Kaituna River to Maketu Estuary Re-diversion:

Model Calibration and Initial Hydrodynamic Impact Assessment

Environment Bay of Plenty
REGIONAL COUNCIL

Final Report
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1 INTRODUCTION

Environment Bay of Plenty (EBoP) has commissioned DHI NZ to build a hydrodynamic and advection/dispersion model of the lower Kaituna River and Maketu Estuary. The model will be used to assess the likely effects of re-diverting flow from the Kaituna River into the Maketu Estuary. The model has been developed so that it can be coupled with an ecological model at a later date if required. This report outlines the set up and calibration of the three dimensional hydrodynamic and advection/dispersion model of the Kaituna River and Maketu Estuary. The model was used to assess the impacts of re-diverting further flow from the Kaituna River to the Maketu Estuary, with emphasis on salinity changes and flooding effects.

1.1 Description of Study Area

The Kaituna River and Maketu Estuary are located in the central Bay of Plenty. The Kaituna River has its headwaters at the outlet of Lake Rotoiti at Okere Arm and enters the sea at Te Tumu near Maketu. The whole catchment area covers 1,250 square kilometres (125,000 ha). It passes through a steep, narrow gorge, before meandering through the alluvial terraces of the mid Kaituna River and the peat and sand deposits of the lower Kaituna basin. Lakes Rotorua and Rotoiti contribute a large proportion of the everyday flows. The Mangorewa River is a major tributary, which contributes greatly to flood flows in the Kaituna River. Other significant tributaries include the Waiari, Ohineangaanga, Raparapahoe and Kopuaroa Streams, which drain the hill country behind Te Puke. Figure 1-1 presents an overview of the study area.

Historically the Kaituna River entered the sea via the Maketu Estuary. The river entered the estuary through the Papahikahawai Channel in the north of the estuary. In 1958 the river was diverted directly to the sea, through the Te Tumu Cut. The estuary has deteriorated as a result of the diversion. A large amount of sedimentation has occurred and without the additional flushing, the estuary mouth has begun to close. Domijan (2000) calculated the reduction in net inter-tidal storage between 1985 and 1996 was 150,000m^3 or 13,640m^3/y. Ever since the diversion there has been support among locals and estuary users to re-divert the river back into the estuary. In 1996, the re-diversion of limited flows occurred via the construction of gated culverts at Ford Cut. It has been calculated that this has resulted in an additional volume of 100,000 m^3 per tidal cycle of flow into the estuary (Domijan, 2000).

Figure 1-1 Study area overview.

1.2 Further Re-diversion of Flow into the Estuary

The Kaituna River and Maketu Estuary Management Strategy was developed with the aims to:

- maintain the cultural values;
- achieve long term sustainable management; and
- improve environmental quality of the Kaituna River, its related waterways and catchment, and the Maketu Estuary.

As a part of the strategy, a number of options were developed to increase the amount of flow diverted to the estuary. EBoP commissioned a one dimensional modelling study to investigate the effects of each of the options on flood and drainage levels, and compare the effectiveness of each in diverting water to the estuary (Wallace, 2007). The costs and economic impacts of each option were also considered in another study (EBOP, 2008). From these investigations one option was chosen as the preferred option. The option is to re-divert flow back through Papahikahawai Channel via twin floodgated box culverts. The one dimensional modelling investigations suggest that this will increase the existing flow to the estuary fourfold (449,000 m^3 per tidal cycle).

1.3 Study Objectives

The objectives of this study have been defined as the following:

- Assess the impacts of re-diverting flow from the Kaituna River through the Papahikahawai Channel in terms of the ratio of freshwater/seawater entering the estuary and the resulting changes to the overall salinity of the estuary.
- Assess the change in flood levels on the properties in close proximity to the study area for a combination of elevated tidal levels and/or river flows.

1.4 Scope of Work

To achieve the study objectives, the scope of work for the study has been defined and summarized as follows:

- Generate a model domain of the Kaituna River, Maketu Estuary and appropriate offshore region.
- Set up a MIKE3 model of the Kaituna River and Maketu Estuary, including culverts at Fords Cut.
- Calibrate the model using data provided by EBoP and other sources.
- Modify the model domain to represent reopening of Papahikahawai Channel and include proposed culverts in the model setup.
- Utilise the model to assess the impacts on salinity of re-diverting further flow from the Kaituna River to the Maketu Estuary via Papahikahawai Channel

- Run model for several flood scenarios to assess change in flood risks under existing and proposed conditions.

- Report on data review, model set up, model calibration and findings from impact assessment of flow re-diversion.

2 DATA REVIEW

This chapter focuses on the data made available for the study from both existing sources and that collected specifically for the study. Field surveys were carried out by EBoP, the University of Waikato and Discovery Marine Ltd.

2.1 Bathymetry Surveys

2.1.1 River

The area of interest for the Kaituna River extended from the Te Matai gauging station, downstream to the river mouth entrance at Te Tumu. Also included in the survey was section of river including the Fords Cut loop. Depth soundings were collected by the University of Waikato on the 8th and 20th June 2006. Locations were obtained using a Garmin Etrex GPS and an echo sounder was used to measure the depths. Depths were provided in electronic form in Moturiki datum. A section of the surveyed area is shown in Figure 2-1.

2.1.2 Maketu Estuary Entrance and Kaituna River Mouth

The entrances to Kaituna River and the Maketu Estuary were surveyed by Discovery Marine Ltd surveyed 18-19 February 2008, during a High Water period. The survey was undertaken using a boat fitted with a full digital hydro graphic survey outfit comprising RTG GPS, digital echo sounder. The data was provided in WGS84 datum, Bay of Plenty 2000 at Moturiki datum. Vertical accuracy of final soundings was assessed as better than 0.15m. The surveyed areas are shown in Figure 2-1.

2.1.3 Maketu Estuary

A Real Time Kinetic (RTK) survey was carried out of the main channel of the Maketu Estuary from the entrance to the Fords Cut channel by Goodhue (2007). The RTK survey was carried out using a boat and echo sounder at approximately 2 hours either side of high tide, when the water depth was sufficient to navigate the channel. The surveyed areas are shown in Figure 2-1.

2.1.4 Papahikahawai Channel

After the submission of the draft report for this study, EBOP requested that further simulations were required with a more accurate representation of the Papahikahawai Channel. Discovery Marine Ltd was commissioned to survey the channel. The survey was carried out over two periods, the 20th August and 27th-28th August 2008. This data was only utilised for two simulations in Section 4 investigating the salinity impacts for proposed layouts, Option B and Option C. The data was provided in New Zealand Transverse Mercator Projection 2000 at Moturiki datum. The surveyed area is shown in Figure 2-2.

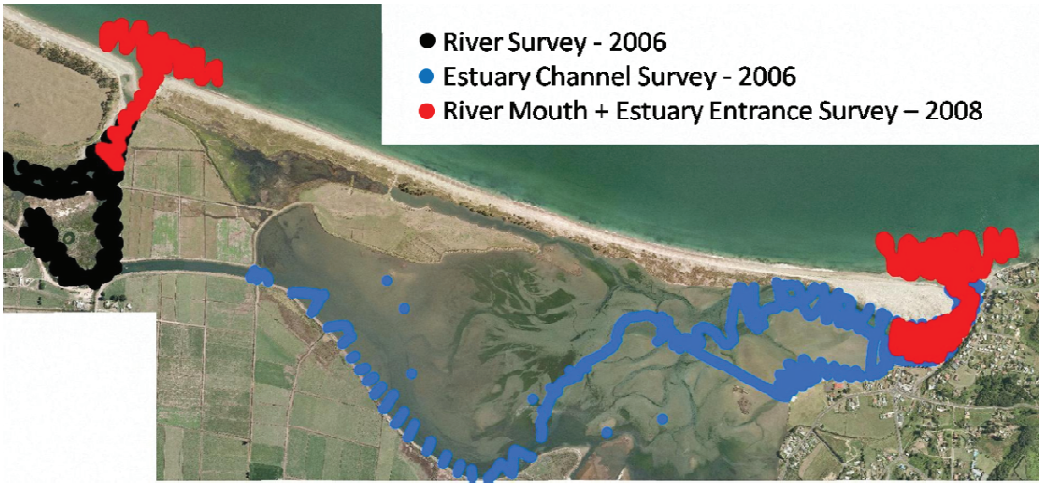

Figure 2-1 Bathymetry surveys

Figure 2-2 Additional bathymetry survey for Papahikahawai Channel.

2.2 Offshore Bathymetry

Offshore bathymetry was obtained from MIKE C-MAP. C-MAP™ is an electronic chart database which covers the world. MIKE C-MAP is an interface to C-MAP™ which allows one to easily extract depth data and tidal information from almost any location in the world relative to chart datum.

2.3 Land Levels

LiDAR data points surveyed in 2008 were provided by EBoP. These were used to obtain levels for the intertidal parts of the estuary and beach. The LiDAR extent is shown in Figure 2-3.

Figure 2-3 Extent of LiDAR land level data supplied by EBoP.

2.4 Climate Data

The following set of climate data was obtained from EBoP:

- Hourly wind and atmospheric pressure observations from Tauranga Airport for the period 23rd April 2008 to 10th June 2008.
- Hourly wind observations from Te Puke for the period 23rd April 2008 to 22nd May 2008.

The wind data is presented in Figure 2-4 and atmospheric pressure data in Figure 2-5.

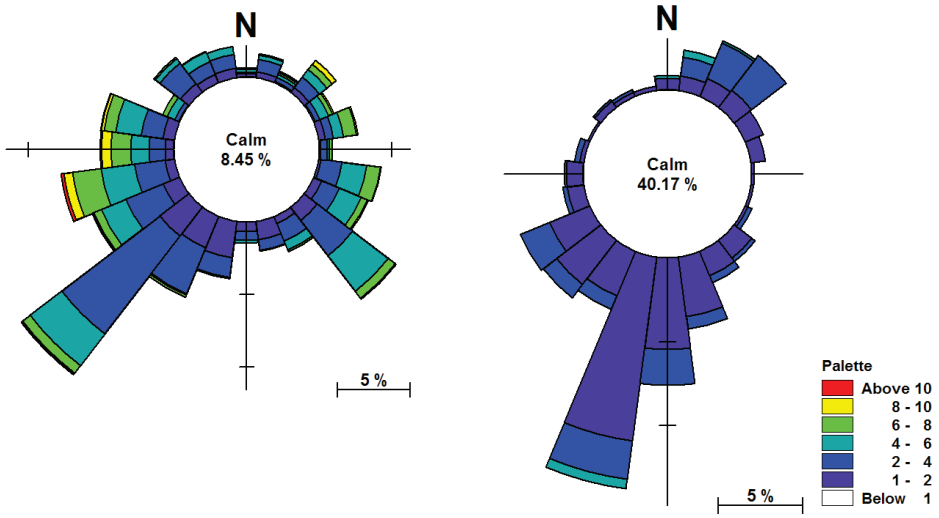

Figure 2-4 Wind data from Tauranga Airport (left) and Te Puke (right).

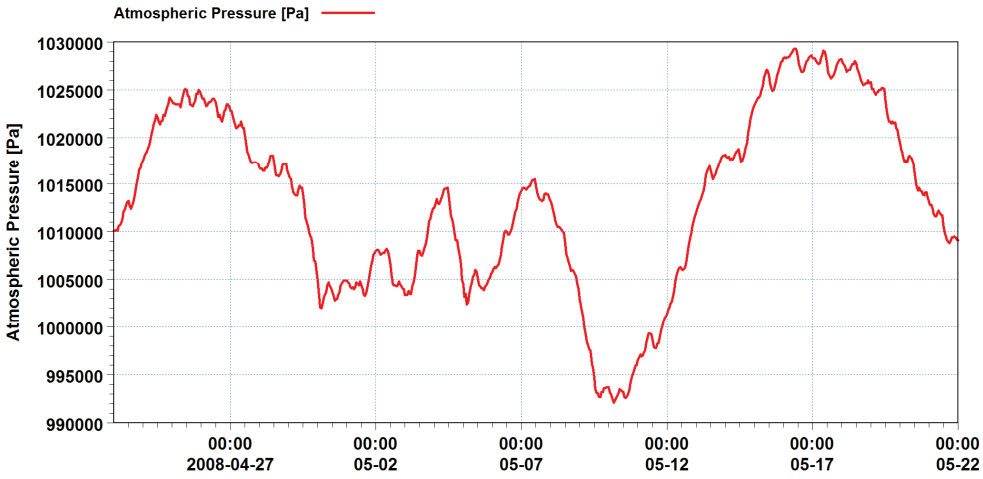

Figure 2-5 Atmospheric pressure at Tauranga Airport.

2.5 Metocean and River Data

Figure 2-6 presents an overview of the data collected in the proximity of the lower Kaituna River and the Maketu Estuary.

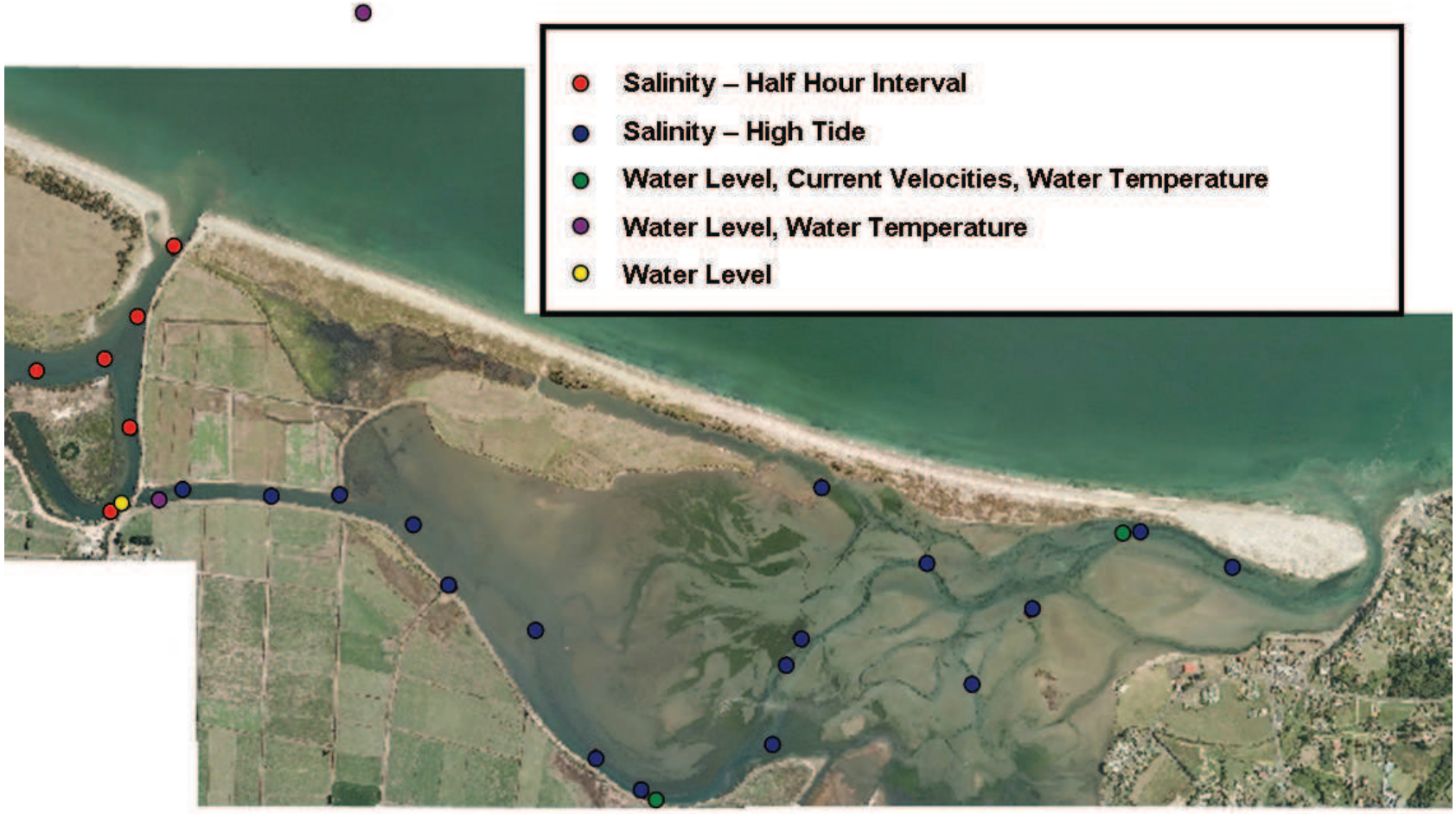

Figure 2-6 Data overview for Kaituna River and Maketu Estuary

2.5.1 River Discharges

Flow discharges from the Kaituna River gauge at Taaheke at outlet of Lake Rotoiti and the Mangorewa River have been provided by EBoP for the period 24th April 2008 to 10th June 2008, see Figure 2-7. There is a control structure above the Taaheke site at the top of the Kaituna River and outlet of Lake Rotoiti, which regulates the flow from the lake.

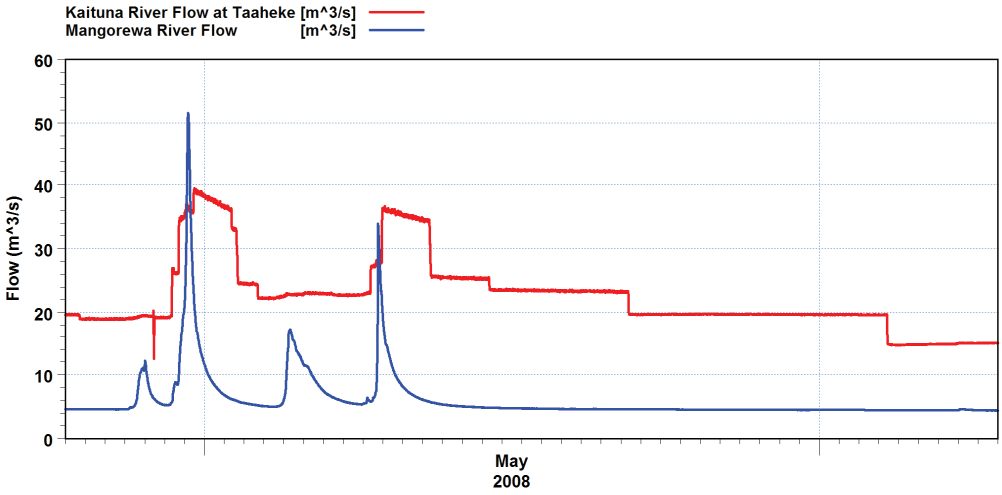

Figure 2-7 River flow for Kaituna River at Taaheke and Mangorewa River.

2.5.2 Water Level, Current and Temperature Data

EBoP have provided water level data from the gauges at Te Matai and at Fords Cut for the period 23rd April 2008 to 10th June 2008, see Figure 2-8. The visible sudden drop in levels is associated with the control structure operation at the top of the Kaituna River.

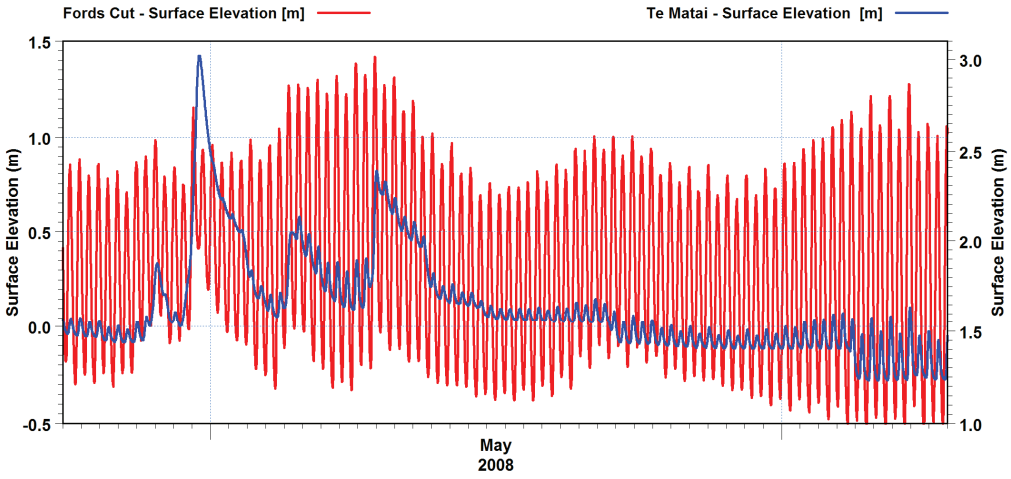

Figure 2-8 Surface elevation from gauges at Te Matai and Fords Cut (Moturiki datum).

Two Hobo pressure sensors were also deployed to obtain instantaneous water level measurements as shown in Figure 2-9. The first sensor was deployed in Fords Cut channel (NZTM 1900846, 5815854) over the period 2nd May 2008 to 20th May 2008. The second sensor was deployed 500m offshore of the Kaituna River entrance (NZTM 1901145, 5817280) in the open ocean for the period 6th May 2008 to 16th May 2008. The Hobo sensors also measured the water temperature as seen in Figure 2-10.

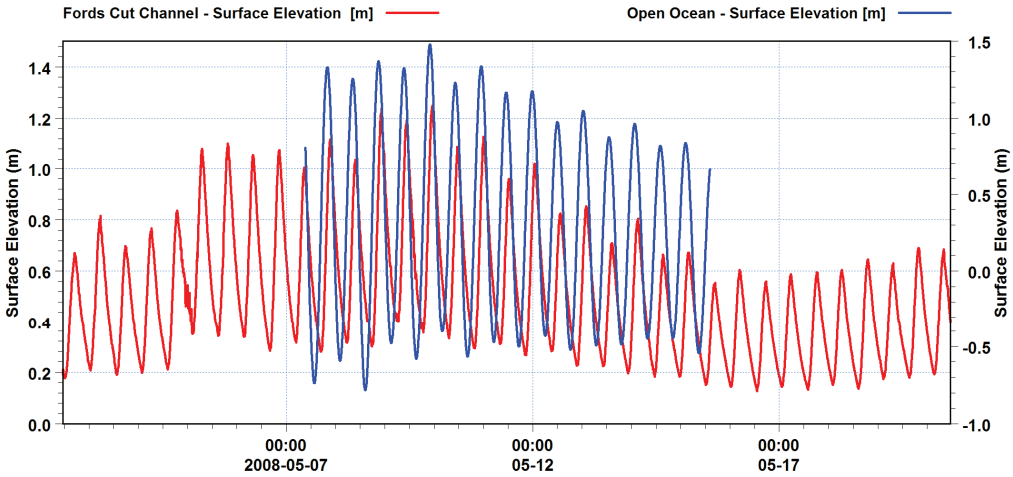

Figure 2-9 Surface elevations measurements from open ocean site and Fords Cut channel (Moturiki datum).

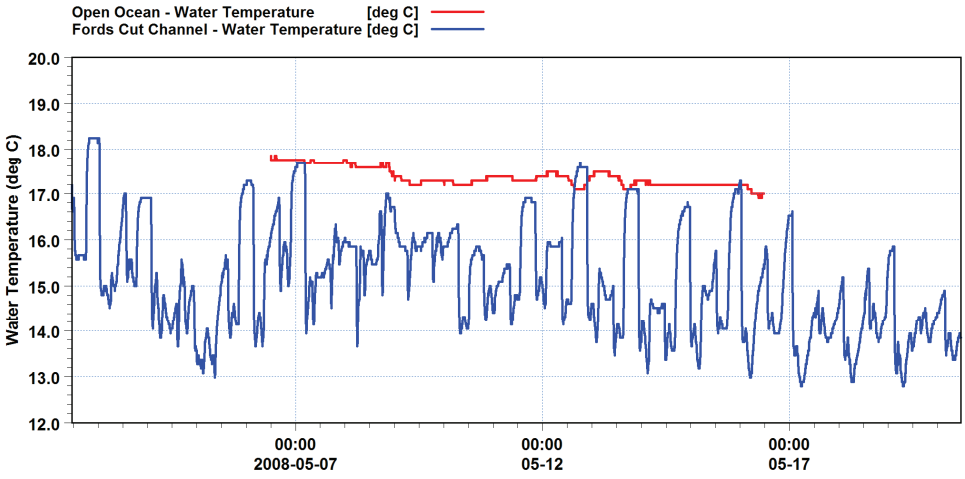

Figure 2-10 Water temperature measurements from open ocean site and Fords Cut channel.

Two triton instruments with pressure sensors were deployed within the estuary at the entrance (NZTM 1903668, 5815763, -0.51m Moturiki datum) and mid estuary (NZTM 1902299, 5814984, -0.67m Moturiki datum) for the period, 25th April 2008 to 8th May 2008, see Figure 2-11. The instruments measured current velocities, as shown in Figure 2-12, and also water temperature, presented in Figure 2-13.

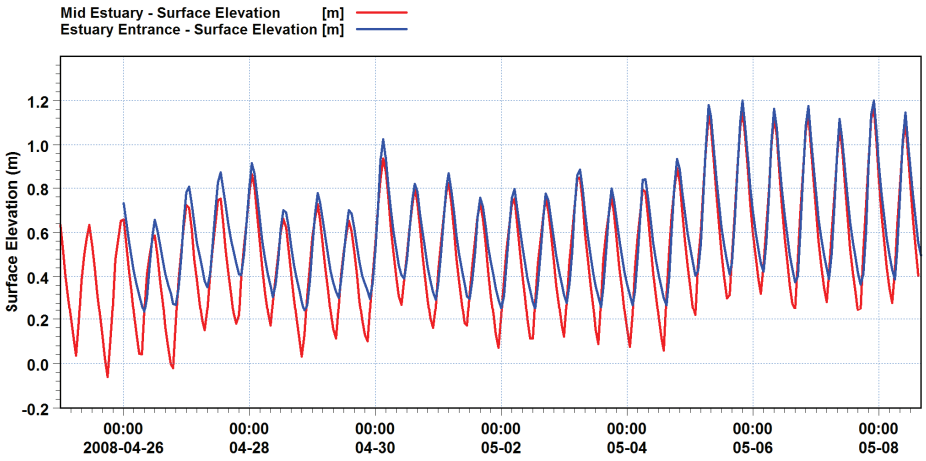

Figure 2-11 Surface elevations for mid estuary and estuary entrance (Moturiki datum).

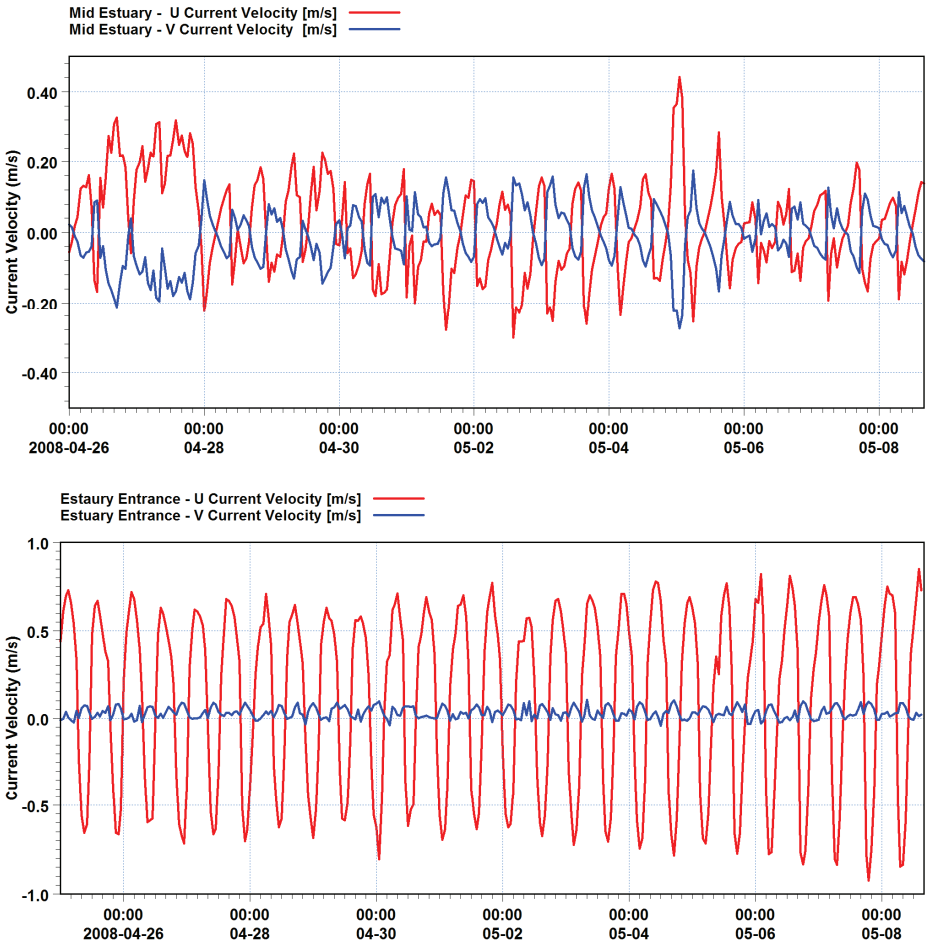

Figure 2-12 Current velocities for mid estuary (top) and estuary entrance (bottom).

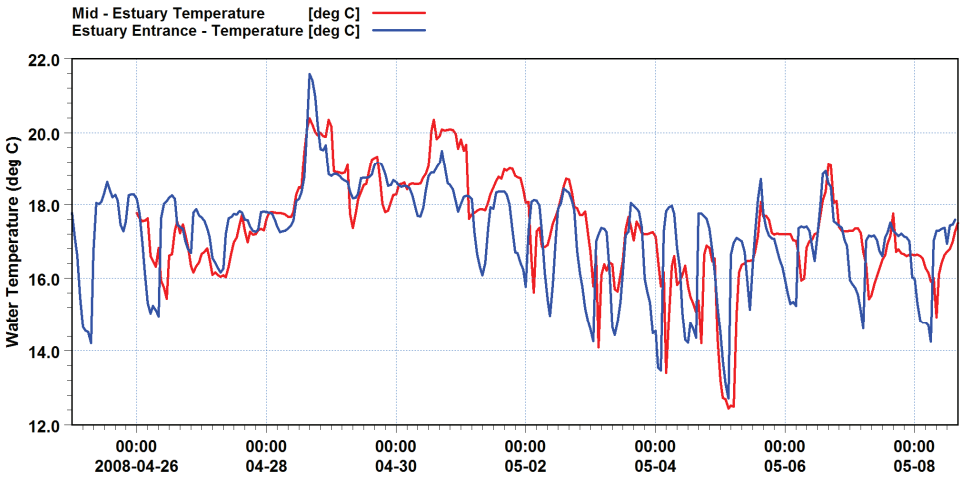

Figure 2-13 Water temperature measurements from within estuary.

Water levels from the Moturiki Island tide gauge (NZTM 1881791, 5830304) were provided by NIWA for the period 22nd April 2008 to 10th June 2008. This data is presented in Figure 2-14. The gauge is located on the open coast and any local variations in MSL that occur for the western Bay Of Plenty are well represented.

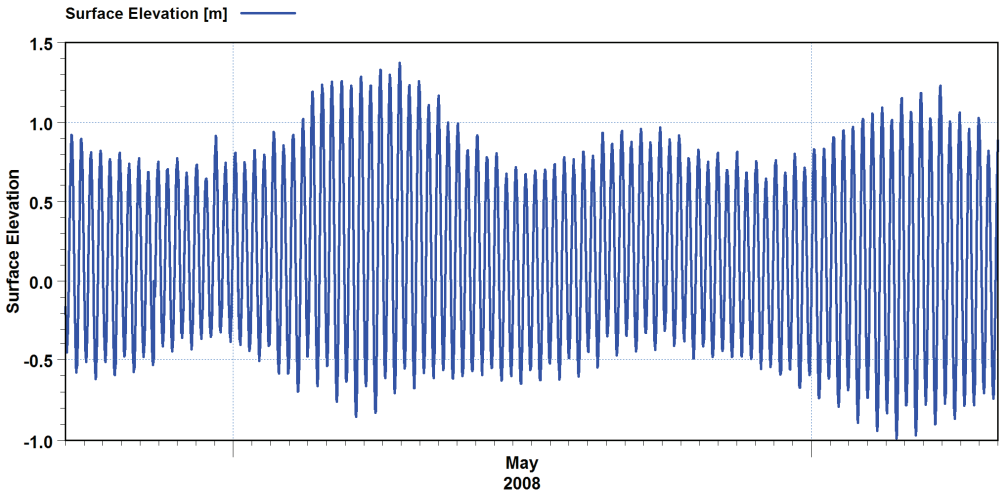

Figure 2-14 Surface elevation from Moturiki Island tide gauge (Moturiki datum).

2.5.3 Salinity Measurements

Salinity profiles were taken at six locations within the Kaituna River in the proximity of Fords Cut, and for seventeen locations within the Maketu Estuary as shown in Figure 2-15. The profiles were measured using a CTD on two days, 30th April 2008 and 29th May 2008. Within the Kaituna River the profiles were collected from Site 1 to Site 6 successively. This was repeated every half hour. Profiles were only measured once within Maketu Estuary at high tide when navigation over the intertidal areas was possible.

Figure 2-15 Salinity profile locations

2.5.4 Fords Cut Culvert Flow Measurements

On two occasions the flow through the Fords Cut culverts connecting the Kaituna River with the Maketu Estuary was measured by EBoP. The flow measurements were taken on the 12th December 2007 over a complete tidal cycle (see Appendix A) and 30th April 2008 over a partial tidal cycle. The measurements are presented in Figure 2-16.

The gates of the Fords Cut culverts are designed to stop flow back into the river from the estuary; however it was observed that a significant amount of water could flow from the estuary to the river as indicated by the negative flow in the December 2007 measurements. It was calculated that at low tide an estimated 9,000 m^3 of water flowed back into the Kaituna River from Fords Cut on 12th December 2007 For the December 2007 measurements an estimated 150,000 m^3 of water flowed through the culverts into the estuary. The tidal range during the measurement period was approximately 1.52m, close to a mean tide. Flow in the Kaituna River was close approximately 30 m^3/s. Previous studies have suggested that the mean discharge rate is approximately 100,000 m^3 per tidal cycle (Domijan, 2000). The flow measurements from April 2008 were taken during a flood event on the Kaituna River with flow varying between approximately 80 - 100 m^3/s during the duration of the flow measurement.

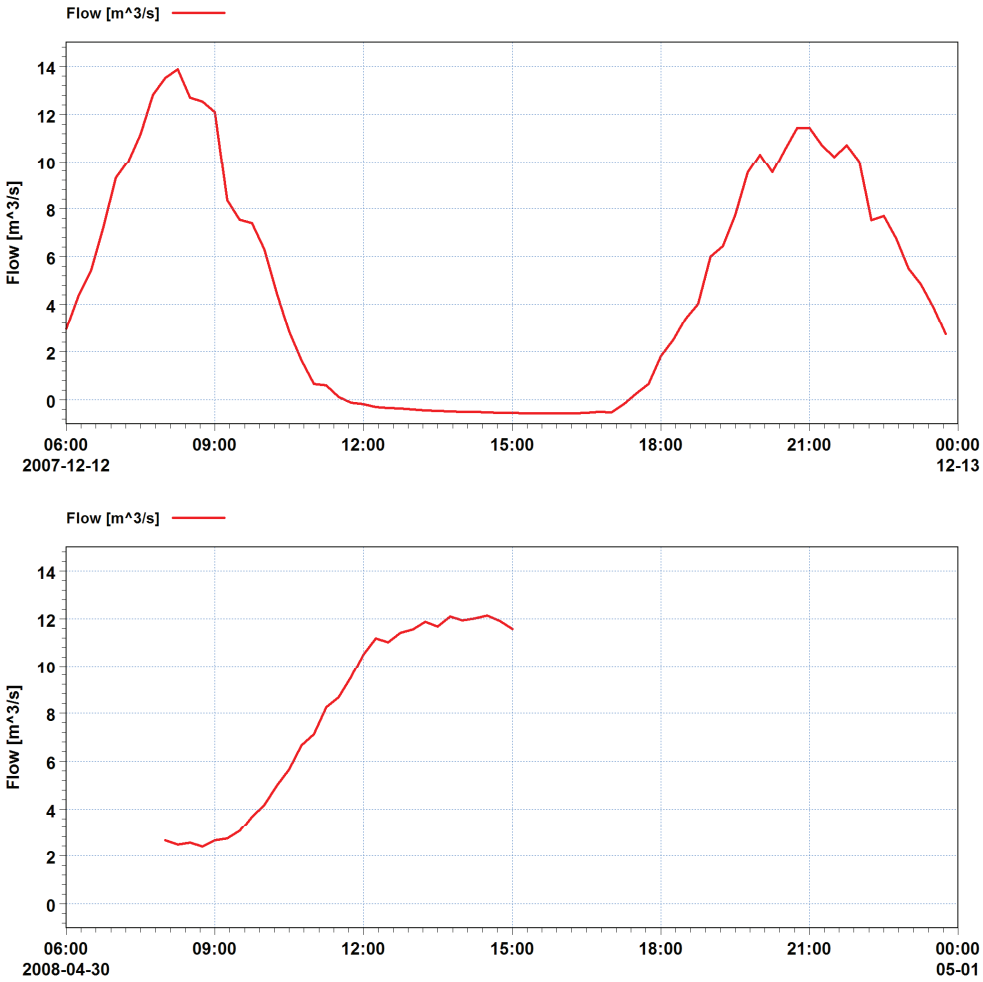

Figure 2-16 Flow through Fords Cut culverts 12th December 2007 (top) and 30th April 2008 (bottom).

A timeline that outlines the collection periods for metocean, river and meteorological data is presented in Figure 2-17.

2.6 MIKE11 Model

A 1D MIKE 11 model of the lower Kaituna River and floodplain was provided by EBoP. This model was built by Phil Wallace to assess the effects on flood and drainage levels from a number of options for re-diverting more Kaituna River flow through the Maketu Estuary (Wallace, 2007). The model extended from upstream of the Te Matai gauge down to estuary and river mouths. The model was used to calculate the resulting flow using Te Matai stage data as a boundary condition.

ID	Task Name	April 2008													May 2008												June 2008											
		1	4	7	10	13	16	19	22	25	28	1	4	7	10	13	16	19	22	25	28	31	3	6	9	12	15	18	21								
1	**Water Levels**																																				
2	Fords Cut - Estuary																																				
3	Open Ocean																																				
4	Te Matai																																				
5	Moturiki Island																																				
6	Fords Cut - River																																				
7	Mid Estuary																																				
8	Estuary Entrance																																				
9	**Water Temperature**																																				
10	Fords Cut - Estuary																																				
11	Open Ocean																																				
12	Mid Estuary																																				
13	Estuary Entrance																																				
14	**Current Velocities**																																				
15	Mid Estuary																																				
16	Estuary Entrance																																				
17	**Wind Data**																																				
18	Te Puke																																				
19	Tauranga																																				
20	**Salinity**																																				
21	River + Estuary																																				
22	River + Estuary																																				
23	**Discharge**																																				
24	Ford Cut Culvert																																				

Figure 2-17 Data collection timeline