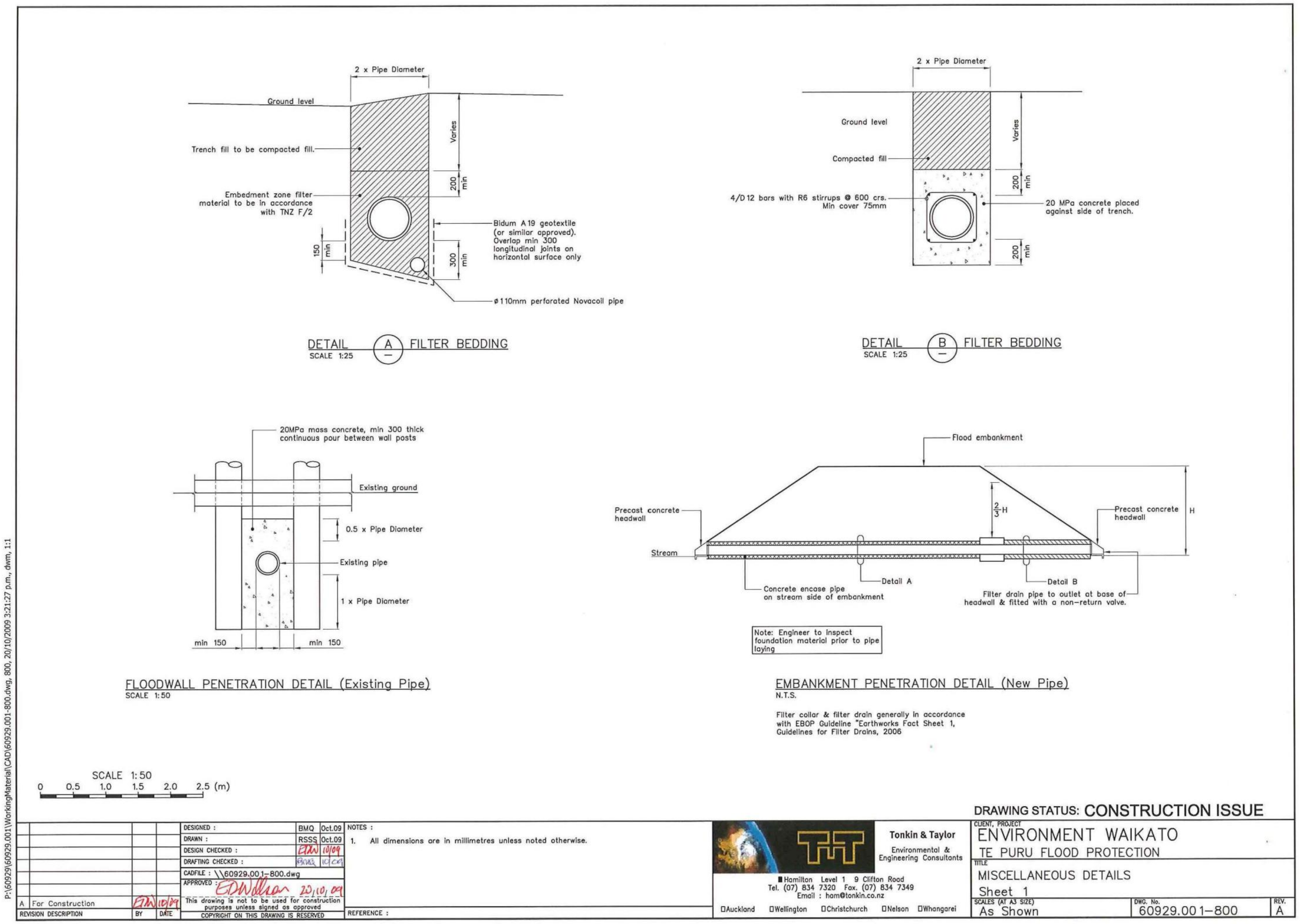
CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION
TITLE
RETAINING WALL DETAILS
Sheet 1
SCALES (AT A3 SIZE) 1:20
DWG. No. 60929.001-700
REV. B


2 x Pipe Diameter
Ground level
Trench fill to be compacted fill.
Varies
200 min
Embedment zone filter material to be in accordance with TNZ F/2
Bidum A19 geotextile (or similar approved). Overlap min 300 longitudinal joints on horizontal surface only
150 min
300 min
ø110mm perforated Novacoil pipe
DETAIL A FILTER BEDDING
SCALE 1:25
Compacted fill
4/D12 bars with R6 stirrups @ 600 crs. Min cover 75mm
20 MPa concrete placed against side of trench.
DETAIL B FILTER BEDDING
SCALE 1:25
20MPa mass concrete, min 300 thick continuous pour between wall posts
Existing ground
0.5 x Pipe Diameter
Existing pipe
1 x Pipe Diameter
min 150
FLOODWALL PENETRATION DETAIL (Existing Pipe)
SCALE 1:50
Flood embankment
Precast concrete headwall
Stream
2/3 H
H
Detail A
Detail B
Concrete encase pipe on stream side of embankment
Filter drain pipe to outlet at base of headwall & fitted with a non-return valve.
Note: Engineer to inspect foundation material prior to pipe laying
EMBANKMENT PENETRATION DETAIL (New Pipe)
N.T.S.
Filter collar & filter drain generally in accordance with EBOP Guideline "Earthworks Fact Sheet 1, Guidelines for Filter Drains, 2006
SCALE 1:50
0 0.5 1.0 1.5 2.0 2.5 (m)
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DRAWING STATUS: CONSTRUCTION ISSUE
DESIGNED : BMQ Oct.09
DRAWN : RSSS Oct.09
DESIGN CHECKED :
DRAFTING CHECKED :
CADFILE : \\60929.001-800.dwg
APPROVED : 20/10/09
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A For Construction
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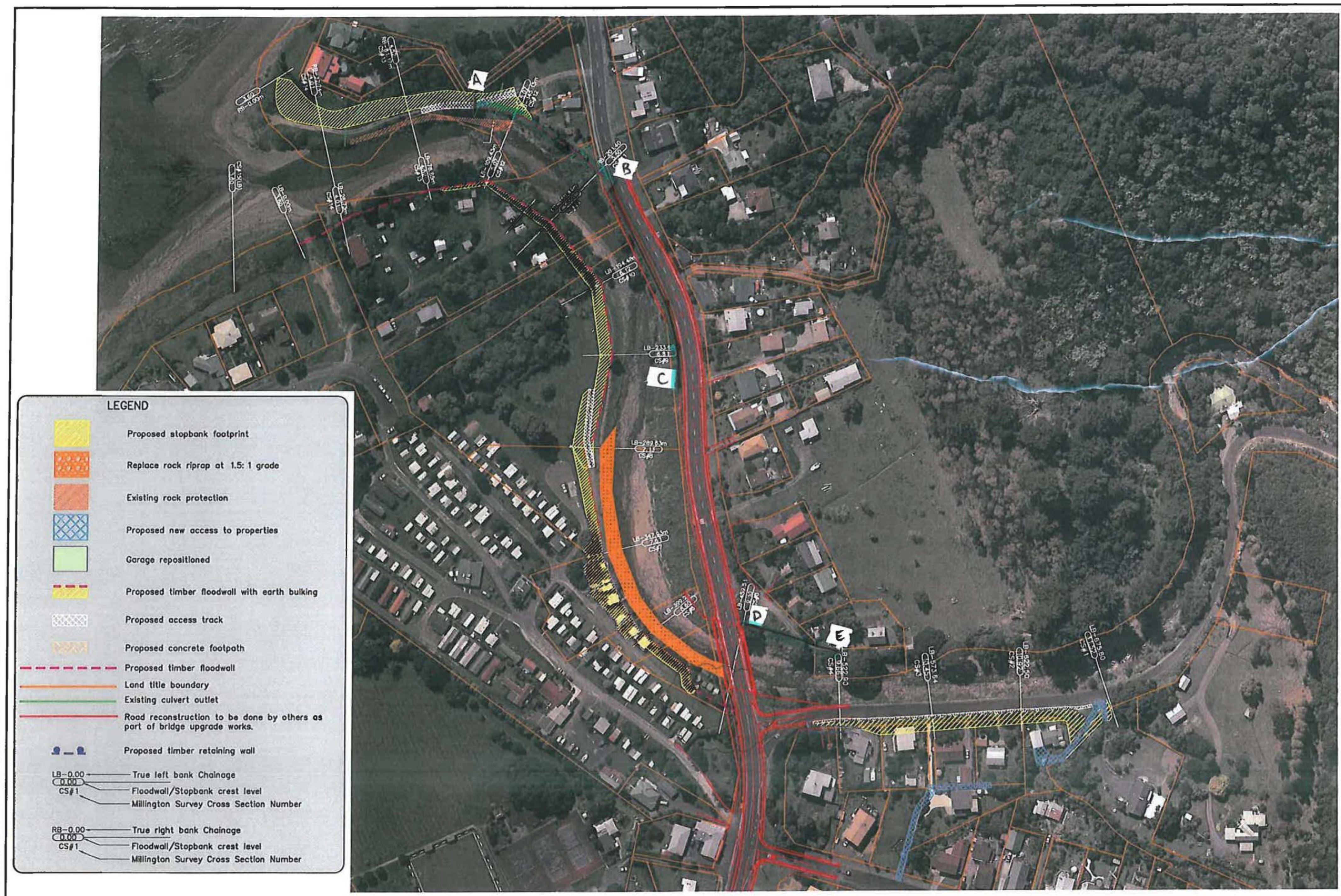
Email : ham@tonkin.co.nz
Auckland Wellington Christchurch Nelson Whangarei
CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION
TITLE
MISCELLANEOUS DETAILS
Sheet 1
SCALES (AT A3 SIZE) As Shown
DWG. No. 60929.001-800
REV. A



SCALE 1: 2000

0 20 40 60 80 100 (m)

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DRAWING STATUS: CONSTRUCTION ISSUE

				DESIGNED :	BMQ	Oct.09
				DRAWN :	RSSS	Oct.09
				DESIGN CHECKED :	EDW	11/09
				DRAFTING CHECKED :	BMQ	11/09
				CADFILE : \\60929.001-200.dwg		
B	Minor Revisions	EDW	11/09	APPROVED : EDWilson 23/11/09		
A	For Construction	EDW	10/09	This drawing is not to be used for construction purposes unless signed as approved		
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NOTES :

1. All dimensions are in millimetres unless noted otherwise.
2. Design Floodwall/Stopbank levels supplied by Environment Waikato.
3. Design 1% AEP Flood levels supplied by Environment Waikato.
4. Cross sections and Land Title Boundaries from F.W.Millington Ltd, Environment Waikato Thames Coast Project – Te Puru Stream Survey Dwg No.2474 Sheets 1 to 8 dated October 2004.

REFERENCE :

Tonkin & Taylor
Environmental & Engineering Consultants
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CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

TITLE
FLOOD PROTECTION WORKS
Site Layout Plan

SCALES (AT A3 SIZE) 1: 2000
DWG. No. 60929.001-200
REV. B

FIELD REPORT / CALC PAD

Environment Waikato REGIONAL COUNCIL

HAMILTON OFFICE 3 Cook Street, Hamilton P.O. Box 4010, Hamilton East Telephone: 0-7-859 0999 Facsimile: 0-7-859 0998
PAEROA OFFICE 13 Opatito Road, Paeroa Telephone: 0-7-862 8376 Facsimile: 0-7-862 6094
TAUPO OFFICE Cnr Paora Hapi & Titiraupenga Sts PO Box 501 Taupo Telephone: 0-7-378 6539 Facsimile: 0-7-378 9049
WHITIANGA OFFICE 33-35 Albert Street PO Box 192, Whitianga Telephone: 0-7-866 0172 Facsimile: 0-7-866 0173

NAME	
ADDRESS	
DATE	14/3/11
REPORT BY	
FILE REFERENCE	

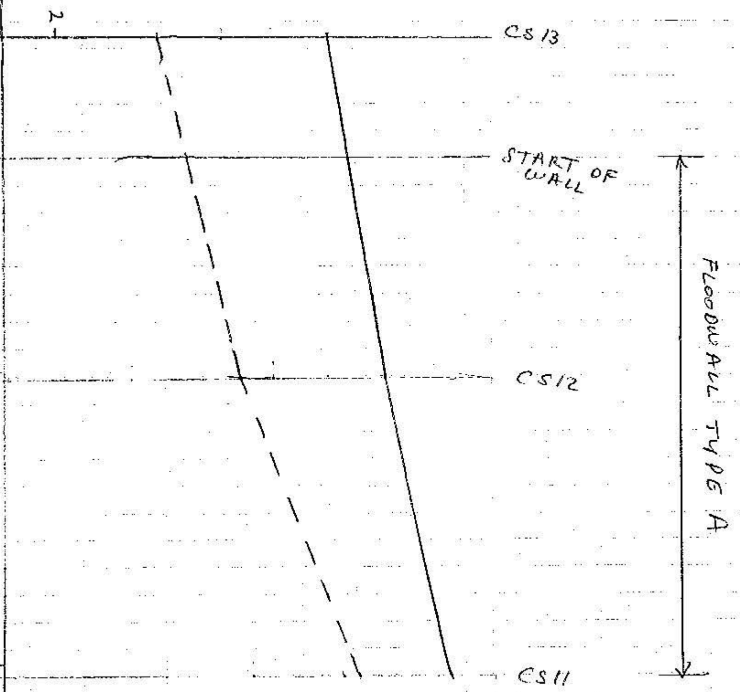
Computed	MAW	14/3/2011
Checked		20
Revised		20
Checked		20
Office		
Job No		
File		
Sheet No.		

Project: TE PURU FLOOD PROTECTION

Description: RIGHT BANK FLOOD WALL

RIGHT BANK FLOOD WALL SECTION A - B

DISTANCE	GROUND LEVEL	DESIGN LEVEL
-22.7	2.94	4.52
0		
41.28	3.71	5.07
96.96	4.8	5.65



VERT - 1:50
HORZ - 1:1000

POLLUTION CONTROL * LAND USE PERMITS * PEST CONTROL * LAND/PASSENGER TRANSPORT * WATER USE PERMITS * SOIL CONSERVATION * REGIONAL WASTE MANAGEMENT
NOXIOUS WEED CONTROL * REGIONAL CIVIL DEFENCE * FLOOD CONTROL * COASTAL PERMITS * LAND DRAINAGE * MARITIME PLANNING * ENVIRONMENTAL PLANNING * ROAD SAFETY

FIELD REPORT / CALC PAD

Environment Waikato
REGIONAL COUNCIL

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DATE	REPORT BY	FILE REFERNCE

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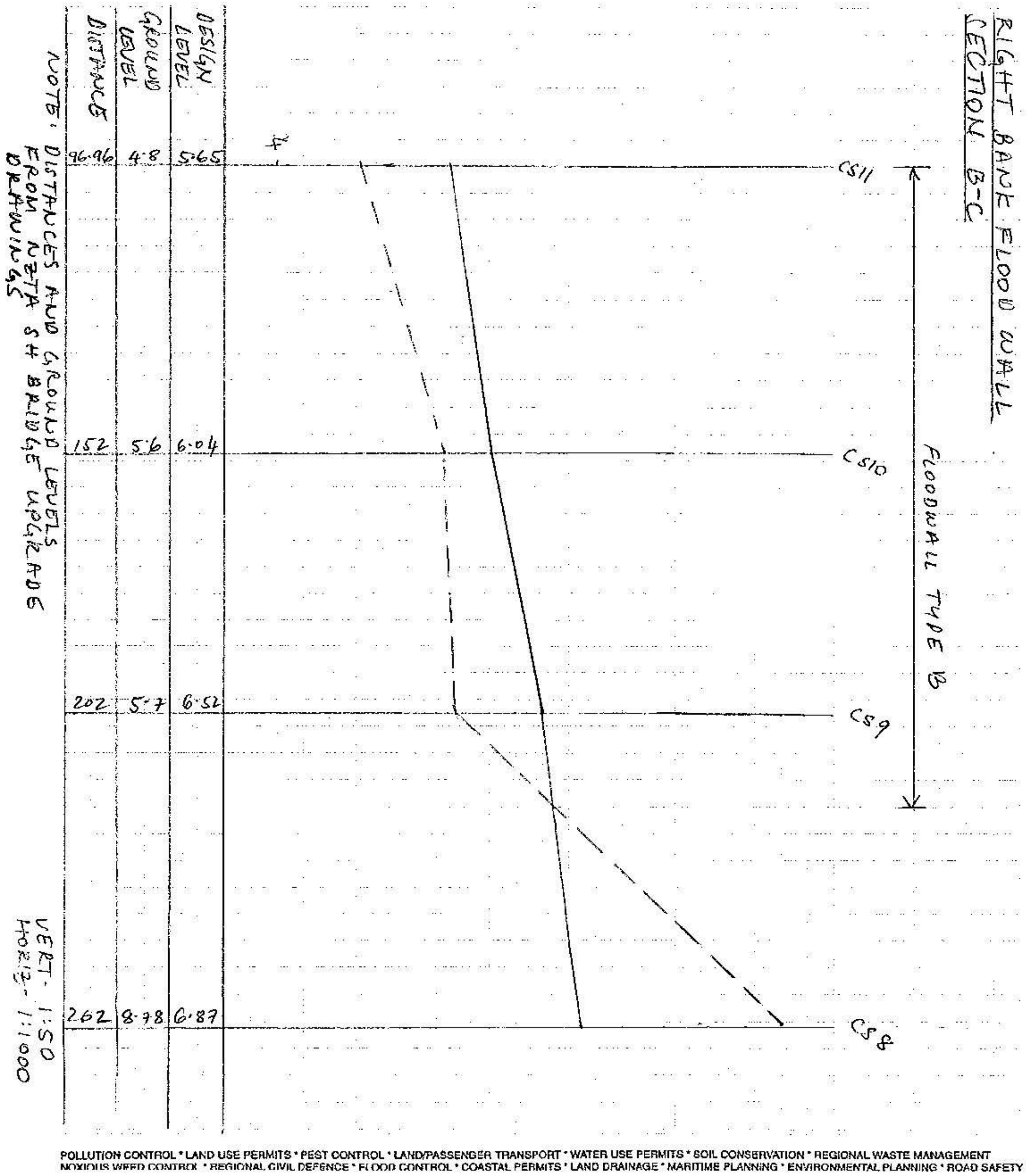
Project: TE PURU FLOOD PROTECTION

Description: RIGHT BANK FLOOD WALL



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DATE	REPORT BY	FILE REFERNCE

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Facsimile: 0-7-866 0173

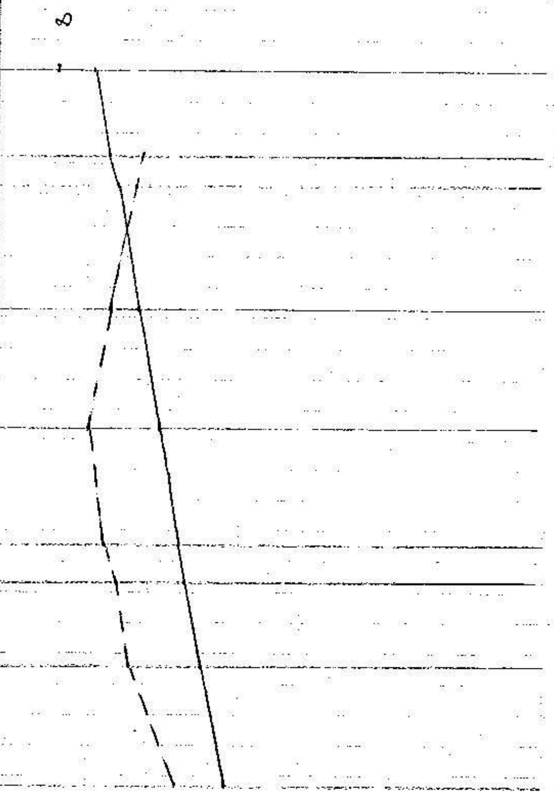
Computed	MAW	14/3/2011
Checked		20
Revised		20
Checked		20
Office		
Job No		
File		
Sheet No.		

Project: TE PURU FLOOD PROTECTION

Description: RIGHT BANK FLOODWALL

RIGHT BANK FLOOD WALL SECTION D-E

DISTANCE	GROUND LEVEL	DESIGN LEVEL	
0		8.32	CS5
7	8.72	8.44	KEYSTONE WALL AT BRIDGE
9.6	8.6	8.49	
19.6	8.44	8.66	
29.6	8.26	8.84	
39.6	8.38	9.01	
42.6	8.51	9.06	
49.6	8.58	9.19	
59.6	8.97	9.36	CS4
68.6			HIGH GROUND



FLOODWALL TYPE B

VERT 1:50
HORI 1:500

POLLUTION CONTROL * LAND USE PERMITS * PEST CONTROL * LAND/PASSENGER TRANSPORT * WATER USE PERMITS * SOIL CONSERVATION * REGIONAL WASTE MANAGEMENT
NOXIOUS WEED CONTROL * REGIONAL CIVIL DEFENCE * FLOOD CONTROL * COASTAL PERMITS * LAND DRAINAGE * MARITIME PLANNING * ENVIRONMENTAL PLANNING * ROAD SAFETY

TE PURU FLOOD PROTECTION SCHEME
RIGHT BANK FLOOD WALL

SECTION A - B

Location	Distance	GL	DCL	Height
CS13	-22.68	2.94	4.52	1.58
Wall start	0			
CS12	41.28	3.71	5.07	1.36
CS11	96.96	4.8	5.65	0.85
	119.64			

NOTE:
Kingi property
Fill, hence ensure foundation 2m deep
Design criteria = 100Y+600mm

SECTION B - C

Location	Distance	GL	DCL	Height
CS11	96.96	4.8	5.65	0.85
CS10	152	5.6	6.04	0.44
CS9	202	5.7	6.52	0.82
CS8	262	8.78	6.87	-1.91

NOTE:
Along SH
To tie into existing footpath
Design criteria = 100YCC

SECTION D - E

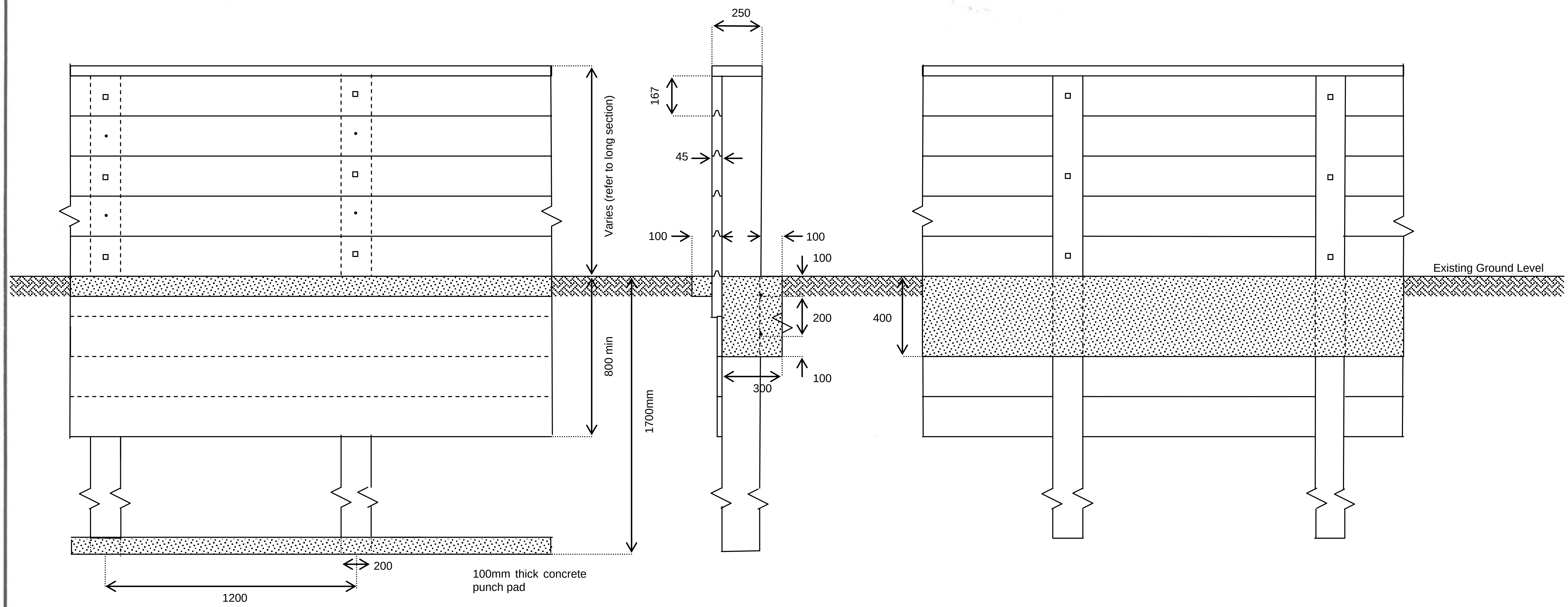
Location	Distance	GL	DCL	Height
CS5	0		8.32	
Keystone wall	7	8.72	8.44	-0.28
	9.6	8.6	8.49	-0.11
	19.6	8.44	8.66	0.22
Mid-point	29.6	8.26	8.84	0.58
	39.6	8.38	9.01	0.63
	42.6	8.51	9.06	0.55
	49.6	8.58	9.19	0.61
CS4	59.6	8.97	9.36	0.39
High ground	68.6			

NOTE:
RB upstream of SH - spillway
Design criteria = 100Y+300mm

Notes to accompany Te Puru Right Bank Floodwall Design - Wall Type A

Posts:	200mm SED timber posts at 1.2m centres Heights vary (refer to long section)
Planks (above ground):	167 x 45 mm timber tongue and groove (ex 200 x 50). 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 extend one board (minimum) below existing ground level.
Planks (below ground):	200 x 25 mm rough sawn timber. Three rough sawn timber planks to start below tongue and groove timber, which extends one board (minimum) below existing ground level. Planks to be nailed.
Capping board: (where applicable)	250 x 50 mm nailed to each post and to the top plank at 200 mm centres.
Foundation (below ground):	Excavated to a minimum depth of 1.7m 100 mm thick concrete punch pad Trench backfilled with compacted clay.
Foundation (ground level):	Stream side - 100 x 100 mm concrete mowing strip flush with final ground level Land side - 300 x 400mm concrete pad flush with final ground level, including steel reinforcement (two 12mm diameter reinforcing bars stapled to each post with a cover of 100mm and vertical spacing of 200mm).
Timber treatment:	H4 planks, H5 posts
Concrete:	17.5 MPa
Drawing key:	Concrete Existing ground Timber

AMENDMENTS				WAIKATO REGIONAL COUNCIL	JOB No.	FIELD BOOK No.
29/09/10: First draft (for review by RP Spooner) 14/03/11: First draft (for review by RP Spooner and DJ Shilton) 24/03/11: Final	SURVEYED			Te Puru Flood Protection Scheme	SCALE 1:20	LEVEL BOOK No.
	DESIGNED			Right Bank Floodwall - Design Type A	FILE REF. Z21 F200 / 75 05 65	DRAWING No. 1314-095000
	DRAWN					SHEET No. 1 of 4
	TRACED					
	CHECKED					
	RECOMMENDED					
	DATE APPROVED	CHIEF ENGINEER				



Front Elevation (river)

Side Elevation

Rear Elevation (land)

AMENDMENTS		
29/09/10: First draft (for review by RP Spooner) 14/03/11: First draft (for review by RP Spooner and DJ Shilton) 24/03/11: Final	SURVEYED DESIGNED DRAWN TRACED CHECKED RECOMMENDED DATE APPROVED	CHIEF ENGINEER

WAIKATO REGIONAL COUNCIL

Te Puru Flood Protection Scheme

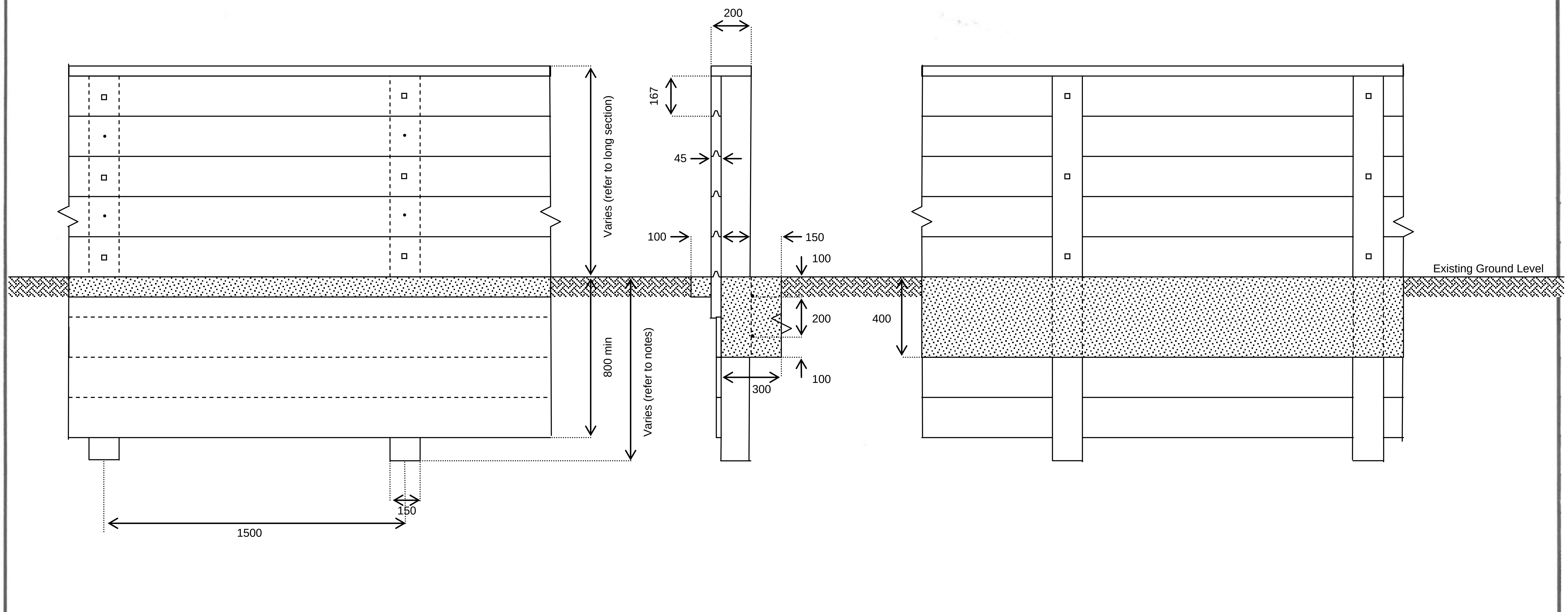
Right Bank Floodwall - Design Type A

JOB No.	FIELD BOOK No.
	LEVEL BOOK No.
SCALE 1:20	DRAWING No. 1314-095000
FILE REF. Z21 F200 / 75 05 65	SHEET No. 2 of 4

Notes to accompany Te Puru Right Bank Floodwall Design - Wall Type B

Posts:	150mm SED timber posts at 1.5 m centres Heights vary (refer to long section)
Planks (above ground):	167 x 45 mm timber tongue and groove (ex 200 x 50). 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 extend one board (minimum) below existing ground level.
Planks (below ground):	200 x 25 mm rough sawn timber. Three rough sawn timber planks to start below tongue and groove timber, which extends one board (minimum) below existing ground level. Reduced to two rough sawn planks where wall height above ground is less than 0.6m. Planks to be nailed.
Capping board: (where applicable)	200 x 50 mm nailed to each post and to the top plank at 200 mm centres.
Foundation (below ground):	Excavated to a minimum depth of 0.9 m for wall height above ground ≤ 0.6 m Excavated to a minimum depth of 1.0 m for wall height above ground: 0.6 m < wall height < 1.0 m Excavated to a minimum depth of 1.2m for wall height above ground ≥ 1.0 m Trench backfilled with compacted clay.
Foundation (ground level):	Stream side - 100 x 100 mm concrete mowing strip flush with existing ground level where sufficient room. Land side - B to C: Floodwall to be constructed against existing footpath. D to E: 300 x 400mm concrete pad flush with final ground level, including steel reinforcement (two 12mm diameter reinforcing bars stapled to each post with a cover of 100mm and vertical spacing of 200mm).
Timber treatment:	H4 planks, H5 posts
Concrete:	17.5 MPa
Drawing key:	Concrete Existing ground Timber

AMENDMENTS			WAIKATO REGIONAL COUNCIL		
29/09/10: First draft (for review by RP Spooner) 14/03/11: Second draft (for review by RP Spooner and DJ Shilton) 24/03/11: Final	SURVEYED DESIGNED DRAWN TRACED CHECKED RECOMMENDED DATE APPROVED	CHIEF ENGINEER	Te Puru Flood Protection Scheme Right Bank Floodwall Design - Type B	JOB No. SCALE 1:20 FILE REF. Z21 F200 / 75 05 65	FIELD BOOK No. LEVEL BOOK No. DRAWING No. 1314-095000 SHEET No. 3 of 4



Front Elevation (river)

Side Elevation

Rear Elevation (land)

AMENDMENTS		WAIKATO REGIONAL COUNCIL	JOB No.	FIELD BOOK No.
29/09/10: First draft (for review by RP Spooner) 14/03/11: Second draft (for review by RP Spooner and DJ Shilton) 24/03/11: Final	SURVEYED DESIGNED DRAWN TRACED CHECKED RECOMMENDED DATE APPROVED CHIEF ENGINEER	Te Puru Flood Protection Scheme Right Bank Floodwall Design - Type B	SCALE 1:20	LEVEL BOOK No. DRAWING No. 1314-095000
			FILE REF. Z21 F200 / 75 05 65	SHEET No. 4 of 4

LEGEND

- Proposed stopbank footprint
- Replace rock riprap at 1.5:1 grade
- Existing rock protection
- Proposed new access to properties
- Garage repositioned
- Proposed timber floodwall with earth bulking
- Proposed access track
- Proposed concrete footpath
- Proposed timber floodwall
- Land title boundary
- Existing culvert outlet
- Road reconstruction to be done by others as part of bridge upgrade works.
- Proposed timber retaining wall
- LB-0.00 — True left bank Chainage; 0.00 — Floodwall/Stopbank crest level; CS#1 — Millington Survey Cross Section Number
- RB-0.00 — True right bank Chainage; 0.00 — Floodwall/Stopbank crest level; CS#1 — Millington Survey Cross Section Number

SCALE 1: 1000

0 10 20 30 40 50 (m)

DRAWING STATUS: CONSTRUCTION ISSUE

A	For Construction	EDW 10/09
REVISION DESCRIPTION	BY	DATE

DESIGNED :	BMO	Oct.09
DRAWN :	RSSS	Oct.09
DESIGN CHECKED :	EDW	10/09
DRAFTING CHECKED :	BJB	10/09
CADFILE : \\60929.001-300_303.dwg		
APPROVED : EDWilson 20.10.09		

This drawing is not to be used for construction purposes unless signed as approved

COPYRIGHT ON THIS DRAWING IS RESERVED

NOTES :

1. All dimensions are in metres unless noted otherwise.
2. Design Floodwall/Stopbank levels supplied by Environment Waikato.
3. Design 1% AEP Flood levels supplied by Environment Waikato.
4. Cross sections and Land Title Boundaries from F.W.Millington Ltd. Environment Waikato Thames Coast Project – Te Puru Stream Survey Dwg No.2474 Sheets 1 to 8 dated October 2004.

REFERENCE :

Tonkin & Taylor
Environmental & Engineering Consultants

Hamilton Level 1 9 Clifton Road
Tel. (07) 834 7320 Fax. (07) 834 7349
Email : ham@tonkin.co.nz

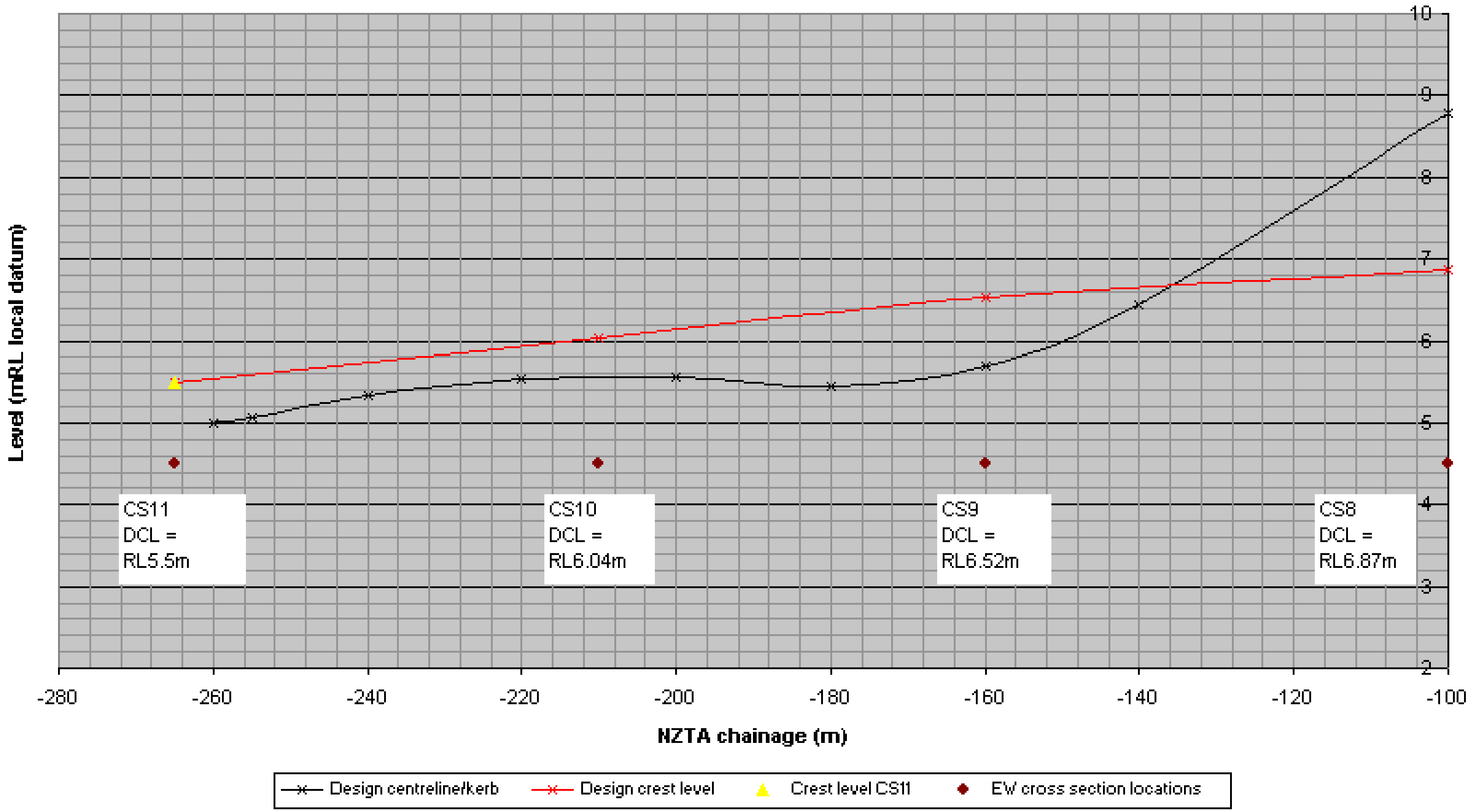
Auckland Wellington Christchurch Nelson Whangarei

CLIENT, PROJECT
ENVIRONMENT WAIKATO
TE PURU FLOOD PROTECTION

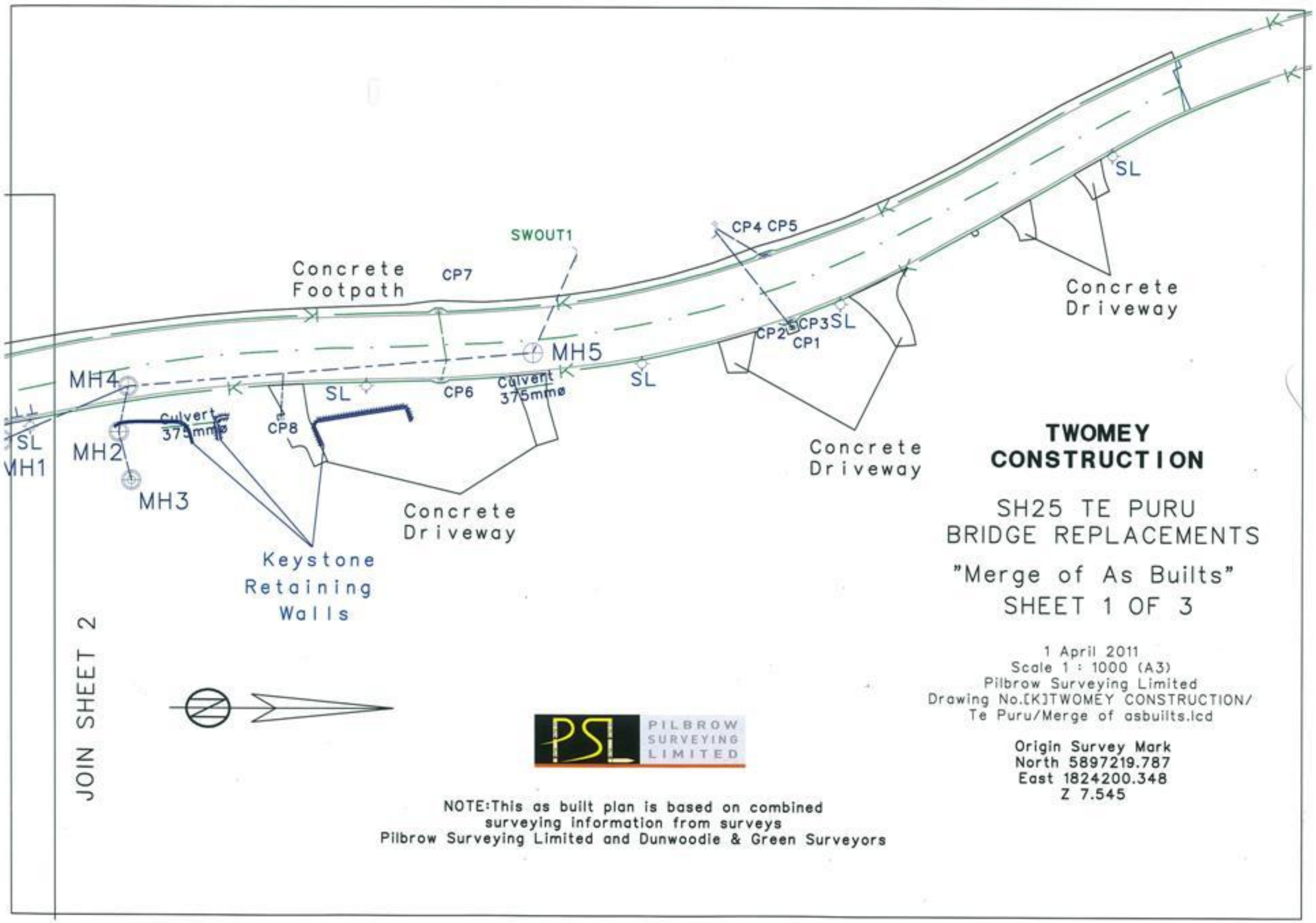
TITLE
FLOOD PROTECTION WORKS LAYOUT PLAN
Left Bank Chainage 0.0m to 300m

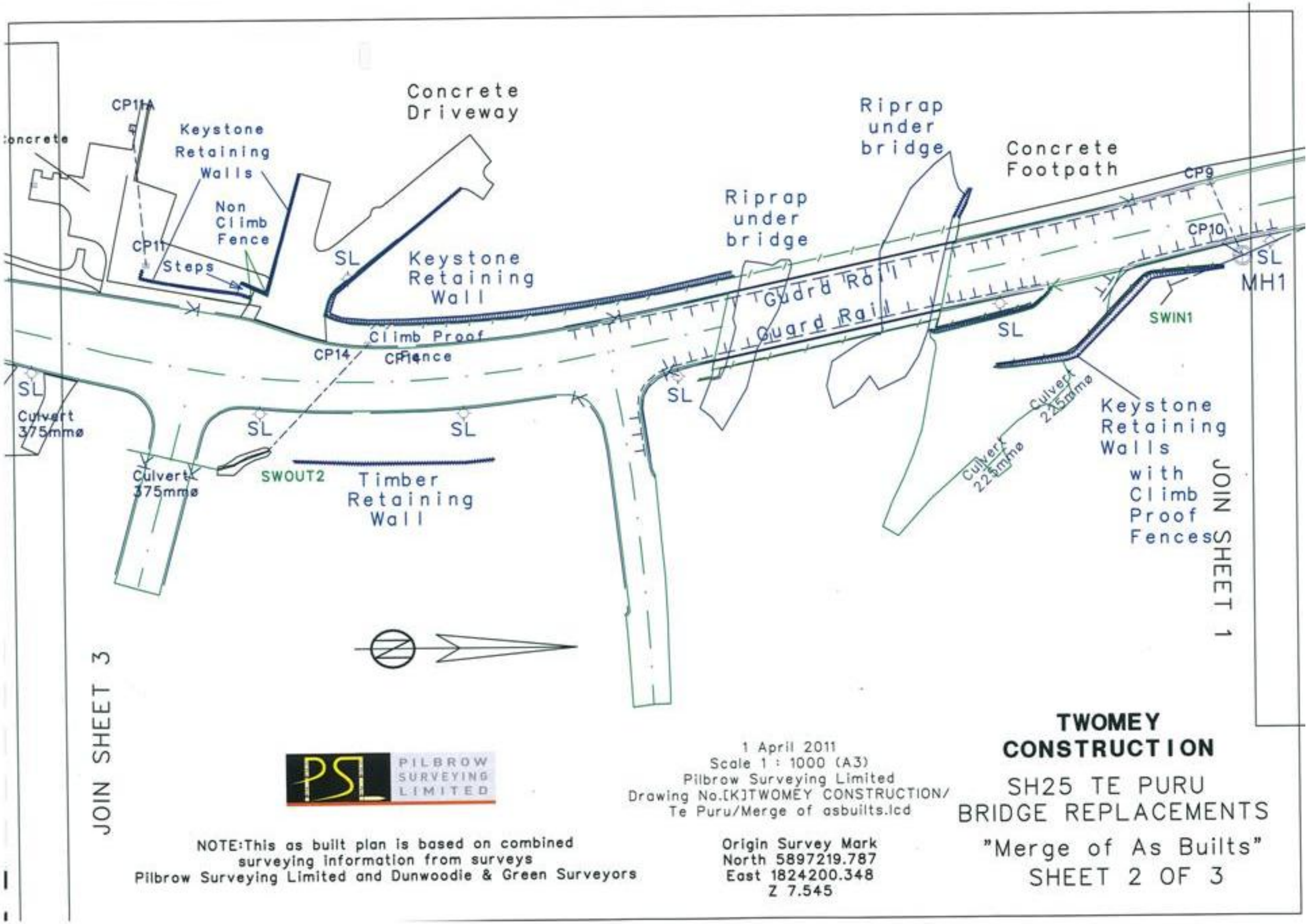
SCALES (AT A3 SIZE)	DWG No.	REV.
1: 1000	60929.001-300	A

Te Puru flood protection - right bank flood wall extension - longsection



Appendix 5 Secondary overland flowpath arrangement





PILBROW SURVEYING LIMITED

1 April 2011
Scale 1 : 1000 (A3)
Pilbrow Surveying Limited
Drawing No.[K]TWOMEY CONSTRUCTION/
Te Puru/Merge of asbuilts.lcd

TWOMEY CONSTRUCTION

SH25 TE PURU
BRIDGE REPLACEMENTS
"Merge of As Builts"
SHEET 2 OF 3

NOTE:This as built plan is based on combined surveying information from surveys Pilbrow Surveying Limited and Dunwoodie & Green Surveyors

Origin Survey Mark
North 5897219.787
East 1824200.348
Z 7.545

TWOMEY CONSTRUCTION

SH25 TE PURU BRIDGE REPLACEMENTS

Drainage As Builts

November 12, 2010

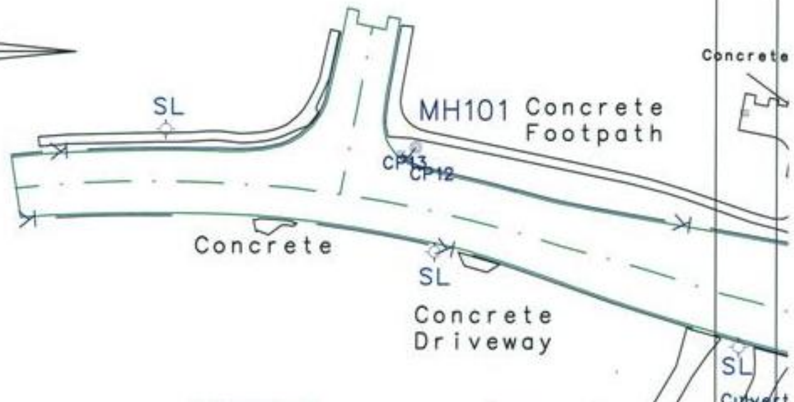
Note: 1. Coordinates and lid level are centre of cast lid or cesspit grate.
2. Inlet invert levels were recorded clockwise from the outlet.
3. Coordinates and levels are in terms of Survey Control provided for construction.

Stormwater Manholes

Point ID	North	East	Lid Level	Outlet Invert Level	Pipe Size (mm)	Inlet Invert Level	Pipe Size (mm)
MH1	5897218	1824263	11.13	6.33	Ø1200	6.37	Ø1200
MH2	5897237	1824262	9.63	7.34	Ø600	7.37	Ø600
MH3	5897239	1824270	8.74	7.47	Ø600	8.74	-
MH4	5897239	1824255	10.53	5.52	Ø1200	6.27	Ø600
MH5	5897303	1824249	7.21	5.03	Ø1200	5.08	Ø1200
MH10	5896981	1824255	5.84	4.75	Ø375	4.78	Ø375

Catchpits

Point ID	North	East	Grate Level	Outlet Invert Level	Pipe Size (mm)	Single or Double Catchpit	Depth to Invert
CP1	5897345	1824245	6.21	5.46	Ø240PV	Field	0.75
CP2	5897344	1824244	6.34	5.44	Ø375	CP2-CP3	0.9
CP3	5897345	1824244	6.34	5.63	Ø225	CP2-CP3	0.71
CP4	5897341	1824233	5.82	4.72	Ø375	CP4-CP5	1.1
CP5	5897340	1824233	5.82	4.94	Ø225	CP4-CP5	0.88
CP6	5897289	1824254	8	7.08	Ø375	Single	0.92
CP7	5897288	1824242	7.9	6.43	Ø375	Single	1.47
CP8	5897263	1824259	8.42	7.76	Ø240PV	Single	0.66
CP9	5897213	1824252	11.44	10.36	Ø375	Single	1.08
CP10	5897215	1824261	11.27	10.35	Ø375	Single	0.92
CP11	5897042	1824263	7.15	6.8	Ø240PV	Single	0.35
CP11A	5897040	1824241	7.03	6.54	Ø150PV	Single	0.49
CP12	5896980	1824256	5.61	4.8	Ø375	CP12-CP1	0.81
CP13	5896979	1824256	5.62	4.85	Ø375	CP12-CP1	0.77
CP14	5897077	1824276	10.09	9.11	Ø375	Single	0.98



TWOMEY CONSTRUCTION

SH25 TE PURU
BRIDGE REPLACEMENTS

"Merge of As Builts"

SHEET 3 OF 3

1 April 2011
Scale 1 : 1000 (A3)
Pilbrow Surveying Limited
Drawing No.[K]TWOMEY CONSTRUCTION/
Te Puru/Merge of asbuilts.lcd

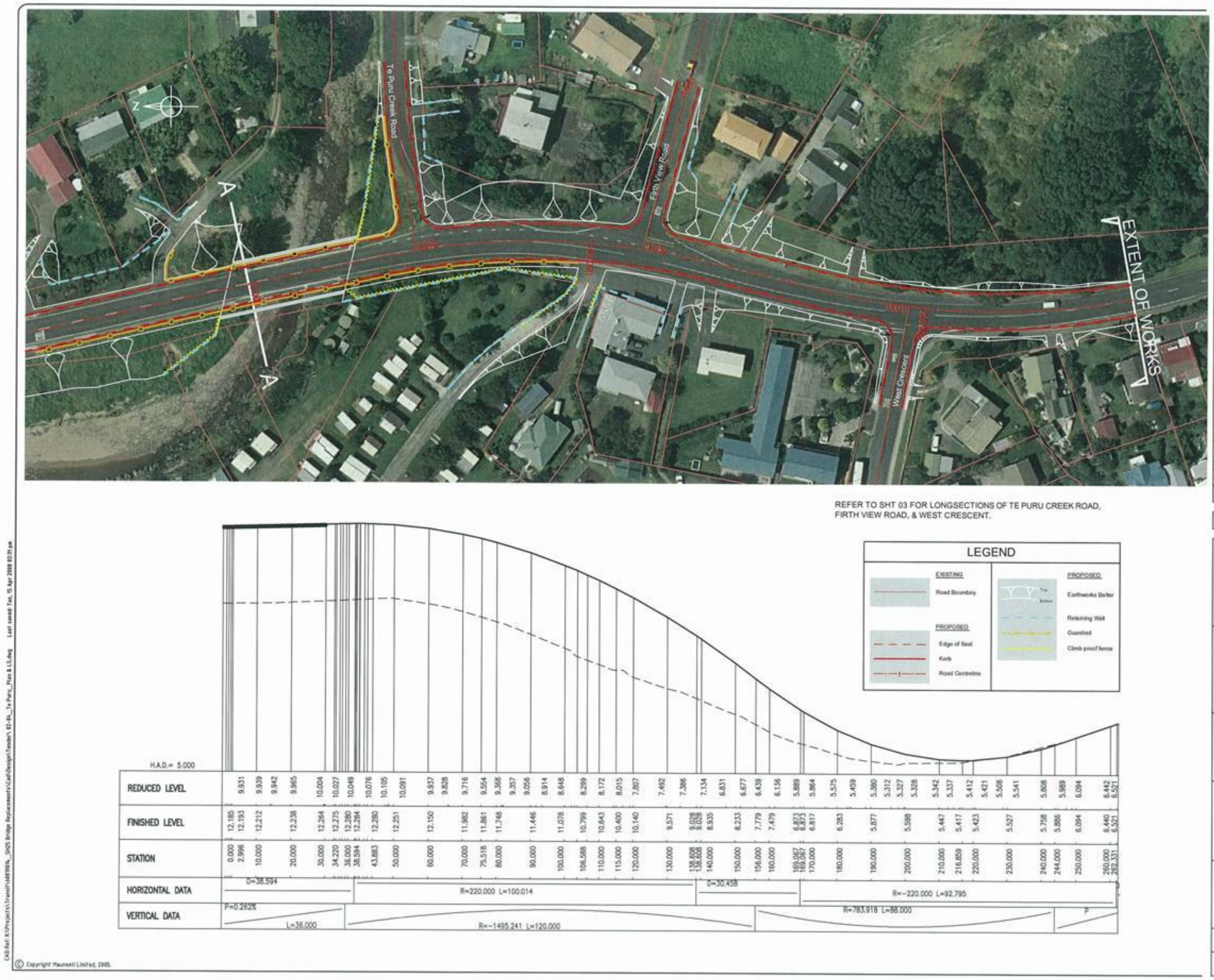
Origin Survey Mark
North 5897219.787
East 1824200.348
Z 7.545

PSL PILBROW SURVEYING LIMITED

JOIN SHEET 2

NOTE:This as built plan is based on combined surveying information from surveys Pilbrow Surveying Limited and Dunwoodie & Green Surveyors

Appendix 6 Bridge upgrade design drawings



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.

This drawing is confidential and shall only be used for the purposes of this project.

MAUNSELL | AECOM

Maunsell Limited

TRANSIT NEW ZEALAND

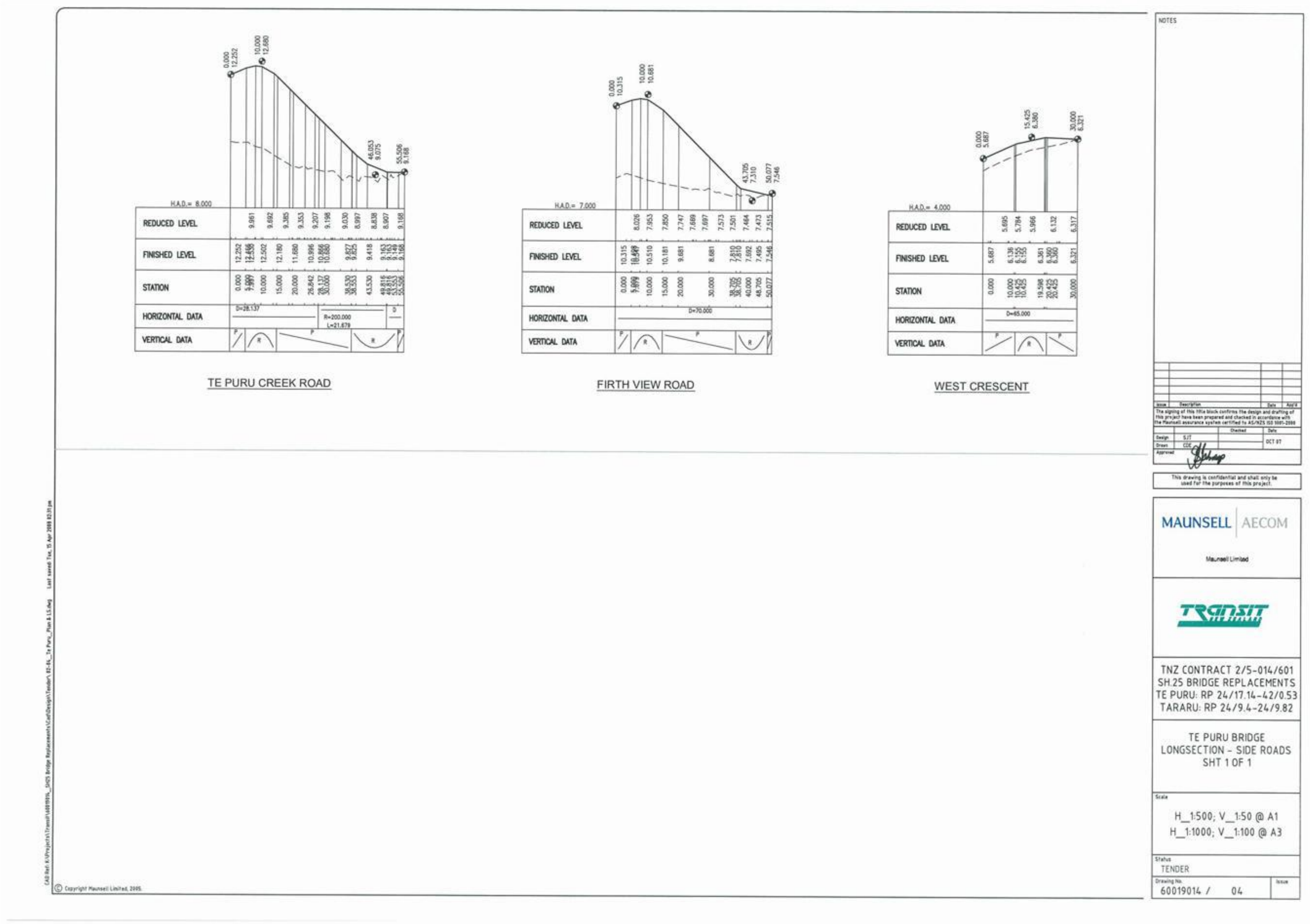
TNZ CONTRACT 2/5-014/601
SH.25 BRIDGE REPLACEMENTS
TE PURU: RP 24/17.14-42/0.53
TARARU: RP 24/9.4-24/9.82

TE PURU BRIDGE
PLAN & LONGSECTION
SHT 2 OF 2

Scale
H_1:500; V_1:50 @ A1
H_1:1000; V_1:100 @ A3

Status
TENDER

Drawing No. 60019014 / 03


TE PURU CREEK ROAD
FIRTH VIEW ROAD
WEST CRESCENT
REDUCED LEVEL
FINISHED LEVEL
STATION
HORIZONTAL DATA
VERTICAL DATA
NOTES
This drawing is confidential and shall only be used for the purposes of this project.
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
TE PURU BRIDGE
LONGSECTION - SIDE ROADS
SHT 1 OF 1
Scale
H_1:500; V_1:50 @ A1
H_1:1000; V_1:100 @ A3
Status
TENDER
Drawing No.
60019014 / 04
Issue
Copyright Maunsell Limited, 2005.

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.
EXTENT OF WORKS
NEW CATCHPITS EITHER SIDE OF ROAD WITH OUTFALL TO RIVER.
SECONDARY FLOW PATH
NEW 450Ø CULVERTS
REPLACE EXISTING CATCHPITS WITH NEW CATCHPIT AND MANHOLE. IL=?
ALL EXISTING SERVICES SHOWN ARE INDICATIVE ONLY
NEW CATCHPIT
NEW 7Ø CULVERTS
Puru Creek Road
Firth View Road
NEW 375Ø CULVERTS
NEW CULVERT (?Ø)
West Crescent
This drawing is confidential and shall only be used for the purposes of this project.
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
TE PURU BRIDGE
DRAINAGE PLAN
SHT 1 OF 1
Scale
1:500 @ A1
1:1000 @ A3
Status
TENDER
Drawing No.
60019014 / 08
Design SJT
Drawn CDE
OCT 07
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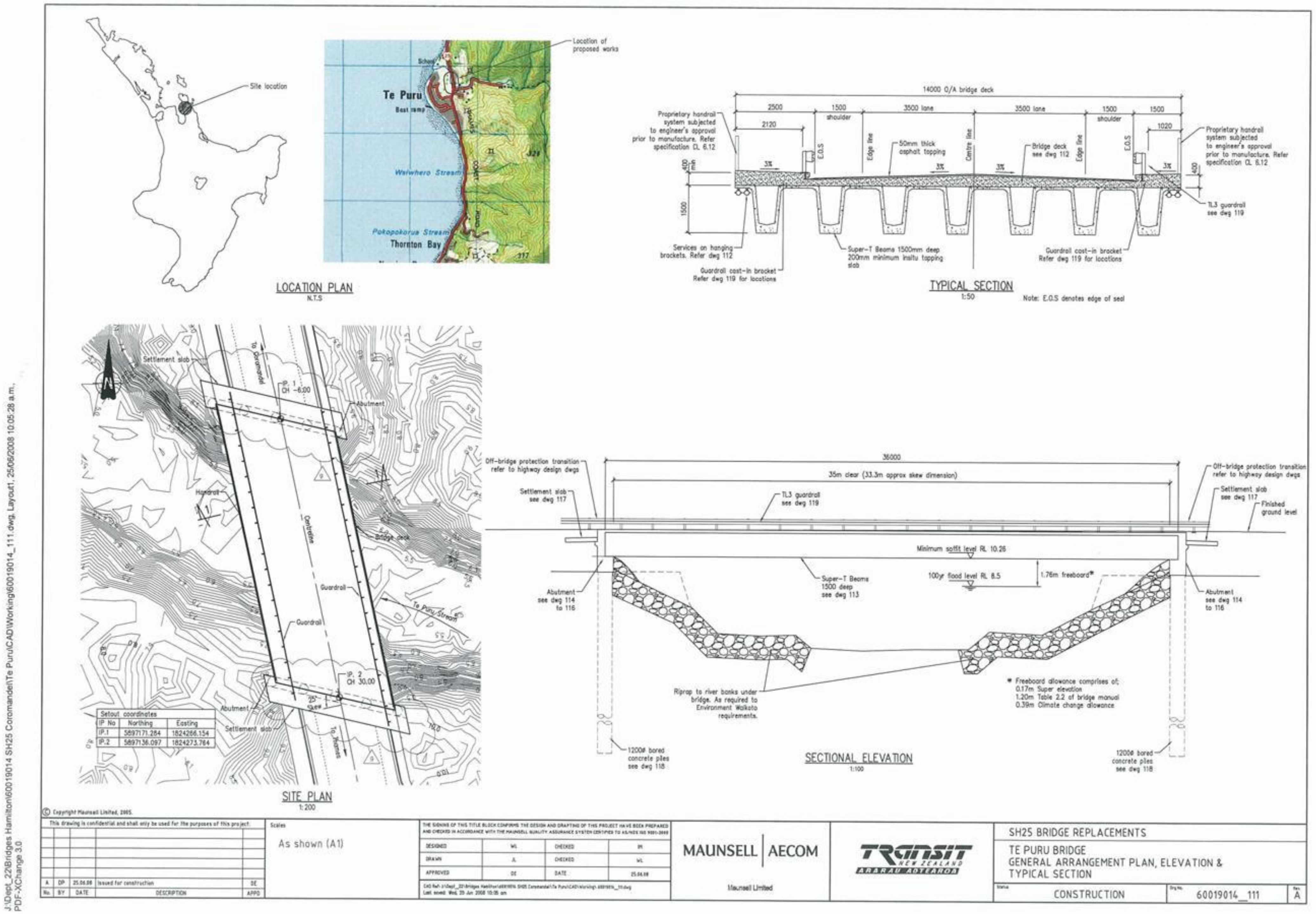
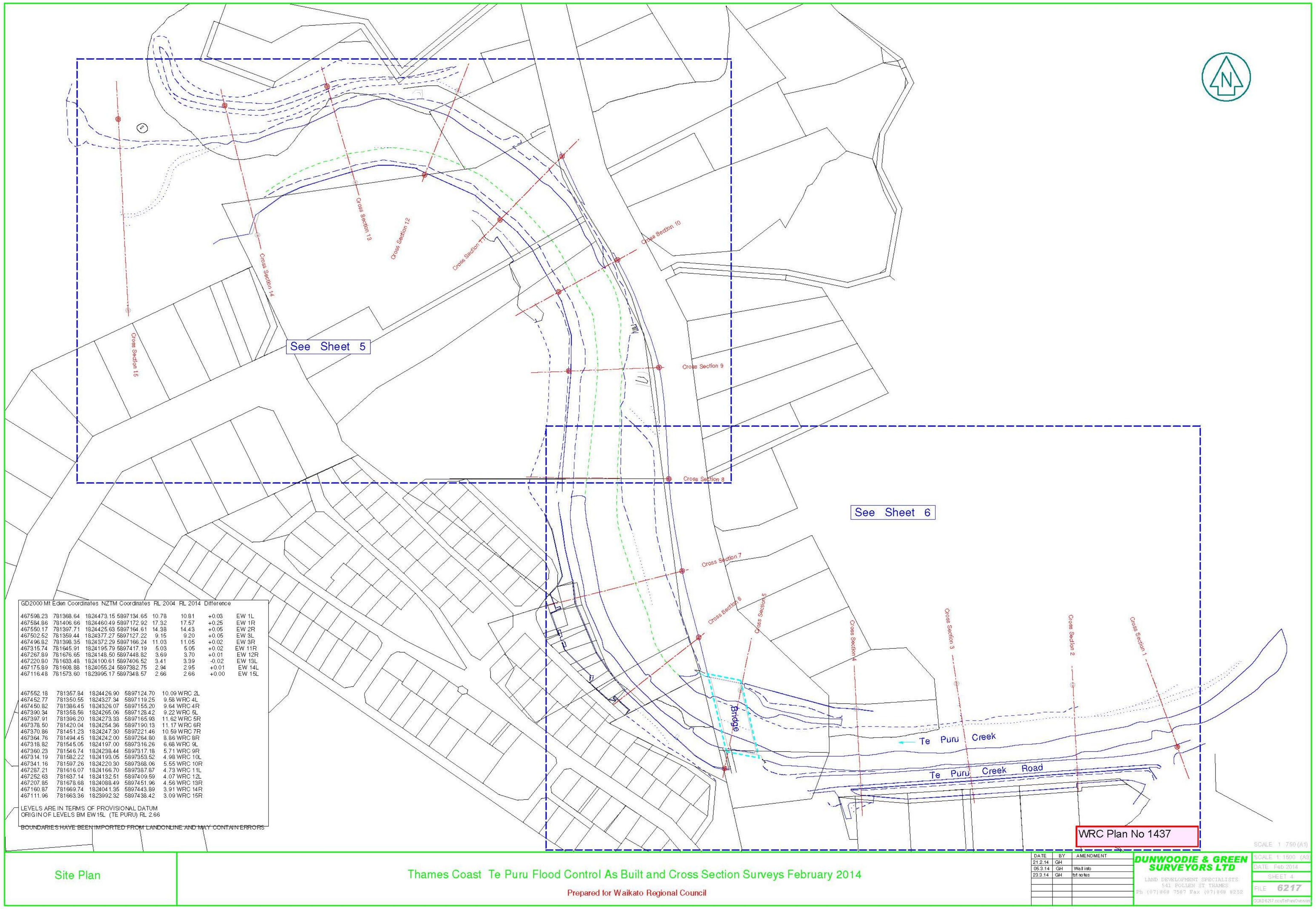
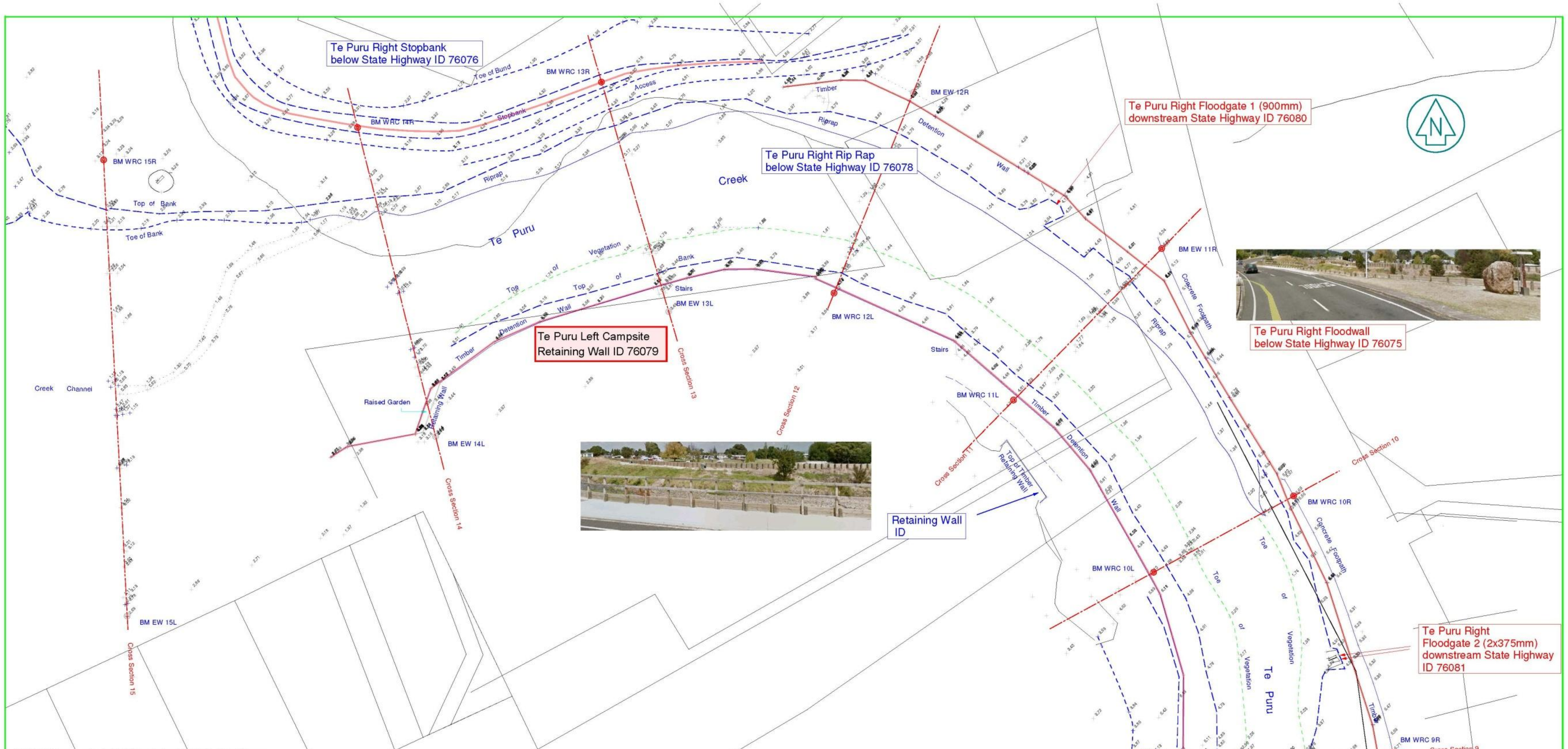


LOCATION PLAN
N.T.S
Site location
Location of proposed works
Te Puru
Waiwhero Stream
Pokopokorua Stream
Thornton Bay
TYPICAL SECTION
1:50
14000 O/A bridge deck
2500
1500
shoulder
3500 lane
3500 lane
1500
shoulder
1500
2120
1020
Proprietary handrail system subjected to engineer's approval prior to manufacture. Refer specification CL 6.12
50mm thick asphalt topping
Bridge deck see dwg 112
TL3 guardrail see dwg 119
Services on hanging brackets. Refer dwg 112
Super-T Beams 1500mm deep 200mm minimum insitu topping slab
Guardrail cast-in bracket Refer dwg 119 for locations
Note: E.O.S denotes edge of seal
SITE PLAN
1:200
Settlement slab
Abutment
Handrail
Bridge deck
Centreline
Guardrail
Te Puru Stream
To Coromandel
To Thames
IP. 1 CH -6.00
IP. 2 CH 30.00
25° Skew
Setout coordinates
IP No | Northing | Easting
IP.1 | 5897171.284 | 1824266.154
IP.2 | 5897136.097 | 1824273.764
SECTIONAL ELEVATION
1:100
36000
35m clear (33.3m approx skew dimension)
Off-bridge protection transition refer to highway design dwgs
Settlement slab see dwg 117
TL3 guardrail see dwg 119
Finished ground level
Minimum soffit level RL 10.26
100yr flood level RL 8.5
1.76m freeboard*
Super-T Beams 1500 deep see dwg 113
Abutment see dwg 114 to 116
Riprap to river banks under bridge. As required to Environment Waikato requirements.
* Freeboard allowance comprises of; 0.17m Super elevation 1.20m Table 2.2 of bridge manual 0.39m Climate change allowance
1200ø bored concrete piles see dwg 118
© Copyright Maunsell Limited, 2005.
This drawing is confidential and shall only be used for the purposes of this project.
A | DP | 25.06.08 | Issued for construction | DE
No. | BY | DATE | DESCRIPTION | APPD
Scales
As shown (A1)
DESIGNED WL CHECKED IM
DRAWN JL CHECKED WL
APPROVED DE DATE 25.06.08
MAUNSELL | AECOM
Maunsell Limited
TRANSIT NEW ZEALAND
ARARAU AOTEAROA
SH25 BRIDGE REPLACEMENTS
TE PURU BRIDGE
GENERAL ARRANGEMENT PLAN, ELEVATION & TYPICAL SECTION
CONSTRUCTION
60019014_111
A
J:\Dept_22\Bridges Hamilton\60019014 SH25 Coromandel\Te Puru\CAD\Working\60019014_111.dwg, Layout1, 25/06/2008 10:05:28 a.m., PDF-XChange 3.0

Appendix 7 As-built survey





GD2000 Mt Eden Coordinates		NZTM Coordinates		RL 2004	RL 2014	Difference	
467598.23	781368.64	1824473.15	5897134.65	10.78	10.81	+0.03	EW 1L
467584.86	781406.66	1824460.49	5897172.92	17.32	17.57	+0.25	EW 1R
467550.17	781397.71	1824425.63	5897164.61	14.38	14.43	+0.05	EW 2R
467502.52	781359.44	1824377.27	5897127.22	9.15	9.20	+0.05	EW 3L
467496.82	781398.35	1824372.29	5897166.24	11.03	11.05	+0.02	EW 3R
467315.74	781645.91	1824195.79	5897417.19	5.03	5.05	+0.02	EW 11R
467267.89	781676.65	1824148.50	5897448.82	3.69	3.70	+0.01	EW 12R
467220.80	781633.48	1824100.61	5897406.52	3.41	3.39	-0.02	EW 13L
467175.89	781608.88	1824055.24	5897382.75	2.94	2.95	+0.01	EW 14L
467116.48	781573.60	1823995.17	5897348.57	2.66	2.66	+0.00	EW 15L

467552.18	781357.84	1824426.90	5897124.70	10.09	WRC 2L
467452.77	781350.55	1824327.34	5897119.25	9.58	WRC 4L
467450.82	781386.45	1824326.07	5897155.20	9.64	WRC 4R
467390.34	781358.56	1824265.06	5897128.42	9.22	WRC 5L
467397.91	781396.20	1824273.33	5897165.93	11.62	WRC 5R
467378.50	781420.04	1824254.36	5897190.13	11.17	WRC 6R
467370.86	781451.23	1824247.30	5897221.46	10.59	WRC 7R
467364.76	781494.45	1824242.00	5897264.80	8.86	WRC 8R
467318.82	781545.05	1824197.00	5897316.26	6.68	WRC 9L
467360.23	781546.74	1824238.44	5897317.18	5.71	WRC 9R
467314.19	781582.22	1824193.05	5897353.52	4.98	WRC 10L
467341.16	781597.26	1824220.30	5897368.06	5.55	WRC 10R
467287.21	781616.07	1824166.70	5897387.87	4.73	WRC 11L
467252.63	781637.14	1824132.51	5897409.59	4.07	WRC 12L
467207.85	781678.68	1824088.49	5897451.96	4.56	WRC 13R
467160.87	781669.74	1824041.35	5897443.89	3.91	WRC 14R
467111.96	781663.36	1823992.32	5897438.42	3.09	WRC 15R

LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66

BOUNDARIES HAVE BEEN IMPORTED FROM LANDONLINE AND MAY CONTAIN ERRORS

Site Plan

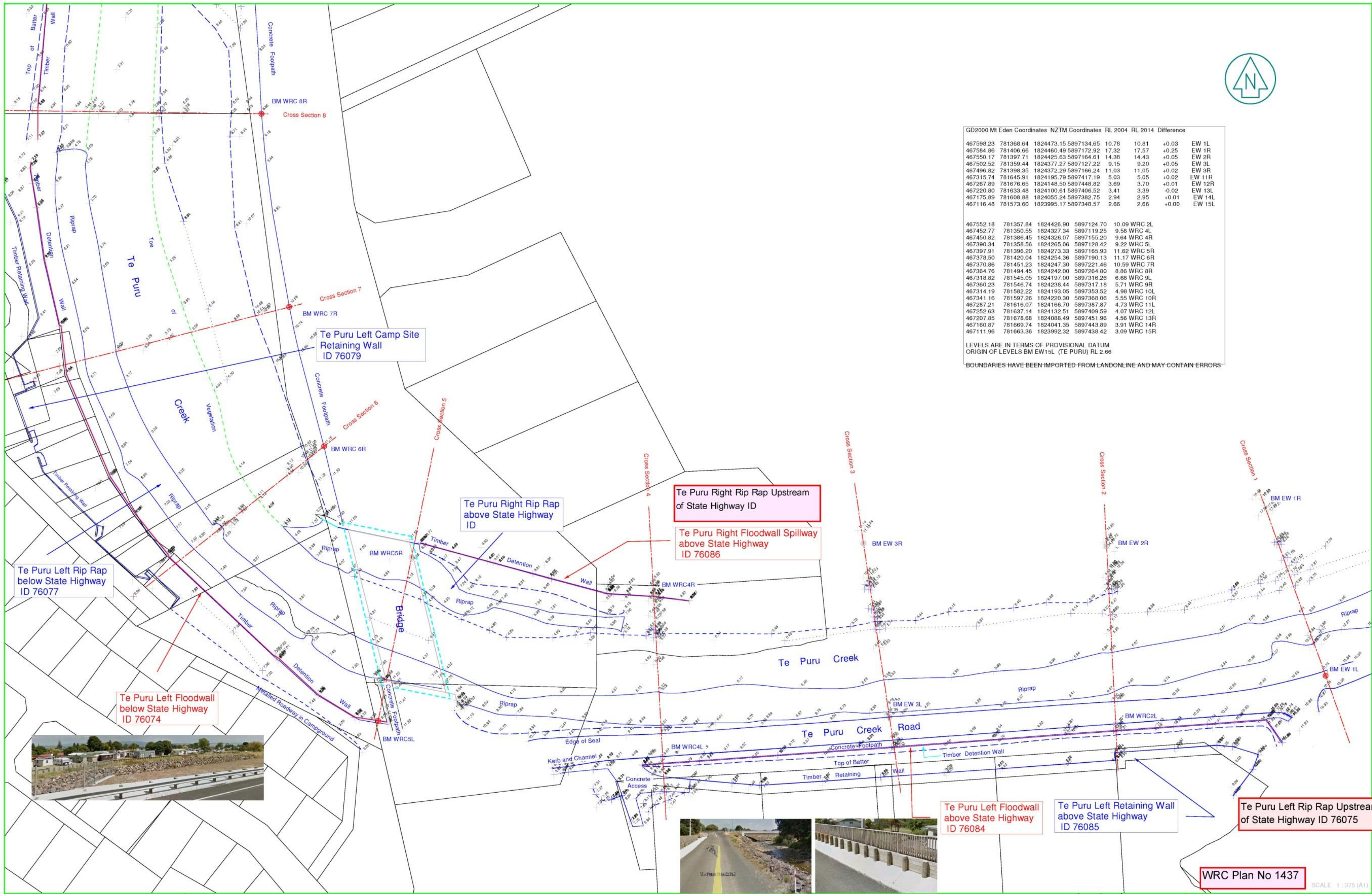
Thames Coast Te Puru Flood Control As Built and Cross Section Surveys February 2014

Prepared for Waikato Regional Council

DATE	BY	AMENDMENT
21.2.14	GH	
05.3.14	GH	Wall Data & Coords
23.3.14	GH	TXT NOTES
06.03.14	GH	Cross Sections 10-11

DUNWOODIE & GREEN SURVEYORS LTD
LAND DEVELOPMENT SPECIALISTS
541 POLLEN ST THAMES
Ph (07)868 7587 Fax (07)868 6252

SCALE 1:750 (A3)
DATE Feb 2014
SHEET 5
FILE 6217



GD2000 Mt Eden Coordinates		NZTM Coordinates		RL 2004	RL 2014	Difference	
467598.23	781368.64	1824473.15	5897134.65	10.78	10.81	+0.03	EW 1L
467584.86	781406.66	1824460.49	5897172.92	17.32	17.57	+0.25	EW 1R
467550.17	781397.71	1824425.63	5897164.61	14.38	14.43	+0.05	EW 2R
467502.52	781359.44	1824377.27	5897127.22	9.15	9.20	+0.05	EW 3L
467496.82	781398.35	1824372.29	5897166.24	11.03	11.05	+0.02	EW 3R
467315.74	781645.91	1824195.79	5897417.19	5.03	5.05	+0.02	EW 11R
467267.89	781676.65	1824148.50	5897448.82	3.69	3.70	+0.01	EW 12R
467220.80	781633.48	1824100.61	5897406.52	3.41	3.39	-0.02	EW 13L
467175.89	781608.88	1824055.24	5897382.75	2.94	2.95	+0.01	EW 14L
467116.48	781573.60	1823995.17	5897348.57	2.66	2.66	+0.00	EW 15L

467552.18	781357.84	1824426.90	5897124.70	10.09	WRC 2L
467452.77	781350.55	1824327.34	5897119.25	9.58	WRC 4L
467450.82	781386.45	1824326.07	5897155.20	9.64	WRC 4R
467390.34	781358.56	1824265.06	5897128.42	9.22	WRC 5L
467397.91	781396.20	1824273.33	5897165.93	11.62	WRC 5R
467378.50	781420.04	1824254.36	5897190.13	11.17	WRC 6R
467370.86	781451.23	1824247.30	5897221.46	10.59	WRC 7R
467364.76	781494.45	1824242.00	5897264.80	8.86	WRC 8R
467318.82	781545.05	1824197.00	5897316.26	6.68	WRC 9L
467360.23	781546.74	1824238.44	5897317.18	5.71	WRC 9R
467314.19	781582.22	1824193.05	5897353.52	4.98	WRC 10L
467341.16	781597.26	1824220.30	5897368.06	5.55	WRC 10R
467287.21	781616.07	1824166.70	5897387.87	4.73	WRC 11L
467252.63	781637.14	1824132.51	5897409.59	4.07	WRC 12L
467207.85	781678.68	1824088.49	5897451.96	4.56	WRC 13R
467160.87	781669.74	1824041.35	5897443.89	3.91	WRC 14R
467111.96	781663.36	1823992.32	5897438.42	3.09	WRC 15R

LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66

BOUNDARIES HAVE BEEN IMPORTED FROM LANDONLINE AND MAY CONTAIN ERRORS

SCALE 1 : 375 (A1)

Site Plan

Thames Coast Te Puru Flood Control As Built and Cross Section Surveys February 2014

Prepared for Waikato Regional Council

DATE	BY	AMENDMENT
21.2.14	GH	
06.04.14	GH	wall details and notes

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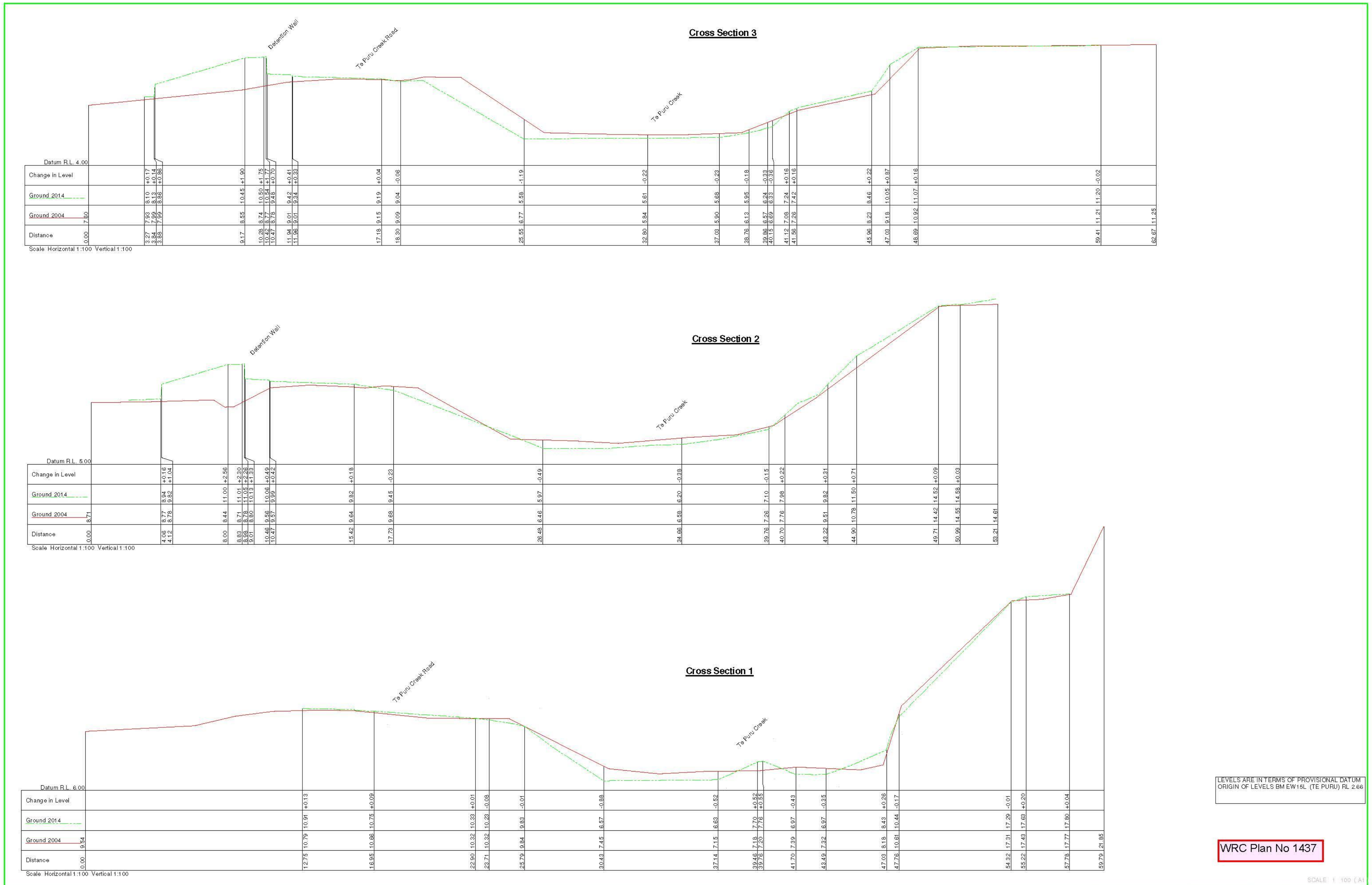
SCALE 1:750 (A3)
DATE Feb 2014
SHEET 6
FILE 6217
CCAD 6217.ccx/TePuruSite2



River Cross Sections

Thames Coast Te Puru Flood Control As Built and Cross Section Surveys February 2014

Prepared for Waikato Regional Council

DATE	BY	AMENDMENT
24.2.14	GH	
28.3.14	GH	TXT

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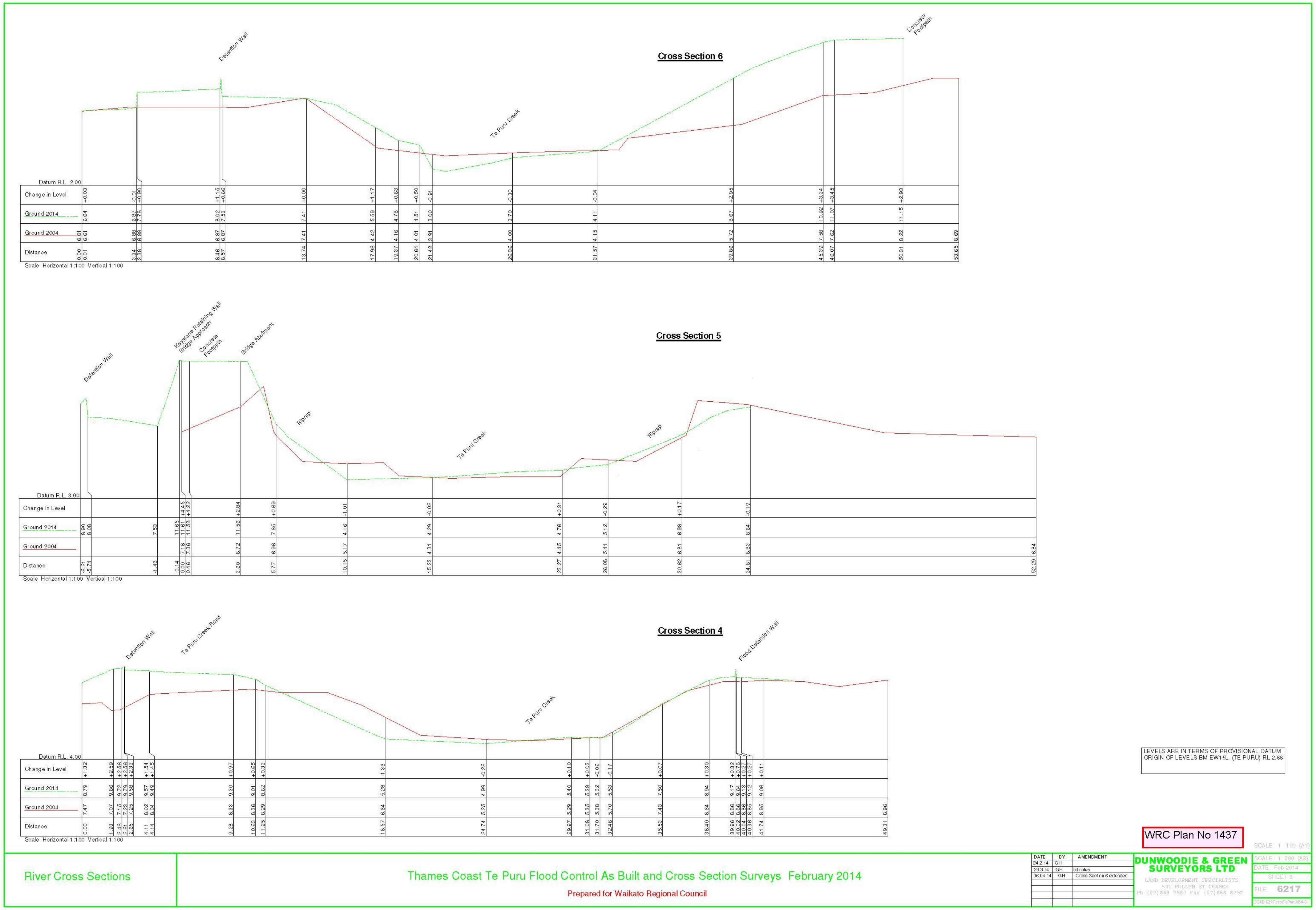
SCALE 1:100 (A1)
DATE Feb 2014
SHEET 7
FILE 6217



Cross Section 6
Detention Wall
Concrete Footpath
Te Puru Creek
Datum R.L. 2.00
Change in Level
Ground 2014
Ground 2004
Distance
Scale Horizontal 1:100 Vertical 1:100
Cross Section 5
Keystone Retaining Wall Bridge Approach
Concrete Footpath
Bridge Abutment
Riprap
Datum R.L. 3.00
Cross Section 4
Te Puru Creek Road
Flood Detention Wall
Datum R.L. 4.00
LEVELS ARE IN TERMS OF PROVISIONAL DATUM ORIGIN OF LEVELS BM EW16L (TE PURU) RL 2.66
WRC Plan No 1437
River Cross Sections
Thames Coast Te Puru Flood Control As Built and Cross Section Surveys February 2014
Prepared for Waikato Regional Council
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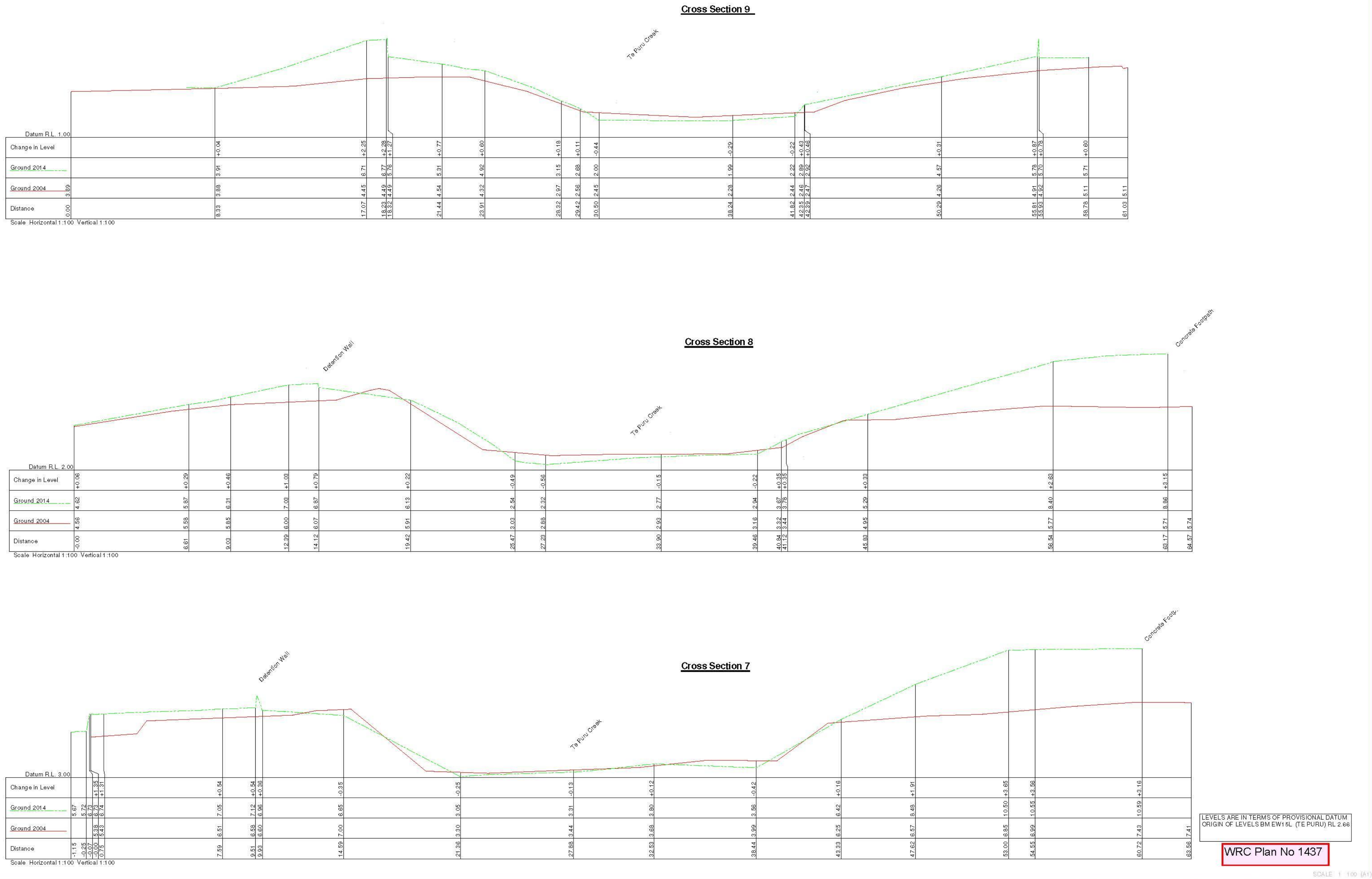
FILE 6217



LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66

WRC Plan No 1437

River Cross Sections

Thames Coast Te Puru Flood Control As Built and Cross Section Surveys February 2014

Prepared for Waikato Regional Council

DATE	BY	AMENDMENT
24.2.14	GH	
06.2.14	GH	CROSS SECTION 9
23.3.14	GH	txt notes
06.04.14	GH	Cross Section 7 extended

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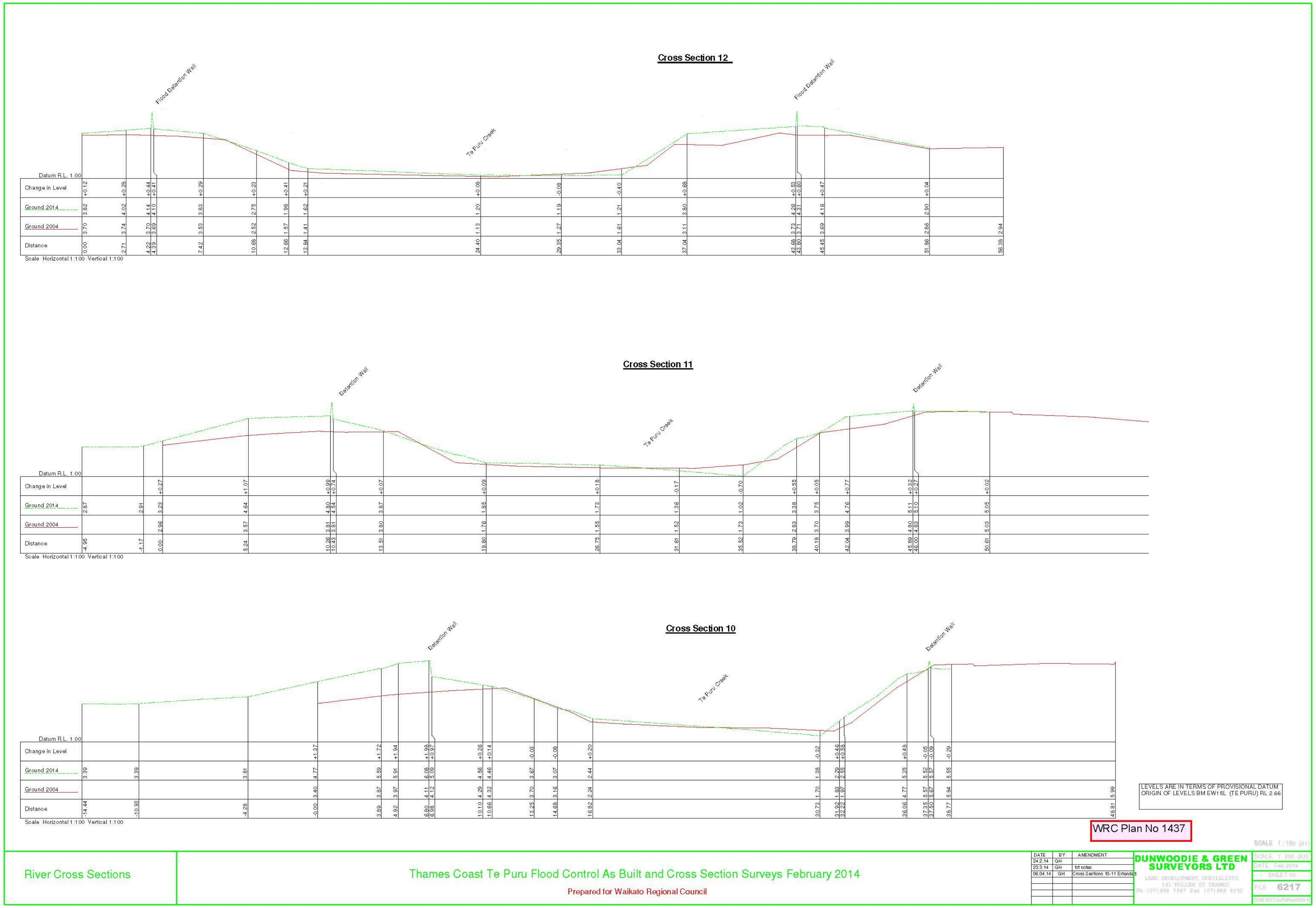
SCALE 1:200 (A3)
DATE Feb 2014
SHEET 9
FILE 6217


Cross Section 12
Flood Detention Wall
Te Puru Creek
Flood Detention Wall
Datum R.L. 1.00
Change in Level
Ground 2014
Ground 2004
Distance
Scale Horizontal 1:100 Vertical 1:100
Cross Section 11
Detention Wall
Te Puru Creek
Detention Wall
Datum R.L. 1.00
Change in Level
Ground 2014
Ground 2004
Distance
Scale Horizontal 1:100 Vertical 1:100
Cross Section 10
Detention Wall
Te Puru Creek
Detention Wall
Datum R.L. 1.00
Change in Level
Ground 2014
Ground 2004
Distance
Scale Horizontal 1:100 Vertical 1:100
LEVELS ARE IN TERMS OF PROVISIONAL DATUM ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66
WRC Plan No 1437
River Cross Sections
Thames Coast Te Puru Flood Control As Built and Cross Section Surveys February 2014
Prepared for Waikato Regional Council
DATE BY AMENDMENT
24.2.14 GH
23.3.14 GH txt notes
06.04.14 GH Cross Sections 10-11 Extended
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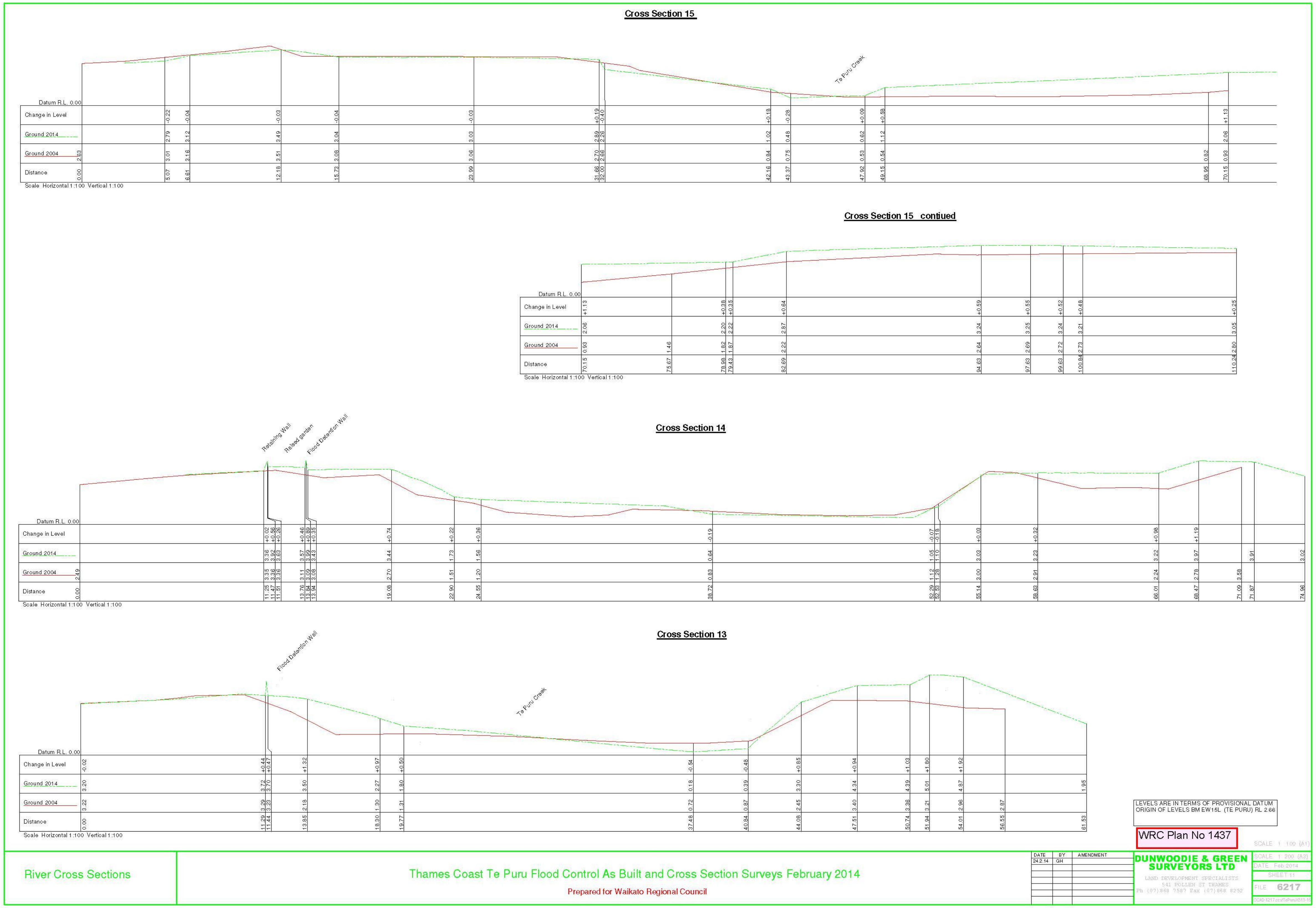
Cross Section 15
Te Puru Creek
Datum R.L. 0.00
Change in Level
Ground 2014
Ground 2004
Distance
Scale Horizontal 1:100 Vertical 1:100
Cross Section 15 contiued
Cross Section 14
Retaining Wall
Raised garden
Flood Detention Wall
Cross Section 13
LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66
WRC Plan No 1437
River Cross Sections
Thames Coast Te Puru Flood Control As Built and Cross Section Surveys February 2014
Prepared for Waikato Regional Council
DATE
BY
AMENDMENT
24.2.14
GH
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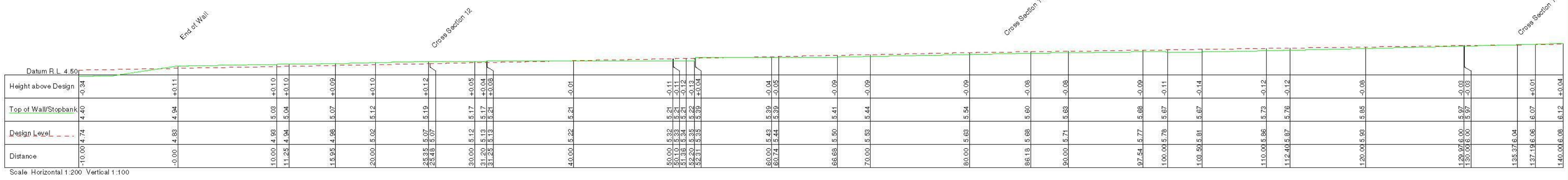
FILE 6217

Notes:
Design information calculated based on Design Levels at Cross Sections CS 13- CS8 shown on EW Te Puru Flood Protection Right Bank Floodwall Design 14/03/2011 Section A-B and Section B-C

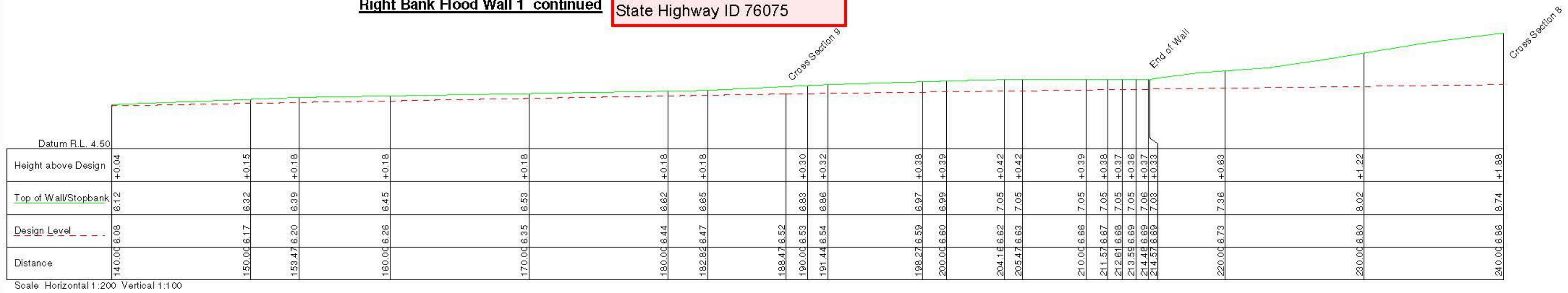
Right Bank Flood Wall 1

Te Puru Right Stopbank below State Highway ID 76075



Right Bank Flood Wall 1 continued

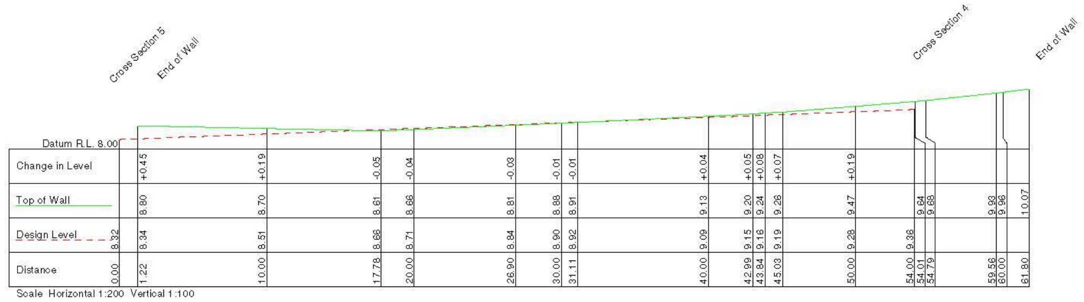
Te Puru Right Stopbank below State Highway ID 76075



Notes:
Design information calculated based on Design Levels at Cross Sections CS 5- CS4 shown on EW Te Puru Flood Protection Right Bank Floodwall Design 14/03/2011 Section D-E

Right Bank Flood Wall 2

Te Puru Right Floodway Spillway above State Highway ID 76075



LEVELS ARE IN TERMS OF PROVISIONAL DATUM ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66

WRC Plan No 1437

SCALE 1:200H 1:100V (A1)
SCALE 1:400H 1:200V (A3)

Right Bank Flood Walls 1 and 2 - Long. Sections

Thames Coast Te Puru Flood Control As Built and Cross Section Surveys February 2014

Prepared for Waikato Regional Council

DATE	BY	AMENDMENT
24.2.14	GH	
05.03.14	GH	SCALE
23.03.14	GH	notes

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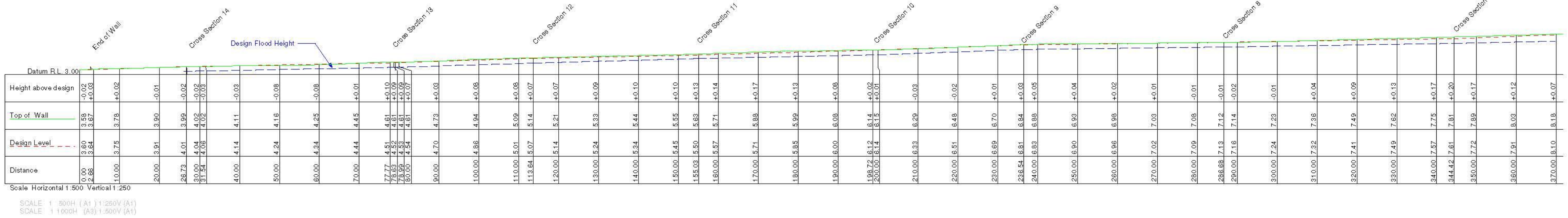
DATE Feb 2014
SHEET 12
FILE 6217

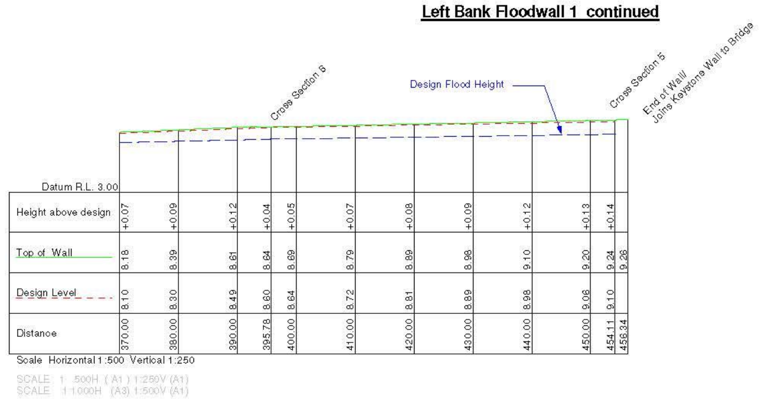
Notes:
Design information calculated based on Design Levels at Chainage 0.00 and Cross Sections CS 14 - CS5 shown on shown on Tonkin and Taylor Drawings 60926.001-400 60929.001-402 (all Revision B)

Left Bank Floodwall 1

Te Puru Left Floodwall below State Highway ID 76074



Left Bank Floodwall 1 continued

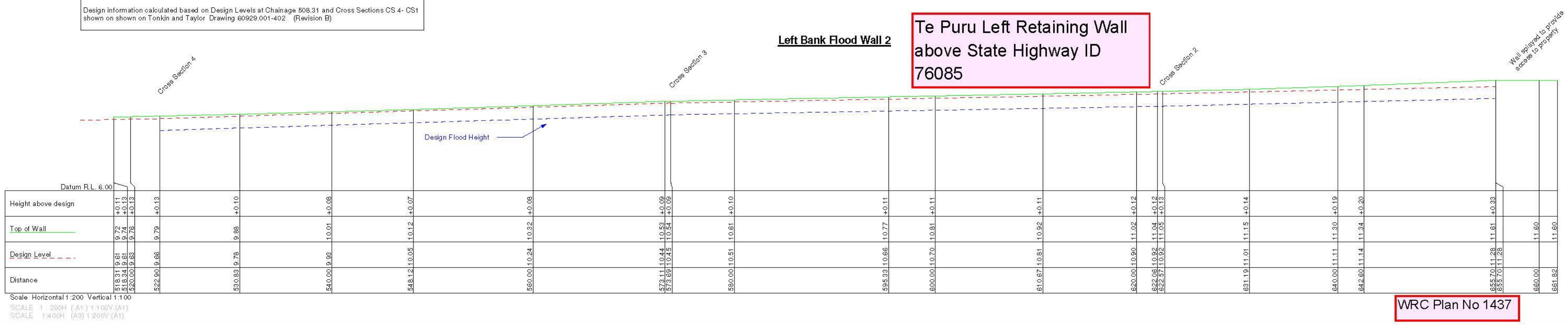


LEVELS ARE IN TERMS OF PROVISIONAL DATUM
ORIGIN OF LEVELS BM EW15L (TE PURU) RL 2.66

Notes:
Design information calculated based on Design Levels at Chainage 508.31 and Cross Sections CS 4 - CS1 shown on shown on Tonkin and Taylor Drawing 60929.001-402 (Revision B)

Left Bank Flood Wall 2

Te Puru Left Retaining Wall above State Highway ID 76085



WRC Plan No 1437

Left Bank Flood Walls 1 and 2 - Long. Sections	Thames Coast Te Puru Flood Control As Built and Cross Section Surveys Prepared for Waikato Regional Council	DATE / BY / AMENDMENT 24.2.14 GH 5.2.14 GM LEFT BANK FLOOD WALL 1	DUNWOODIE & GREEN SURVEYORS LTD FILE 6217