

**KAITUNA RIVER REDIVERSION AND  
ONGATORO/MAKETŪESTUARY ENHANCEMENT  
PROJECT**

**SUMMARY OF EFFECTS RESULTING FROM WATER  
LEVEL CHANGES**

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## 1 INTRODUCTION

The proposed Kaituna River Re-diversion and Ongatoro/Maketū Estuary Enhancement Project (the Project) will alter the existing regime of water levels in the lower Kaituna River (the River) and in the Ongatoro/Maketū Estuary (the Estuary). The effects of the Project on water levels in the estuary and in the lower river have been investigated by DHI in a comprehensive numerical modelling study<sup>1</sup>.

This report summarises the existing environment in the lower Kaituna River and in the Ongatoro/Maketū Estuary and explains the operation of the drainage and flood protection scheme. It also summarises changes caused by the Project in water levels under normal day-to-day operations and during high rainfall and assesses the effects on land drainage, water supplies and rural stopbanks.

## 2 DEFINITIONS

The following abbreviations and definitions are used in this report:

RL – Reduced Level. This indicates that the levels stated are relative to Moturiki Datum, being RL 0m, and approximately equal to mid tide level in the open sea.

AEP – Annual Exceedance Probability. By way of example an event with an AEP of 1% has a probability of 1/100 of occurring or being exceeded in any one year. Similarly an event with an AEP of 5% has a probability 1/20. These are often referred to as the 100 year and 20 year events respectively.

## 3 EXISTING ENVIRONMENT

The Kaituna River catchment is 125,000 hectares in size and encompasses Lakes Rotorua and Rotoiti as well as a number of tributaries from the hill country around Te Puke. About half the catchment lies below the outlet of Lake Rotoiti where a structure known as the Okere Gates controls lake levels and river flows. The river at Te Matai has a mean flow of 36 m<sup>3</sup>/s and a 1% AEP flow estimated at 410 m<sup>3</sup>/s (DHI 2014).

The lower Kaituna catchment area includes a large, low-lying alluvial plain, extensive sand dune ridges to the west and higher ground rising to the rocky Okurei Point where Maketū Township lies. Much of the land is low relative to both river and sea levels. It is therefore vulnerable to flooding and relies on flood protection and an effective drainage system for its current land uses. These uses are predominantly dairy farming on the alluvial plain and housing on the low-lying land at Maketū.

Historically, the lower catchment was predominantly wetland known as the Kawa Swamp. This wetland was progressively drained and cleared from the 1800s, although the farmland created was affected by significant and regular floods, including especially large events in 1907 and 1951. Parts of the area were inundated by floods on average twice per year and most of the plain was inundated during a 10% AEP flood event (Campbell, 2002).

These floods and associated drainage problems led to the creation of two River Boards and eventually to the present-day Kaituna Catchment Control Scheme (the Scheme) operated by Bay of Plenty Regional Council. In 1956 the River Board diverted the Kaituna River out to sea at Te Tumu and thereby almost completely cutting the River off from the Estuary (there was some seepage and stopbank over-topping on spring tides).

These works had the effect of lowering river and estuary water levels, particularly at low tide, and therefore improving gravity drainage opportunities. Flood peaks were also lowered by these works. Significant river-straightening, stopbanking and drainage works occurred during the 1970s and 1980s which form the basis for the Scheme as it operates today. The Scheme

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<sup>1</sup> Kaituna River Rediversion and Ongatoro/Maketu Estuary Enhancement Project, Numerical Modelling, DHI 6<sup>th</sup> June 2014

is largely funded by targeted rates on those whose land benefits, with the balance funded from general rates collected by Bay of Plenty Regional Council.

The Scheme Objectives (Levels of Service) are:

1. Security from floods of up to the 1% AEP in the Kaituna Basin. The 1% AEP event is the worst case from the two following scenarios (the numbers 3 and 4 are used for consistency with the DHI report):
  - Scenario 3: 1% AEP River Flood combined with a 5% AEP Sea Flood
  - Scenario 4: 1% AEP Sea Flood combined with a 5% AEP River Flood
2. Provision of satisfactory drainage for the Kaituna Basin by:
  - Clearing floodwater off farmland, generally to a 3 day 20% AEP standard (37.5mm per day). This is achieved primarily by gravity drainage out of flapgated culverts into the Kaituna River and Ongatoro/Maketū Estuary.
  - Maintaining water levels in the drains between RL-0.1m and RL-0.3m. This is achieved primarily by pumping.

The Scheme assets in the lower Kaituna catchment area of interest to the Project are shown in Appendix 1. These consist of:

- 67 kilometres of stopbank.
- 88 kilometres of canals and drains.
- Seven pump stations (and 14 pumps).
- Three weir structures.
- Five major floodgate structures.
- Riverbank protection - six kilometres of planting and 1.5 kilometres of rock or rubble.
- Mole/groyne structure at the river mouth.

Flood events in the Kaituna River are influenced by the control gates at Lake Rotoiti. Storage of floodwater in lakes Rotorua and Rotoiti have the effect of attenuating peak flows in the lower catchment but sustaining high flows over a longer period than would otherwise be the case. Flood peaks are also influenced by the short and steep tributaries surrounding Te Puke, particularly the steep Mangorewa and Raparapahoe catchments which contribute a relatively large proportion of peak flows.

The greatest determinant of peak water levels in the lower River and Estuary is the level of the sea during high spring tides, especially if combined with low pressure systems and storm surge. Large areas of land are regularly subjected to surface flooding during rainfall events.

Since 1996 the Department of Conservation has re-diverted some 5% (approximately 150,000 m<sup>3</sup> per mean tidal cycle) of the Kaituna River's flow back into the Estuary via four culverts leading into Ford's Cut. These culverts also allow a proportion of flood flows to enter the Estuary.

An assessment of the extent to which the Scheme meets its Objectives (or provides the specified Levels of Service), was provided for Bay of Plenty Regional Council by Campbell (2002):

1. In general terms, the greater part of scheme objectives appear to have been met.
2. Flooding from the river or major canals in the area protected to 1% AEP appears unlikely to occur in a design storm event.

3. As in all schemes, there are areas which sustain ponding from time to time, caused by internal catchment run-off as being distinctly separate from river or canal flood flows.
4. Some problems have been encountered with urban floodwater, but this is expected to be improved by works budgeted for the current financial year [1999].
5. Flooding has occurred in the small compartments above State Highway 2, but this to be expected, given the lower design level of protection.
6. Some minor extensions to the maintenance area have recently been initiated, in the Ohineangaanga, Waiari and Raparapahoe Streams.
7. Drainage in the Kaituna Basin generally appears to be satisfactory for the predominantly dairy farming use of the land. There is one property in particular towards the eastern end of the Kaituna Road which has not received satisfactory service from the pumped outlet, and where a private pump has been recently installed to augment scheme flood-gated drainage.

Note that flood protection and drainage at Maketū Township are not provided by the Scheme. These services, to the extent that they exist, are provided by the Western Bay of Plenty District Council in Maketū Township.

The following sections describe flooding and drainage assets and their operation in three separate areas (shown below on Figure 1 and detailed where appropriate in the Appendices).



Figure 1: Areas where the effects of the Project on flooding and drainage are described in this report.

### 3.1 Existing flood risk to land protected by the Scheme

The land surrounding the lower Kaituna River and Ongatoro/Maketū Estuary is classified as a flood hazard zone in the Operative Western Bay of Plenty District Plan as shown in Appendices 2, 3 and 4. However, the land (except the land within Maketū Township) is protected from River and Estuary flooding by Scheme stopbanks and flap-gated culverts as shown in Appendix 1.

These stopbanks are designed to protect land from inundation during 1% AEP flood events plus freeboard<sup>2</sup>.

The stopbanks around the estuary have a design crest level of RL 2.74m and the stopbanks along the lower River have a design crest level of RL 3.2m. DHI (2014) have modelled the peak water levels in the Estuary as RL 1.60m for scenario 3 and RL 2.00m for scenario 4. DHI have also modelled the peak water levels in the lower River (at the Ford Rd Drain outlet) as RL 2.44m for scenario 3 and RL 2.21m for scenario 4.

When the effects of climate change (as recommended by the Ministry for the Environment) are included, the modelling predicts peak water levels during a 1% AEP flood event of up to RL 2.53 m in the Estuary and RL 2.90m in the lower River at the Ford Rd Drain outlet.

The recent flood event in June 2014 was approximately a 20% AEP and river levels did not threaten to overtop any of the stopbanks in the Project's area of interest.

The modelling provides strong evidence that the stopbank levels are sufficient to provide protection from the two design flood scenarios with the existing situation (ie disregarding the effects of the Project).

### **3.2 Existing flood risk to land in Maketū Township not protected by the Scheme**

Some of Maketū Township is at risk of flooding and identified in the Operative Western Bay of Plenty District Plan (2012) as a flood hazard zone in Maps U152 and H13. This land is not protected by the Scheme from River and Estuary flooding and is reliant on natural high ground, Maketū Rd and private works for protection. Parts of Maketū Township are inundated when the Estuary water level exceeds RL 1.60m is predicted by DHI to occur potentially during scenario 3 and definitely in scenario 4. This land is currently at risk of inundation from high sea levels more frequent than the 1% AEP based on the District Plan which uses a 2% AEP flood event plus an allowance for climate change as the criterion for flood hazard zone classification.

What this means is parts of Maketū are already at risk of flooding from water levels in the Estuary during high sea levels.

### **3.3 Existing flood risk to land north of Ford's Cut**

There is a section of land at the upper (western) end of the estuary lying directly to the north of Ford's Cut that is not protected by Scheme assets (the Brain land). It does have some private stopbanking around the estuary edge and also provided by two causeways in the estuary. These are the causeways between the Brain land and Papahikahawai Island and between the island and Maketū spit. These banks have a crest level of between RL 1.7m and RL2.0m and this land is at risk of flooding if the river is high but more so if the estuary is high during high sea levels as for Maketū Township.

### **3.4 Drainage of land around River and Estuary within the Scheme**

Drainage of water from the farmland adjacent to the lower river and the estuary relies on the Kaituna Flood Protection and Drainage Scheme which comprises a network of open drains, and gravity and pumped outlets to the river and estuary (Appendix 1).

During dry weather the groundwater from within the farmland enters these drains and flows under gravity through culverts during low tides out to the river and the estuary. When the tide rises water is prevented from entering the drains by flapgates that close as the downstream water level rises (see Figure 2 below).

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<sup>2</sup> Freeboard is extra height added to the top of stopbanks to allow for uncertainty of analysis and unexpected water level increases

At some drain outlets (Diagonal Drain, Ford Rd, Dean and Singleton) there are pumps that begin to operate as the water levels rise in the drains. These levels are quite low in order to keep water levels in the farmland low enough for efficient farming. The pumps switch on when the water reaches RL-0.1m and will continue to operate until the water level drops to RL-0.3m. Therefore these pumps operate 3 or 4 times per day on a continuous basis to maintain these levels.

The power cost to operate these pumps in the 2013-2014 year was \$16,200 for the Ford Rd pumpstation and \$3,500 for the Singleton Pumpstation. No cost has been obtained for the privately owned Dean Pumpstation but based on comparisons with the other two sites power costs have been estimated at \$1000 per year.

When rain falls on the farmland more water enters these drains and flows to the estuary in the same way. If the rain is so heavy that water can't enter the river or estuary fast enough the water builds up in the drains and waits to discharge as the rain eases. The pumps will commence operation.

An upgrade of the capacity of the Ford Rd Pumpstation is currently planned by the Regional Council.



*Figure 2 Outlet end of Ford Rd Drain to river showing drain (upstream) side on left and river (downstream) side on right. In the left hand photo the pumpstation and its intake grill can be seen to the right of the culverts. At this time the river level was high and the flapgates were closed*

### **3.5 Drainage of land in Maketū Township**

In locations where the natural land surface is not high enough and slopes to the estuary, there are some open drains and streams that discharge under Maketū Rd through two flapgated culverts. These operate under gravity as described above and there are no pumpstations.

*Otumakoro Stream* - The area just upstream of this culvert under Maketū Rd at Spencer Ave floods at present during heavy rain. The culvert is a 900mm diameter concrete pipe with a downstream flapgate to prevent high estuary levels reaching upstream. The catchment drained has an area of about 1.4km<sup>2</sup> and is a combination of housing, roads and grassland. Estimates of flow from the catchment compared to the size of the culvert indicate it is well undersized, unable to cope with the flow and is a major cause of the flooding experienced by adjacent landowners.

### **3.6 Drainage of land north of Ford's Cut**

The Brain land has a series of open drains leading to one pumpstation discharging to the river under Ford Rd. This land is very low and flat and poorly drained (see Figure 3).



Figure 3 Brain land. In the right hand photo can be seen the green pumpstation discharging under Ford Rd to the river.

#### 4 EFFECTS OF THE PROJECT ON THE LOWER RIVER

The lower river is defined as that from the outlet of Diagonal Drain downstream to Te Tumu and includes the new section of channel down to Ford Rd Pumpstation. This is shown in Figure 4 below which has been extracted from the DHI report which also shows points of reference used by DHI. The Ford Rd Pumpstation is Point 3.



Figure 4 The lower river and points used for water level comparisons (from DHI Figure 8-8)

##### 4.1 Normal River Flow

By increasing the size of the channel and the number of culverts from the river to the estuary, the Project has the effect of releasing water faster from the lower river. On a day-to-day basis when the river is not in flood or not very low, referred to as “usual” flows, the river level is slightly lower during high tides due to this release. During low tides there is no change near Diagonal Drain outlet (Point 1 in the river) but is higher at Fords Rd Drain outlet (Point 3 in the river) because more water has been allowed to flow past this point. The following figures 5 and 6 show these effects for two different locations in the river over a 15 day tidal cycle. Figure 5 is for Point 1 in the river and the water level changes indicated are less than 20mm i.e. there

is only a minor change seen in the high tide levels. Figure 6 is for Point 3 in the river and the higher low tide is seen between the red and blue line.

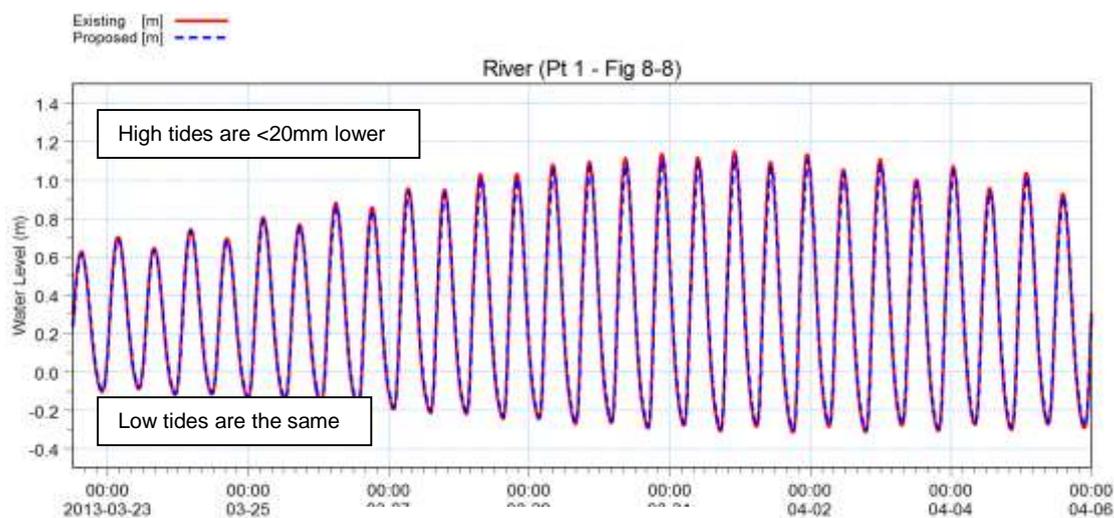


Figure 5 Point 1 in the river

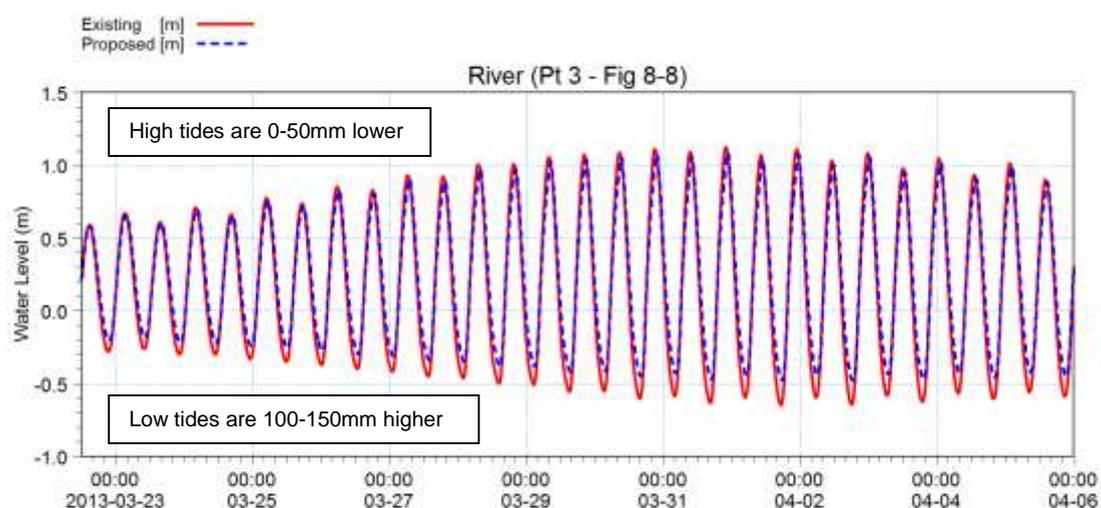


Figure 6 Point 3 (Ford Rd pumpstation)

Detailed analysis of the capacity of the culverts and the pumpstations at the outlets of the drains has been undertaken (see Appendix 6).

It has been concluded that the water level increases caused by the Project will reduce the flow rates through the culverts and increase the time the pumps have to operate to maintain the desired water levels in the drains. Mitigation options are discussed below.

## 4.2 Heavy Rain on the Farmland

The effect of heavy rain on the adjacent farmland under the existing situation has been described above i.e. drain flows increase and rely on low water levels in the river to drain out and the pumping systems. Along this reach of river the two key drain outlets are Diagonal Drain and Ford Rd Drain. At Diagonal Drain the Project does not change the river water level at low tide and slightly lowers it at high tide. Therefore there will be no change in gravity or pumped drainage from this outlet and there may even be a small benefit due to the lower high tide.

At Ford Rd Drain outlet the high tide is lower so there will be no change during these periods. However the low tide will be higher. This change and its effect on drain flows has been investigated in detail by looking at the flow characteristics of the outlet (Appendix 6).

It has been concluded that the water level increases caused by the Project will reduce the flow rates through the culverts and increase the time to drain the farmland. Mitigation options are discussed below.

### 4.3 High River Flow and Stopbanks

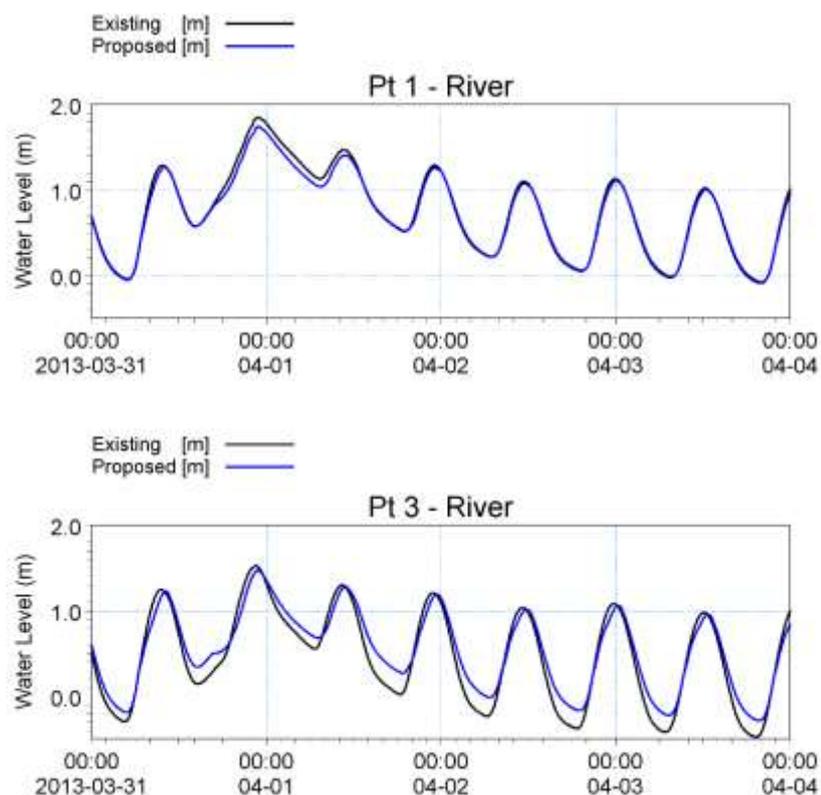
Section 8.2 of the DHI report provides results for six flood scenarios and the resulting water levels at the four different locations shown in Figure 4 above. The six flood scenarios are various combinations of high river flows and normal and high sea levels, with and without climate change increases.

In all cases the peak water level drops in the lower Kaituna River. Flood waters coming down the river are able to escape more easily through the larger channel and culverts to the estuary in addition to the river mouth at Te Tumu (DHI has undertaken morphological studies that conclude the river mouth will remain at its existing flood release capacity (DHI Section 7)).

In conclusion there is no adverse effect on the stopbanking system along the river.

### 4.4 High River Flow and Land Drainage

This situation occurs when there has been heavy rain throughout the catchment that raises the river levels and floods the farmland and raises the water levels in the drains. The drains are at full capacity and rely on low water levels in the river to discharge their flows. The pumps are also in operation. The scenario investigated is that required by the Scheme e.g. a 20% AEP flow (1 in 5 year) in the river combined with a 20% AEP sea level. DHI have modelled this scenario and provided information on water levels in the river as a result of the Project. The results are shown in Figure 7 below.



*Figure 7 Water Levels now and proposed in the Lower River during a 20% AEP flood in the river and a 20% AEP sea level Point 3 is the Ford Rd drain outlet at which can be seen the slight peak taken off the flood and the higher low tides as the flood recedes.*

At the Ford Rd Drain outlet the peak water level in the river is reduced and the subsequent high tide levels stay the same. There will be no effect on drain flows at these times and in fact they will beneficially increase. However, the mid and low tide water levels are higher. This increase and its effect on flows out of the culverts and pumpstation has been investigated in detail (Appendix 6).

It has been concluded that the water level increases caused by the Project will reduce the flow rates through the culverts and increase the time to drain the farmland. Mitigation options are discussed below.

#### **4.5 Low River Flows**

Investigations by DHI have confirmed that water levels in the river during low river flows will be lowered by the Project. A 5-year 7-day low flow was modelled. During this period the Project causes the water levels to be lower in the river but magnitude of lowering is not large (approximately 5cm) under the worst circumstances. However, lower water levels have the potential to adversely affect water supplies drawing from the river.

Three water supplies rely on river water as follows:

- Mr Allan Titchmarsh's stockwater supply and irrigation water supply – these extract water from the river via two floating intakes just upstream of the inlet to the new diversion channel. There is no effect on the ability of these supplies to take the volumes required but there is a higher chance of extracting saline water. This will be mitigated by providing Mr Titchmarsh with a salinity monitoring device on his intakes and an additional storage tank for his stockwater.
- The Lower Kaituna Wetland Management Reserve – during dry spells when river flow is low, the Reserve relies on spring high tide water levels for water through three intakes of flapgated culverts. In their Section 9.2 DHI report that during low flows in the river the spring high tides are reduced and, over a spring tide cycle, the volume into the wetland will reduce by about 10%. DHI has suggested installing a second culvert at Intake No 2 of 900mm diameter with an invert at RL-0.5m. This has been tabled with the stakeholders (DOC, Fish and Game and BoPRC Nat Hazards) and it forms the basis of discussions and further analysis. There is an indication from some of the stakeholders that the location may be of greater benefit to the wetland if it is further upstream.

#### **4.6 Conclusions**

In the lower river down to the Ford Rd Drain outlet the effects of the Project are:

- During normal river flows there will be slightly higher low tides and lower high tides and the changes will be magnified during river floods.
- There will be longer periods of higher mid and low tides after the flood peaks.
- The pumps maintaining the low levels in the Ford Rd will operate for up to 10% longer
- The farmland will take longer to drain
- There will be 10% less water entering the Lower Kaituna Wetland Management Reserve.

## 4.7 Proposed Mitigations for Effects on the Lower River

The mitigation options proposed below are subject to final detailed design in consultation with scheme stakeholders. However the mitigation options are available and have been agreed in principle with the manager of the Scheme, the Natural Hazards Group of the Bay of Plenty Regional Council, and with the stakeholders in the Lower Kaituna River Management Reserve.

### 4.7.1 For Project Effects on Farmland Drainage Around the Lower River

To mitigate the increased running costs at the Ford Rd Pumpstation brought about by increased pumping times, the Project will contribute to upgrades already planned by the Scheme for the increase calculated from the detailed investigations.

To mitigate the reduce flow under gravity through the culverts draining into the river at Ford Rd the Project will fund the additional capacity required that is attributable to the additional effect of the Project. This will consist of a contribution for the upgrade already planned and this work will be completed prior to commissioning of the Project.

### 4.7.2 For Project Effects on the Lower Kaituna Wetland management Reserve

To mitigate the lower volumes of water able to flow into the Lower Kaituna Wetland Management Reserve a new culvert will be installed. The exact size and location will be agreed with the stakeholders and certified by the council. The installation will be designed to mitigate the reduced water volume.

### 4.7.3 For Project Effects on Water Intakes

To mitigate the higher risk of saline water at the water supply intake of Mr Titchmarsh the Project will provide and install a salinity monitoring device.

## 5 EFFECTS OF THE PROJECT ON THE ESTUARY AND MAKETŪ TOWNSHIP

As a result of the improvements at Fords Cut the estuary will fill up slightly faster with water from the river, less water will come in from the open sea and the estuary levels will be slightly higher. The area discussed in this section is shown in Figure 8 below, extracted from the DHI report, which also shows points of reference used by DHI. The Singleton Pumpstation is near Point 4 and the Maketū Township is near Point 5. There are other farm drain outlets along the stretch of estuary shoreline between Points 1 and 4.

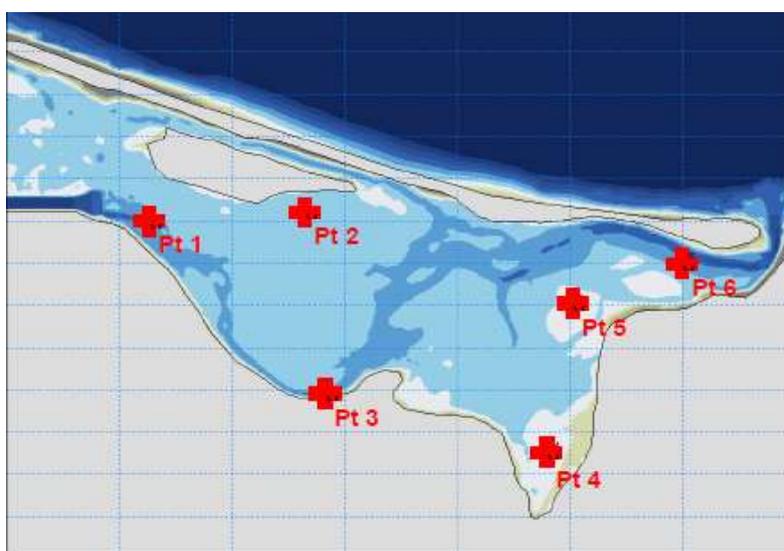


Figure 8 The estuary and points used for water level comparisons (from DHI Figure 8-6)

There are two areas investigated in this section:

- The farm land drained out of Singleton Outlet and by inference the other gravity drain outlets around the estuary from the farmland.
- The land drained out of Maketū Township particularly from the Otumakoro Stream.

## 5.1 Normal Conditions

Normal conditions are those that exist on a day-to-day basis i.e. the “usual” situation (with no rain events or high flows etc). Figure 9 below show the water levels in the estuary over a 15 day tidal cycle both before and after the Project. It can be seen that water levels are slightly higher because the flow from the river into the estuary increases as a result of the Project. Detailed analysis at the Otumakoro, Burgess and Singleton outlet has been undertaken to understand the effect of the Project on the drainage from this and similar outlets.

There is no effect on the flow from Otumakoro Stream because the culvert size controls this flow not the downstream water level in the estuary.

At the Singleton outlet, it has been concluded that the water level increases caused by the Project will reduce the flow rate through the culvert and increase the time the pumps have to operate to maintain the desired water levels in the drains (Appendix 6). Mitigation options are discussed below.

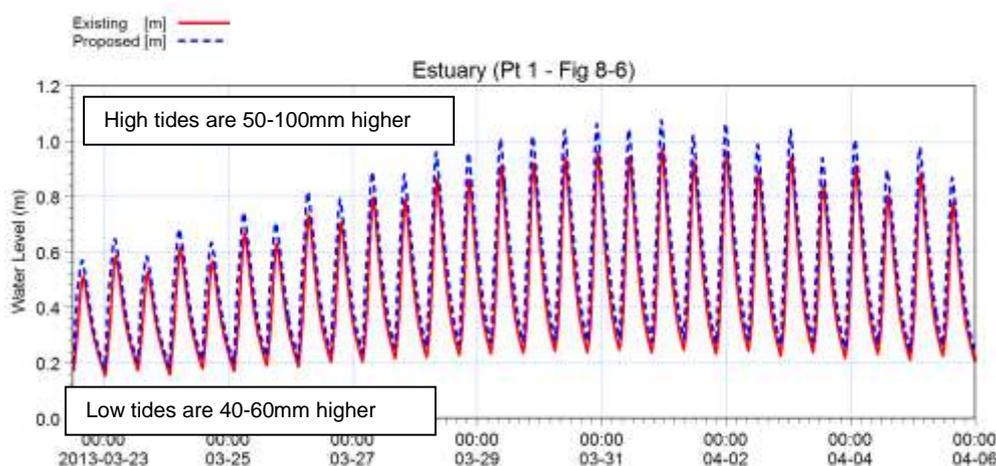


Figure 9 Water Levels in the Estuary

## 5.2 Heavy Rain on the Land

The effect of heavy rain on the adjacent farmland under the existing situation has been described above i.e. drain flows increase and rely on low water levels in the estuary to drain out. The effect of the Project is to raise the downstream water levels in the estuary.

### 5.2.1 Singleton Outlet

Detailed analysis of the Singleton Pumpstation and gravity outlet has been undertaken (Appendix 6).

It has been concluded that the water level increases caused by the Project will reduce the flow rate through the culvert and increase the time the pumps have to operate to maintain the desired water levels in the drains. Mitigation options are discussed below.

### 5.2.2 Otumakoro Stream

The effect of higher estuary water levels has been investigated as it relates to drainage out of the catchment above Spencer Ave (Otumakoro Stream) in Maketū township. Under normal day-to-day flows of less than 1 cumec through the culvert, there is no effect of the raised water levels in the estuary.

During heavy rain in the local Maketū catchment an estimate of peak rainfall runoff has been made using the Rational Method using a Time of Concentration of 20 minutes and a 2%AEP (50yr) rainfall event generated by HIRDS (with a 2% increase for climate change). The catchment has been split into 90% grass and 10% impermeable roofs, roads etc. The peak flowrate has been estimated at 15 cumecs.

The geometry of the culvert and road crossing has been obtained from WBOPDC and the peak flowrate has been used to determine present headwater levels. A constant tailwater level has been assumed being estuary water level. Analysis confirms the observations that the culvert is not large enough to pass this flow and the stream overtops Maketū Rd. The resulting headwater level is estimated at RL 1.8m and will cause flooding of adjacent properties. This is consistent with observations made on site most recently on the 18<sup>th</sup> April 2014.

Assuming this culvert remains in place an estimate has been made of the effect of the higher water levels in the estuary resulting from the Project on the headwater level upstream of this culvert. This comparison has been made for 3 scenarios:

- Normal high tide.
- Estuary water level resulting from a 5%AEP flood in the river (DHI Scenario 2).
- Estuary water level resulting from a 5%AEP flood in the river combined with a 1%AEP sea level (Scenario 4).

In the first two scenarios the higher estuary water levels has no effect on the headwater level upstream of the culvert. In the third scenario the water level rises 5cm lifting the upstream water level from RL1.80m to RL1.85m. The incremental effect of this rise on the flooding already occurring upstream is negligible.

A larger culvert crossing has also been analysed as a preliminary indication of the size ultimately required. A large rectangular crossing was assumed, effectively a bridge, of 10 metres span and 1 metre water way height. It is also assumed Maketū Rd crest will be raised to RL1.9m and the downstream channel to the estuary is widened. The same three scenarios was used and the same result was recorded i.e. 5cm rise in the worst case.

It is concluded that the Project has a less than minor effect on the capacity of the existing culvert under Maketū Rd at Spencer Ave. If the culvert is to be replaced then its capacity needs to take into account the water levels caused by the Project in existence at the time it is upgraded (ie including any increased levels attributable to the Project's operations).

### 5.3 High Estuary Water Levels and Stopbanks

DHI has provided predictions of water levels in the estuary during a number of high river flow and high sea events. In all cases the water level rises in the estuary. This is because the estuary will receive more flood water coming from the river through the larger culverts. The magnitude of this rise varies between 5cm and 40cm depending on the scenario and generally persists for 3 to 4 high tides.

Around the southern shore of the estuary the farmland is protected with stopbanking with a design crest level of RL2.74m. The maximum post-Project water level predicted<sup>3</sup> is RL2.06m

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<sup>3</sup> 5%AEP river flow during a 1%AEP sea.

which is 6cm above the existing flood level but is within the existing design and freeboard levels. Hence no mitigation is required.

The effect of the predicted sea level rise due to climate change has also been reported for this worst case scenario. In this case the predicted water level is RL2.52m.

### **5.3 High Estuary Water Levels and Maketū Flooding**

The effects of the Project have been investigated on water levels in the estuary around the Maketū Township foreshore. This area is low lying and presently at risk of flooding as shown by the Planning Maps in Appendices 2, 3 and 4. Some protection is already provided by high land in front of the Whakaue Marae, by Maketū Rd and by one informal stopbank for houses at 631 to 641 Maketū Rd.

Appendix 5 contains aerial photos of the Maketū Township showing various flood hazards for various high river, estuary and sea combinations. Each of these sheets show the existing flood hazard in blue and that caused by the Project in red.

Sheet 2 shows the water levels during a 1% AEP flood (1 in 100 year) in the river combined with a 5% AEP (1 in 20 year) sea level. The benefit of Maketū Rd is clearly seen but the road crest level of RL1.68m at the west end of town provides little freeboard against the present flood level of RL1.6m. The incremental or additional risk of flooding caused by the Project is quite apparent during this kind of event as it would cause an increase in water level up to RL1.76m. This would overtop Maketū Rd to the west of the town and flood waters will travel in a north-easterly direction towards the Marae and Wilson Rd. We have investigated what actions are required to ensure that this potential effect of the Project is effectively mitigated and set out further details below in 5.7.

However Sheet 4 shows the other combination of the 1%AEP event (ie a 1% sea level and 5% Kaituna River) which results in a higher water level as can be seen by the greater extent of blue. Excluding any sea level rise predicted due to climate change, this is the event on which the present flood hazard planning maps are based. The present flood level is RL1.99m and it inundates significant areas and if any work was to be done to mitigate flood hazard in Maketū this sheet shows the level of required protection. The effect of the Project on this level is minor as can be seen by the small area of red being an extra 6cm up to RL2.05m. Allowing for freeboard of say 300mm the required stopbank crest or house floor level is RL2.35m. Again, we have investigated what actions are required to ensure that this potential effect of the Project is effectively mitigated and set out further details below in 5.7.

Sheet 3 shows the effects of a 1% flood in the Kaituna with normal sea level. The effect of the Project is to increase the flood level by 36cm under that scenario. This is considered to be a relatively minor effect overall.

Sheet 5 shows the effect of the predicted rise in sea level of 500mm caused by climate change increasing the flood hazard line to RL2.52m. In fact a recently built house has a minimum floor level of RL2.8m. There is no incremental Project rise in this case.

### **5.4 High Estuary Water Level and Farmland Drainage**

This situation occurs when there has been heavy rain throughout the catchment that raises the river and estuary levels, and floods the farmland and raises the water levels in the drains. The drains are at full capacity and rely on low water levels in the river and estuary to discharge their flows. The pumps are also in operation. The scenario investigated is that required by the Scheme e.g. a 20% AEP flow in the river combined with a 20% AEP sea level. DHI have modelled this scenario and provided information on water levels in the estuary as a result of the Project.

During this scenario water levels in the estuary are increased by the Project and analysis has been undertaken of the effect of this rise on the ability of the drainage scheme to provide the expected level of service. This is because the flow from the river into the estuary increases as a result of the Project.

At the Singleton Gravity Drain outlet, and likely at other gravity outlets into the estuary, it is concluded that the water level increases caused by the Project will reduce the flow rates through the culverts and increase the time the pumps have to operate to maintain the desired water levels in the drains (Appendix 6). Mitigation options are discussed below.

## 5.5 Conclusions

In the estuary the effects of the Project are:

- During normal river flows there will be slightly higher water levels and the changes will be magnified during high river flows.
- Longer periods of higher low tides after flood peaks.
- Some minor reduction in drainage capacity adverse effect on drainage from the farmland surrounding the estuary.
- Increased flood risk around Maketū Township during the 1%AEP event (1 in 100 year).
- No effect on flows through the culvert under Maketū Rd at Spencer from the Otumakoro Catchment.

## 5.6 Proposed Mitigation Options for the Estuary and Maketū Township

The mitigation options proposed below are subject to final detailed design in consultation with scheme stakeholders. However the mitigation options are available and have been agreed in principle with the manager of the Drainage Scheme, the Natural Hazards Group of the Bay of Plenty Regional Council. The owner of the private pumpstation is being consulted at time of reporting. WBoPDC are being consulted with on the flood management for the Ongatoro/Maketū Estuary.

### 5.7.1 *For Project Effects on Farmland Drainage Around the Estuary*

To mitigate the increased power costs at Singleton Pumpstation and Dean Pumpstation brought about by increased pumping times, the Project will provide compensation for the increased power costs as assessed during the detailed investigations.

To mitigate the reduced flow under gravity through the culverts draining into the estuary along the southern shoreline between Ford's Cut and Singleton Pumpstation, the Project will contribute to upgrades already planned by the Scheme. This work will be completed prior to commissioning of the Project.

### 5.7.2 *For Project Effects on Flood Risk to Maketū*

To mitigate the potential effect of increased flooding risk around Maketū Township two realistic options exist. They are:

- Construction of stopbanks.
- Control of flows through the new culverts into the estuary.

Construction of stopbanks relies on cooperation from the Western Bay of Plenty District Council (WBOPDC) and the Maketū Community because it involves mitigation of the existing flood risk as well as the increase caused by the Project. The Project cannot address the flooding risk that already exists for Maketū. WBOPDC and the Community have identified they have an existing flood risk but they do not currently have a strategy to manage this risk, other than the control of new land and building development. Any contribution from the Project to the

control of the Project portion of the risk mitigation must be provided in conjunction with these two parties.

The most appropriate and effective way the Project can ensure it does not increase the flooding risk is to manage the additional flows from the Kaituna River by controlling these flows through the new culverts. At times where flooding risk is increased, the Project will limit the river flow into the estuary, meaning there will be no additional effects caused by the Project.

Operational controls will be placed on the culverts in accordance with an Operation and Maintenance Manual (OMM) to be prepared by the consent holder prior to tendering the works for construction. This Manual will be prepared by the applicant in conjunction with the Western Bay of Plenty District Council and the Natural Hazards Group of the Regional Council. The OMM will include, among other things, a section on flood management. The OMM will be certified by the BoPRC prior to commissioning of the Project.

### *5.7.3 Flood Management*

The objective of the flood management section of the OMM will be to mitigate the Project's effects on the risk of flooding at Maketū Township. The flood management section will outline in detail how the consent holder will predict and monitor water levels in Ongatoro/Maketū Estuary, and how these water levels will be managed if required. The requirement for management will be triggered when the Project's effect on water levels is likely to place at risk of flooding dwellings or infrastructure in Maketū Township that would otherwise not be at risk. Flows from the Kaituna River up to the 5% AEP flood (1 in 20 of occurring in any year) are not predicted to cause flooding at Maketū Township when sea levels are normal. Only when significant storm surges coincide with spring high tides is there a risk of flooding at Maketū Township and the only when these sea conditions coincide with significant river floods will the Project's effects contribute to the flood risk. These situations are predicted to occur very rarely i.e. with an annual exceedance probability of 1 to 3%.

Responsibility for implementing flood management will lie with the consent holder. However, responsibility for managing flood protection in Maketū Township lies with the Western Bay of Plenty District Council. The documentation will detail all relevant roles and responsibilities.

The flood management section will stipulate how many of the new culverts will be closed and for how long to reduce the peak flood level in the estuary during times when that peak is predicted or measured to rise above tolerable levels at Maketū Township as a consequence of the additional re-diverted flow from the river.

#### *Outline of Flood Management Section of OMM*

The flood management section will contain requirements for matters including:

- Installation of a telemetered water level recording device in the estuary near the Maketū Township to continuously record estuary water levels and transmit these to the Bay of Plenty Regional Council
- Continued operation and monitoring of the existing water level devices in the Kaituna River at Te Matai and at the Ford Rd Pumpstation
- Receipt of the continuous record of sea level from the NIWA gauge at Tauranga (Moturiki)
- Development of a sea level prediction model to provide predicted sea levels.
- Use of the flood forecasting model being developed by the Bay of Plenty Regional Council that allows prediction of flows in the Kaituna River and water levels at Ford Rd and in the estuary. This model will use the water level data received from the sites described above and the hydraulic model developed by DHI for these investigations.

- Design and installation of devices on the new culverts that allow practical and reliable reduction of flow into the estuary.
- Tabulated water levels in the river and the estuary at which warnings will be issued and actions taken i.e. closure of certain culverts.

### *Flood Forecasting and Management*

The Bay of Plenty Regional Council's Flood Forecasting Model is already used to prepare for flood events and manage structures around the region when water levels reach, or are predicted to reach, trigger levels. Similar flood management plans to the approach proposed here exist for the Kaituna Catchment Control Scheme, other parts of the Bay of Plenty Region, and indeed around the world.

The flood management section will specify the actions required when predicted water levels reach warning levels. A likely summary of the warning levels would operate as follows:

- i. The first warning level will involve notification of the consent holder, the Bay of Plenty Regional Council Duty Flood Manager, the Western Bay of Plenty District Council's nominated officer and any appropriate people within the Maketū community. At the first trigger the Duty Flood Manager will put on standby the appropriately trained personnel required to carry out any actions required in the event that higher water levels are predicted or measured, and arrange an inspection of the culverts by the appropriate person.
- ii. The second warning level will specify the number of culverts to be closed, the time by which the closure must occur, the predicted duration of the closure, and any monitoring required. The Duty Flood Manager will task the appropriate person or persons with the required actions and will receive confirmation that they have been completed. Regular, scheduled communication between Duty Flood Manager and persons tasked with any response actions shall occur.
- iii. During any flood event triggering the first or second warning level there will be continuous logging of communication between the Duty Flood Manager and any other personnel involved in the response. In addition, there will be continuous logging of water levels, and the recording of any actions when tasked and completed.
- iv. Following any flood event triggering the first or second warning level there will be a report prepared by the consent holder and presented to BoPRC. Second warning level events will trigger a review of the OMM's flood management section by the Duty Flood Manager and the consent holder to ensure that the Flood Forecasting Model is providing warnings as required, and that the actions specified in the OMM are appropriate to mitigate the Project's effects. Such reports will recommend any changes to the OMM and presented to the consent authority.
- v. Following any flood event triggering the second warning level, and in any case at least once every two years, the consent holder will report to an open meeting with the Maketū community and representatives of Western Bay of Plenty District Council, perhaps through the Maketū Community Board, on the operation of the Project and the OMM.

### *Communication*

The consent holder will meet with the Utilities Manager of Western Bay of Plenty District Council as required, but at least once per year, to review the operation of the Project and the OMM, and to discuss flood management within Maketū Township.

All residents and ratepayers within the flood hazard zone at Maketū Township will be notified in writing prior to Project's implementation with information summarising the OMM, and given an opportunity to provide feedback. Residents and ratepayers will be

made aware of where responsibilities for flood management lie, and to whom complaints or suggestions can be directed (Western Bay of Plenty District Council's Utilities Manager for flood protection generally and the consent holder for flooding effects caused by the Project).

A process for investigating complaints and suggestions will also be included in the OMM so that potentially affected residents and ratepayers, Western Bay of Plenty District Council and the consent holder are all clear on how these will be addressed.

#### *Long Term Possibilities*

In the longer term management of flood risk at Maketū Township may be provided by other methods. These other methods may include Western Bay of Plenty District Council constructing flood defences at Maketū Township; BOPRC operating the Okere Gates outlet at Lake Rotoiti in such a way as to reduce the Kaituna River's flow at Te Tumu at the top of the tidal cycle (while still complying with the resource consent conditions for that structure); and/or BOPRC providing flood storage capacity in the lower catchment by re-aligning stopbanks and creating wetlands. Should such methods be implemented then a review of the OMM will occur and changes made to reflect the change in flood risk as appropriate.

Relevant changes in technology will also trigger a review of the OMM if these could lead to better predictions of water levels, automation of flood management response actions, or similar improvements, at an acceptable cost.

#### *5.7.4 Flood Control Effects on Project Benefits*

In developing this mitigation the potential for the limits on flood flows to undermine the beneficial effects of the Project have been considered. The mitigation action will be required very infrequently because the flood risks described above are very unusual i.e. the 1%AEP flood event has a probability of 1/100 of occurring in any one year. Therefore for a very high proportion of the time the benefits predicted from the Project will be achieved.

## **6 CONCLUSIONS**

The Project changes the water levels in the lower river and Ongatoro/Maketū estuary during normal weather conditions, low flow conditions and when the river is in flood. The effects of these water level changes have been investigated on water supplies, land drainage and flooding.

### **6.1 In the lower Kaituna River**

The Project lowers water levels during low flows, reducing water into the Lower Kaituna Wetland Management Reserve but this can be effectively mitigated by adding a further culvert. The Project also lowers river water levels during floods, hence providing some benefit to the flood protection and drainage scheme.

At the Ford Rd Drain outlet the Project raises the water levels at mid and low tides on both a day-to-day basis and during floods. This reduces the ability of the drainage scheme to achieve its objectives. The Project will mitigate this reduction by contributing funding toward culvert upgrades that are planned by the Scheme and by funding increased power costs. The exact extent and form of mitigation will be the subject of further consultation and investigation but will address any additional effects attributable to the Project.

## **6.2 In the Ongatoro/Maketū Estuary**

Around the farmland in the upper estuary, the Project raises water levels a minor amount during floods but the existing stopbank system can accommodate the rise.

Around the estuary shoreline between Ford's Cut and Singleton Pumpstation, the Project raises the water levels through all tides on both a day-to-day basis and during floods. This reduces the ability of the drainage scheme to achieve its objectives. The Project will mitigate this reduction by contributing funding toward culvert upgrades at gravity outlets that are planned by the Scheme. The exact extent and form of mitigation will be the subject of further consultation and investigation but will address any additional effects attributable to the Project.

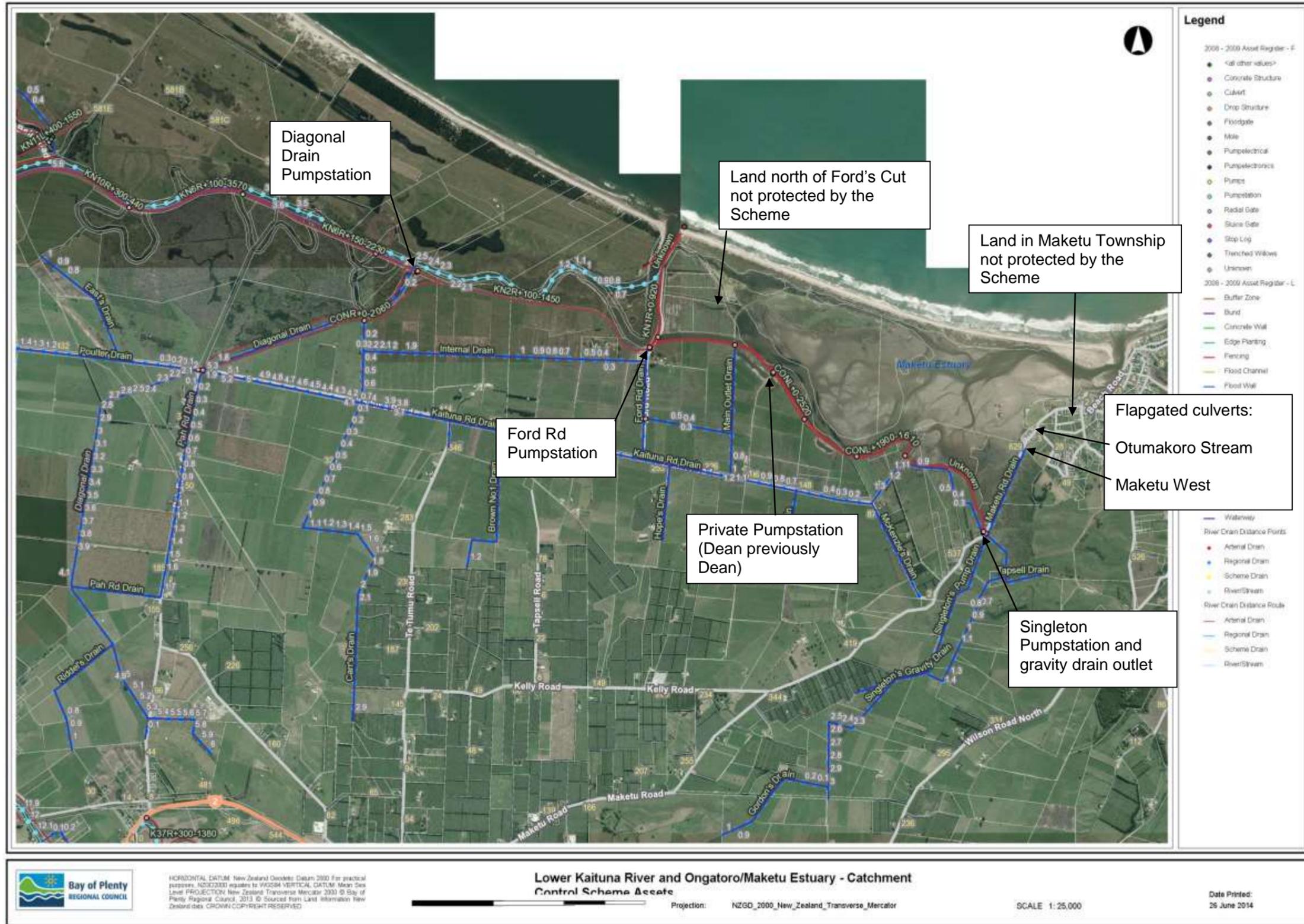
Along the estuary shoreline from Singleton Pumpstation through Maketū Township to the existing boat ramp the Project results in higher water levels during floods. In the more frequent events the increase in flooded land is small and of grass reserve, and is therefore considered to be a minor effect. In the less frequent events (1%AEP) during which some areas of Maketū are presently at risk of severe flooding, the increase caused by the Project varies between less than minor to significant. This increase can be mitigated by controlling of flood flows through the new culverts to ensure the additional risk does not arise.

At the outlet of the Otumakoro Stream under Maketū Rd at Spencer Ave the Project has a less than minor effect on the capacity of the drain. An upgraded culvert crossing is necessary now to alleviate flooding in the area and is under consideration by the District Council. The increased water levels in the estuary caused by the Project will have a negligible effect on water levels upstream of this culvert or any correctly designed new culvert.

## 7 REFERENCES

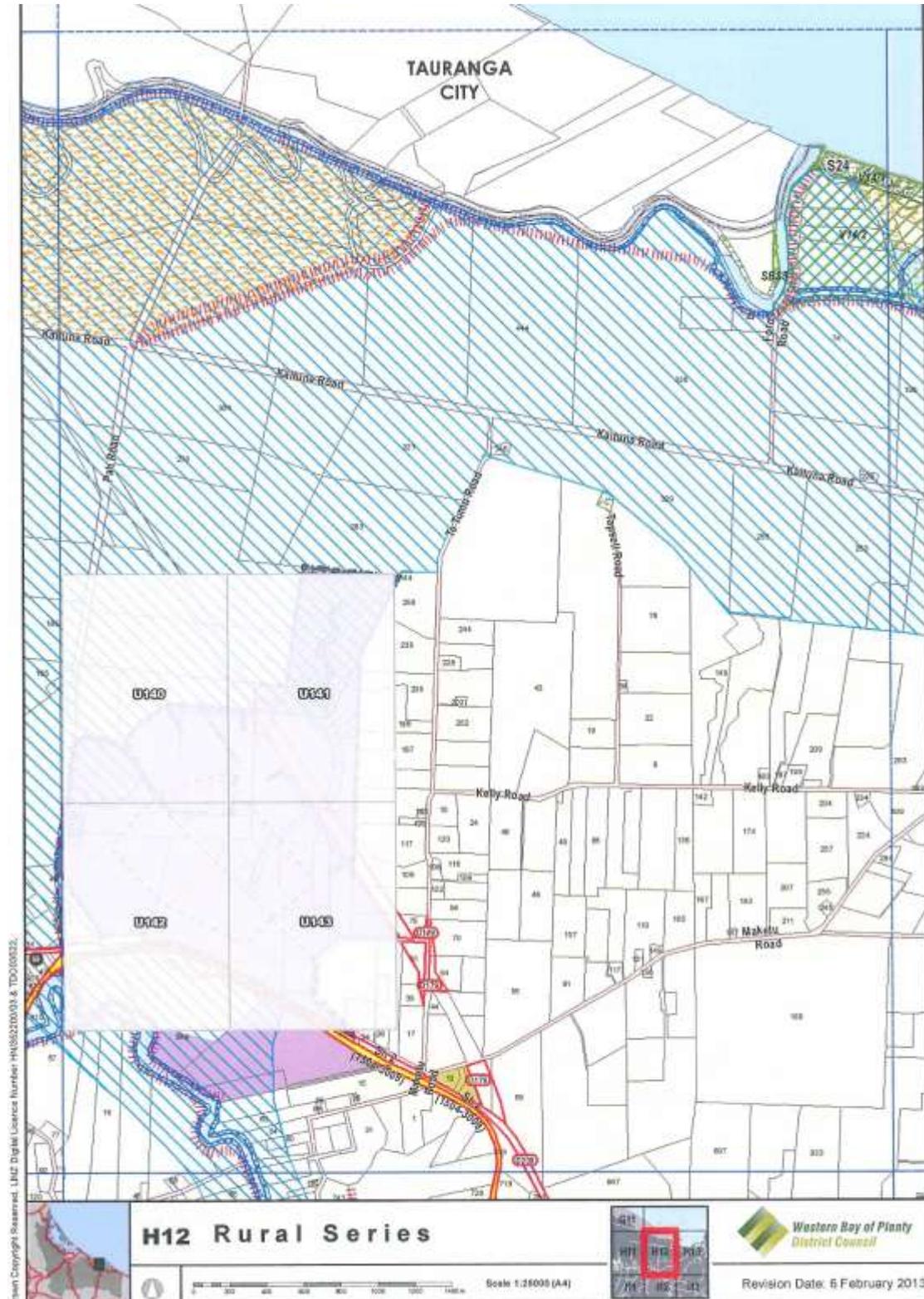
- DHI 2014 Kaituna River Re-Diversion and Ongatoro/Maketū Estuary Enhancement Project, Numerical Modelling, DHI Water and Environmental, Final Report June 2014.
- Campbell 1999 Kaituna Catchment Control Scheme, Proposed Differential Analysis Report, D R Campbell 1999 (sourced from <http://www.boprc.govt.nz/media/33586/Report-990800-KaitunaBenefitAnalysisReport.pdf>)

Appendix 1 Lower Kaituna Catchment Control Scheme Assets



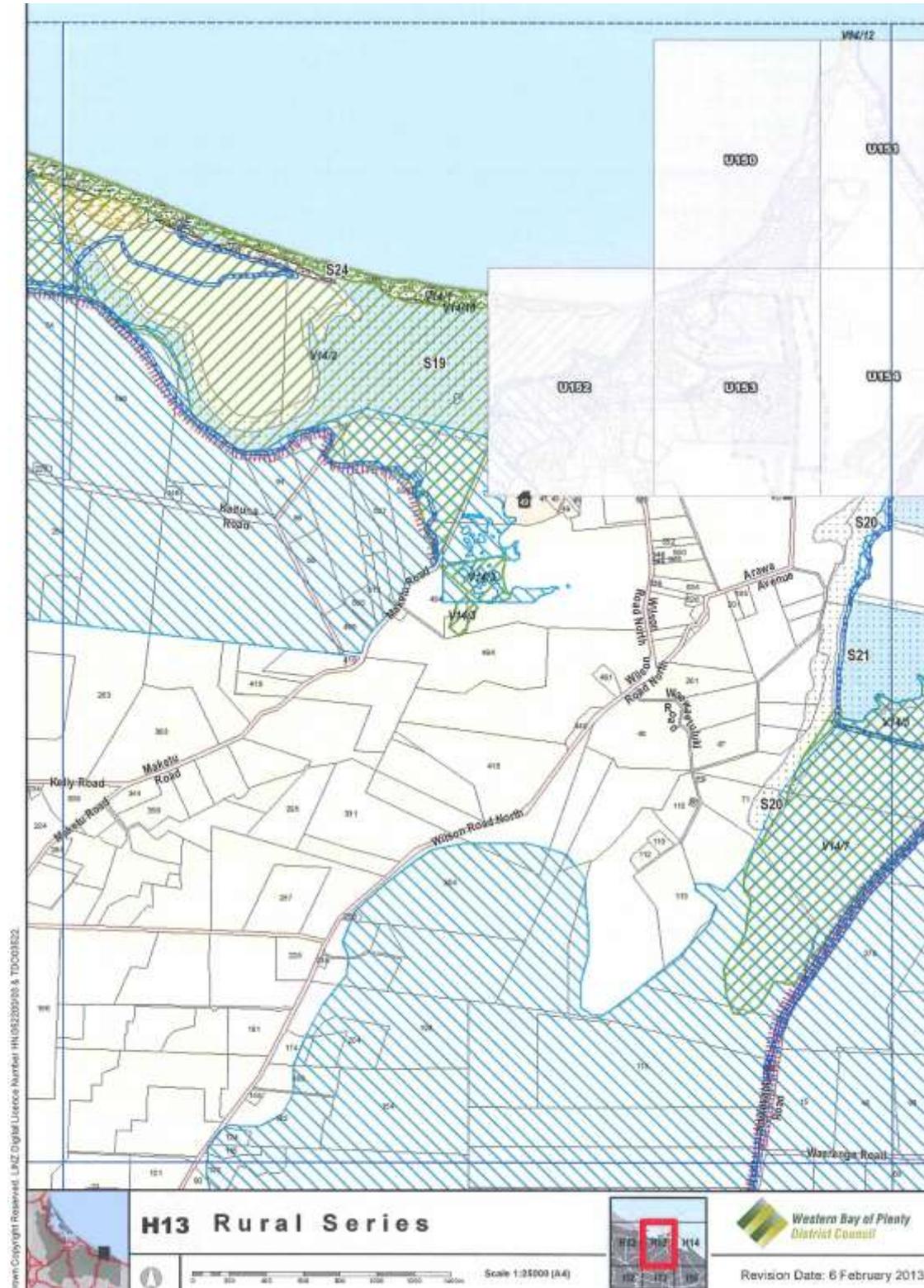
## Appendix 2 Flood Hazard Zone at Te Tumu

As mapped on Western Bay of Plenty District Plan (blue hatched area shows flood hazard zone)



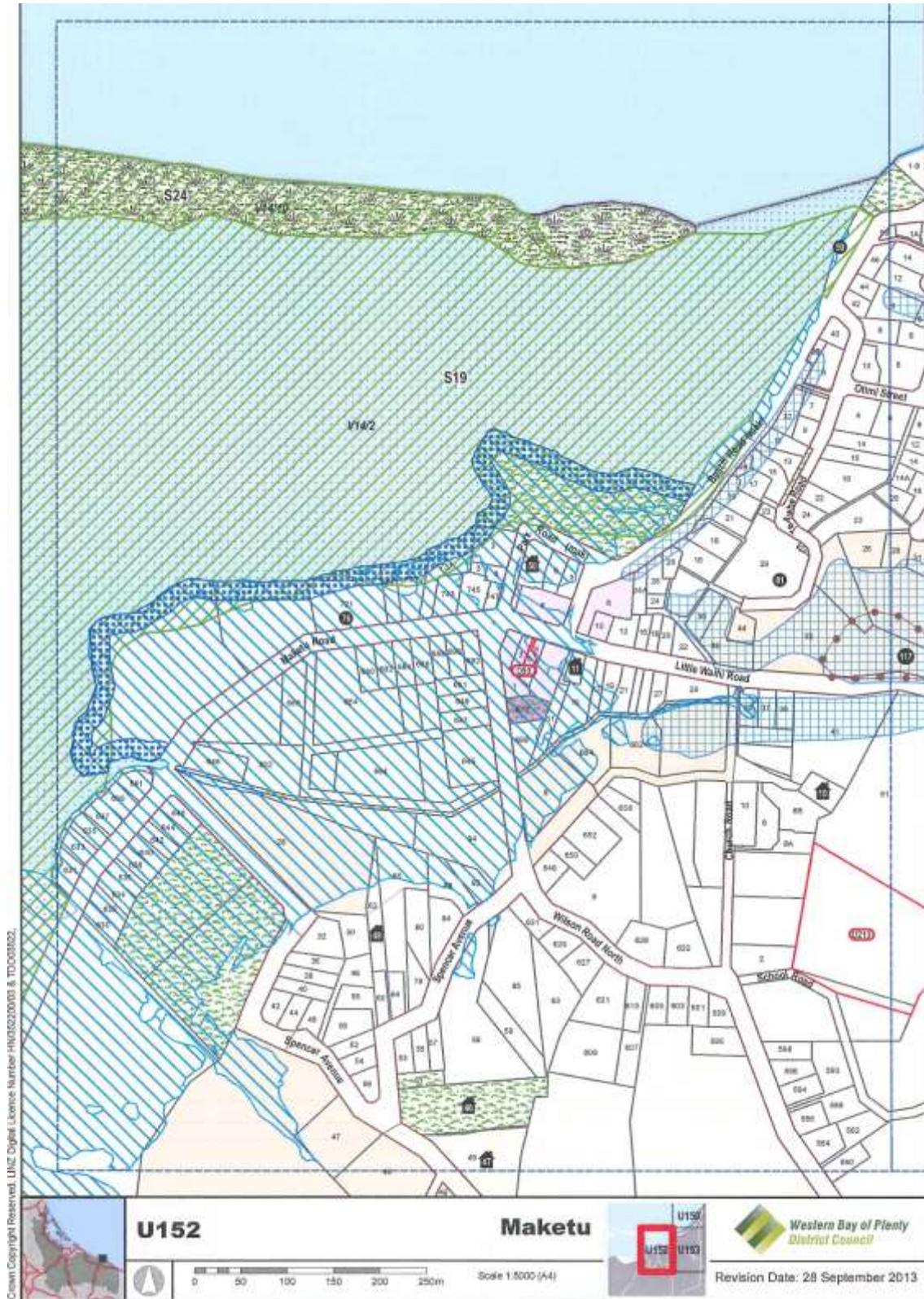
### Appendix 3 Flood Hazard Zone On Rural Land At Maketū

As mapped on Western Bay of Plenty District Plan (blue hatched area shows flood hazard zone)



### Appendix 4 Flood Hazard Zone On Urban Land At Maketū

As mapped on Western Bay of Plenty District Plan (blue hatched area shows flood hazard zone)



## **Appendix 5 Aerial Photos of Flood Risks around Maketū Township**



ENVIRONMENTAL SERVICES  
 Environmental Services  
 100-102 Beach Road, Maketu  
 Bay of Plenty Regional Council  
 Maketu  
 07 348 0000  
 www.boprc.govt.nz



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**Reference**

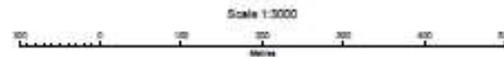
- Existing Flood Hazard RL 1.02m
- Increased Hazard RL 1.22m

Kaituna Ongaroto/Maketu Rediversion and Wetland Creation Project  
 Existing flood hazard and increase due to the project  
 during a 5% AEP flood in the Kaituna River

GIS - 474083  
 Sheet 1 of 5  
 Project 13 080714



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**Reference**

- Existing Flood Hazard RL 1.59m
- Increased Hazard RL 1.76m

Kaituna Ongatoto/Maketu Rediversion and Wetland Creation Project  
 Existing flood hazard and increase due to the project  
 during a 1%AEP flood in the Kaituna River AND a 5%AEP sea level

GIS - 474083  
 Sheet 2 of 5  
 Project 12060214



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**Reference**

- Existing Flood Hazard RL 1.08m
- Increased Hazard RL 1.44m

Kaituna Ongaroto/Maketu Rediversion and Wetland Creation Project  
 Existing flood hazard and increase due to the project  
 during a 1% AEP flood in the Kaituna River

GIS - 474083  
 Sheet 3 of 5  
 Project 1206014



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**Reference**

- Existing Flood Hazard RL 1.00m
- Increased Hazard RL 2.05m

Kaituna Ongatoto/Maketu Rediversion and Wetland Creation Project  
Existing flood hazard and increase due to the project  
during a 5% AEP flood in the Kaituna River AND a 1% sea level

GIS - 474093  
Sheet 4 of 5  
Printed 15/03/2014



## **Appendix 6 Detailed Analyses of Flows from Drains into Estuary**