Hydro Tasmania Consulting

Pohangina River - Flood and Hazard Mapping

Study Report

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1. Introduction

Hydro Tasmania Consulting (HTC) was commissioned by Horizons Regional Council (HRC) to develop a two-dimensional hydraulic model of the Pohangina River from it's confluence with the Manawatu River to approximately 40km upstream near Komako.

The scope of the project involved developing a calibrated hydraulic model of Pohangina River and then using model to develop flood inundation extents, flood depths and flood hazards for the 1 in 100 AEP and 1 in 200 AEP design events.

This report briefly summarises the hydrologic and hydraulic modelling that was carried out and development of the design flood outputs.

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2. Inflow Derivation

Inflow hydrographs have been derived for input to the hydraulic model for the purposes of model calibration and design flood inundation runs. The hydrographs are based on the measured flow records supplied by HRC at Pohangina River at Mais Reach. The flow record at Pohangina River at Piripiri was investigated during the February 2004 event but it was not utilized during the derivation of inflow hydroraphs due to advice from HRC that the readings from the site were not accurate or reliable.

Inflow hydrographs have been produced for eight input locations in the hydraulic model. The locations of these inputs are displayed in Figure 2-1 below.

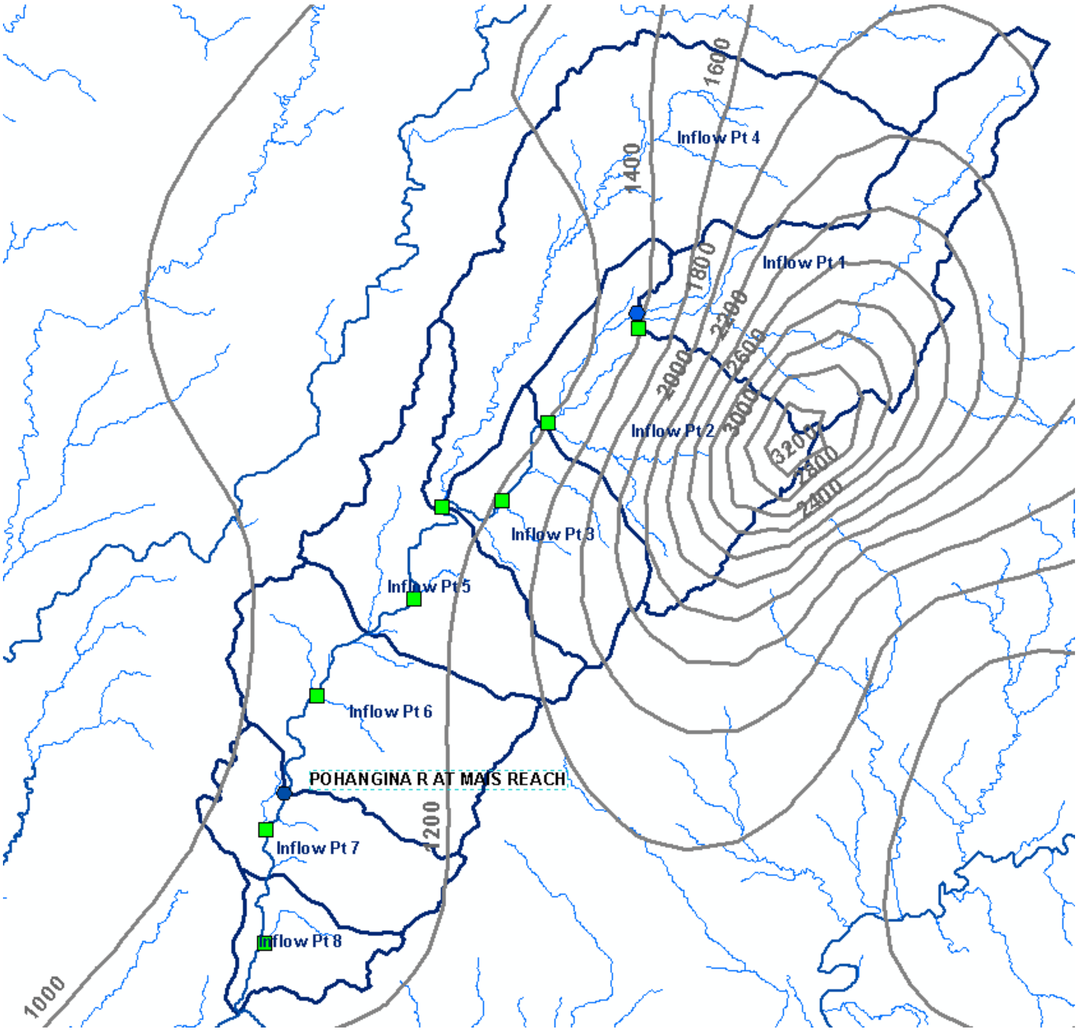

Figure 2-1 Pohangina map showing catchment boundaries of inflow locations and rainfall distribution over the catchment.

The inflows at each location have been derived by scaling of the measured Mais Reach hydrograph based on catchment areas and average catchment rainfall (as defined by the isohyets displayed in

Figure 2-1). Timing differences between the origin of the flow data and the model inflow location were accounted for by applying direct time offsets to the input data so that the catchments located well upstream of Mais Reach would experience their flood peak earlier.

Table 2-1 provides details of each inflow location including the catchment, catchment mean annual rainfall, and time offset applied during inflow derivation.

Table 2-1 Details of each inflow location

Site Identifier	Catchment Area (km^2)	Mean Annual Rainfall (mm)	Time Offset Compared to Mais Reach
Inflow Point 1	95.7	2300	4 hr
Inflow Point 2	76.8	2200	3 hr
Inflow Point 3	45.0	1450	2 hr
Inflow Point 4	133.3	1400	2 hr
Inflow Point 5	59.8	1180	1 hr
Inflow Point 6	75.1	1120	0 hr
Inflow Point 7	40.1	1100	0 hr
Inflow Point 8	20.5	1100	0 hr
Total CA	**546.3**	**1578**	
Mais Reach CA	**485.7**	**1638**	

The Feb 2004 event was selected for calibration as estimates of actual flooding were available for use in checking the hydraulic model results.

The estimated inflow hydrographs for the Feb 2004 flood event are provided in Appendix A.

3. Hydraulic Model Set-up

3.1 Introduction

The hydraulic modelling for this project was carried out using the MIKE FLOOD (version 2008) software package. This software package combines both the MIKE 11 1D and MIKE 21 2D software packages into a single model, where the significant river channels are modelled using MIKE 11 cross sections and out of channel flooding is modelled using the MIKE 21 grid.

3.2 General Setup

A MIKE FLOOD model was developed for the Pohangina River from the confluence with the Manawatu River upstream to approximately Komako. The model was split into two sections to facilitate shorter run times. Without splitting the model a single run took approximately 7 days to complete.

With the model split into two, each run consists of:

1. Running upper model
2. Extracting results from upper model
3. Running lower model

The MIKE 11 part of the model for the Manawatu River was extended to Manawatu Gorge gauge site for better estimation of travel time of flood from the gorge to the confluence of Pohangina River. The extent of the MIKE FLOOD model is shown in Figure 3-1 with the model boundary, inflow locations, gauging site and bridges included in the model highlighted.

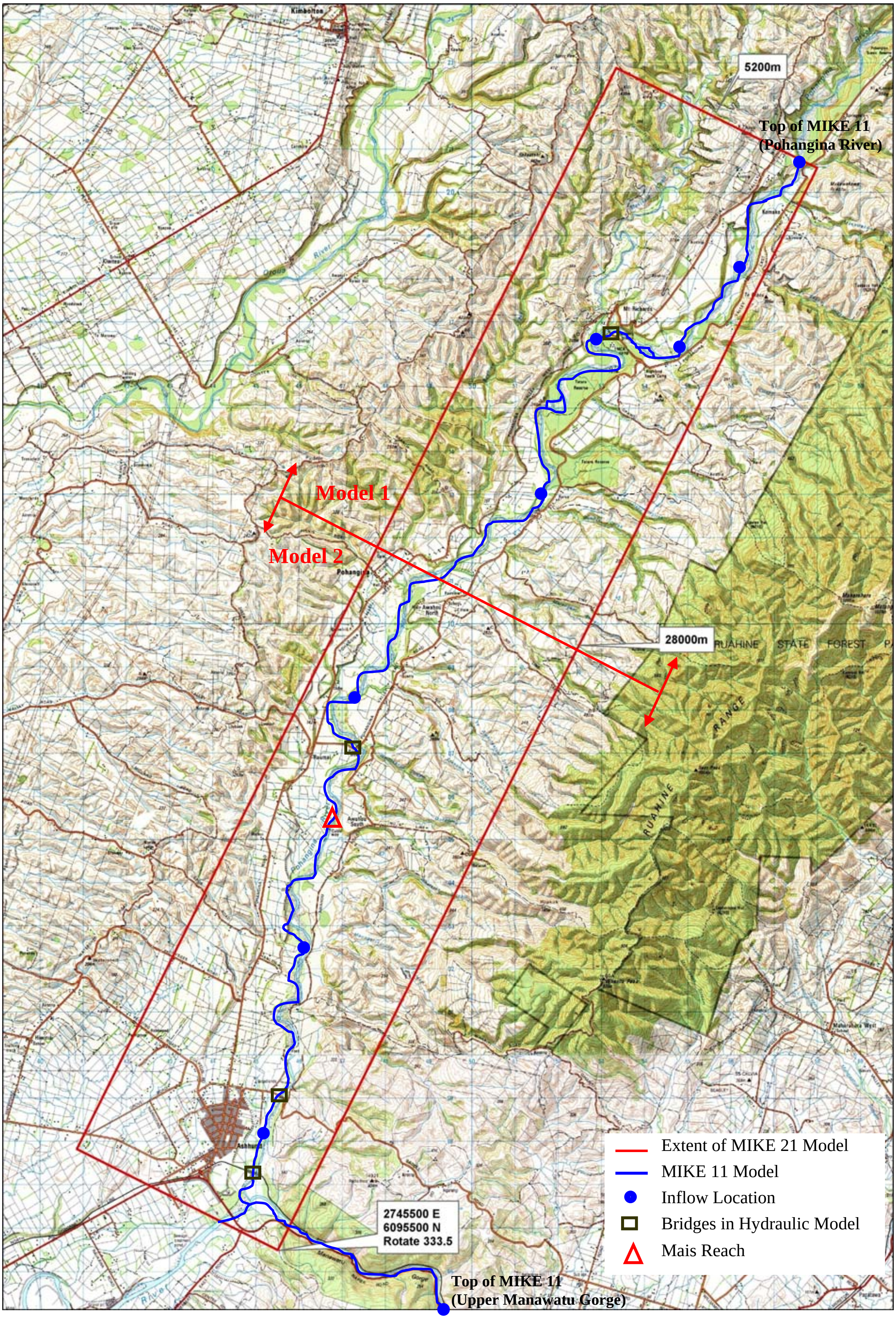

Figure 3-1 MIKE FLOOD Model Extent

3.3 River Cross Sections

River channel cross-section were provided by HRC based on detailed survey carried out in 2000, 2002 and recently in 2008. The 2008 survey was commissioned by HRC as part of this project to obtain cross-sectional information at bridges.

Review of the 2000 and 2002 river channel survey found there was not always a good match of the river channel locations compared with recent LiDAR survey (2007). Figure 3-2 shows a plan view of the 15mile surveyed cross-section (with MIKE 11 left and right channel bank markers) plotted on top of LiDAR. It appears that the river channel has migrated over time as the river channel markers from the surveyed section do not line with the river channel defined by the LiDAR. It was agreed between HRC and HTC that a consistent survey data set should be used for the model and as such the 2000 and 2002 river channel cross-section survey was not used in this study.

All river channel cross sections were based on the recent 2008 survey near bridge structures and LiDAR survey elsewhere, with the river channel below the water surface (not picked up by the LiDAR), approximated as being triangular in shape with the following depths as provided by HRC:

- 0.35m depth between the confluence with the Manawatu River and Ashhurst Bridge.
- 0.3m from Ashhurst Bridge to Raumai Bridge.
- 0.25m from Raumai Bridge to Piri Piri Bridge.

HTC noted that, based on comparing the 2000/2002 survey and LiDAR (refer to Figure 3-3), the water depth below the lowest LiDAR level could be significantly greater than the 0.25m to 0.35m recommended by HRC. HTC was advised to adopt the depths (shown above) as originally suggested by HRC as:

- Based on HRC's experience the river depth at the time of LiDAR was unlikely to be greater than 0.35m for significantly stretches of river.
- Where the survey comparison showed a significant depth greater than 0.35m, it is likely that the location was at an isolated pool within the river reach.

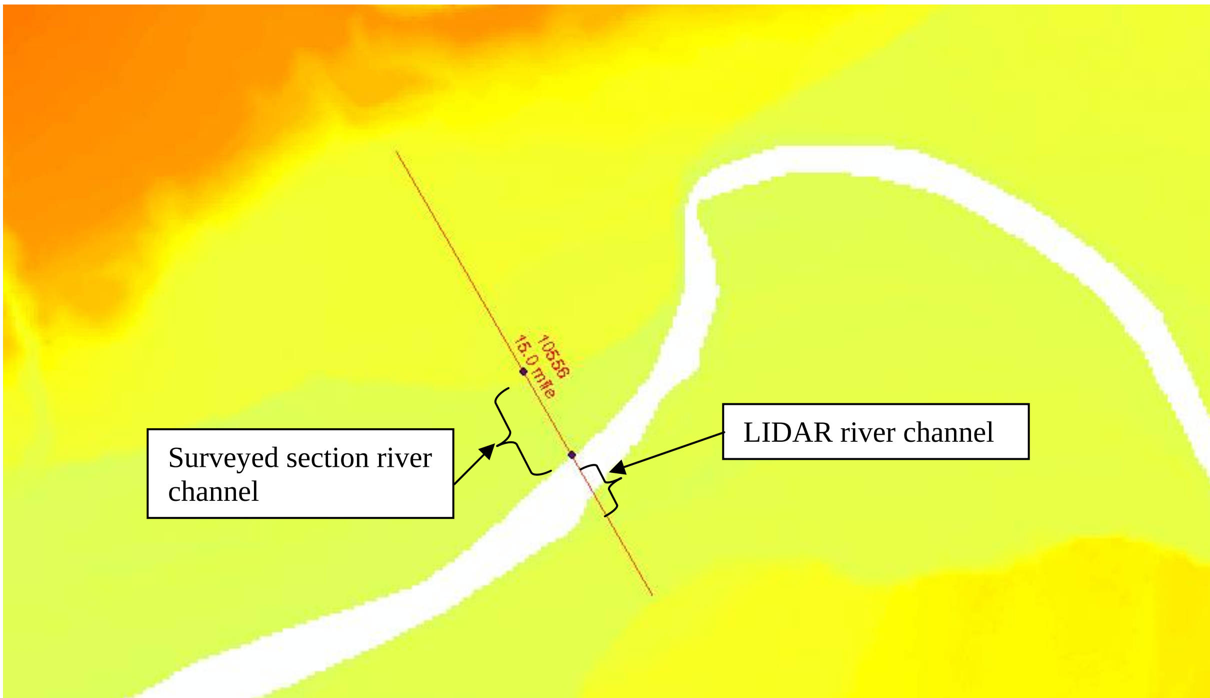

Figure 3-2 Ground Survey and LiDAR mis-alignment

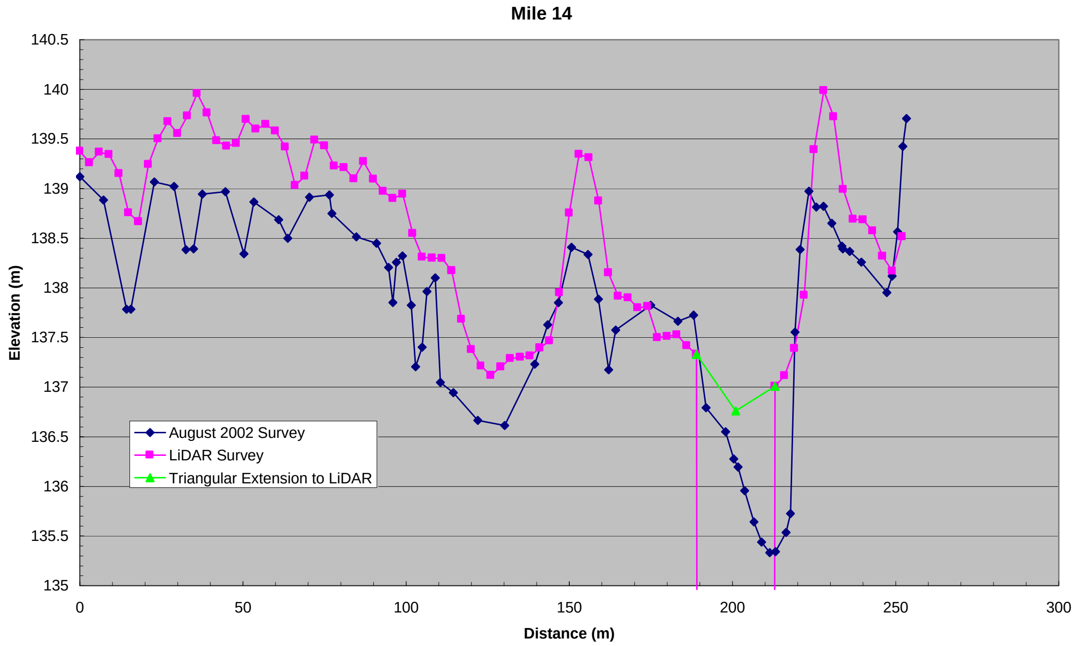

Figure 3-3 Modifications to LiDAR Sections

3.4 Floodplain DEM

A 12.5m grid size was used for the MIKE 21 model, using the LiDAR data provided by HRC. This grid size was chosen for the purpose of reducing the run-time of the MIKE FLOOD model. As a reference, the design flood events described below, had a run-time of approximately 2.5 days.

The LiDAR data, which had a very high resolution, was resampled to create a digital elevation model (DEM) with a 12.5m grid size using ARC GIS software. Relevant features such as levees, roads and creek inverts were identified and given priority to ensure they were included in the re-sampled DEM. This re-sampled grid then formed the bathymetry for the MIKE 21 model.

3.5 Inflow Locations

The MIKE FLOOD model was set up to read inflows at nine locations as shown in Figure 3-1. These inflows are located at:

- Manawatu River upstream of Upper Gorge at the upper extent of the MIKE 11 model (recorded flood hydrograph of Manawatu Gorge gauge site).
- Inflow Pt. 1 - Pohangina River upstream of Komako at the upper extent of the MIKE 11 model.
- Inflow Pt. 2 - Pohangina River at confluence of Ekaou Stream.
- Inflow Pt. 3 - Pohangina River at confluence of Porewa Stream.
- Inflow Pt.4 - Pohangina River at confluence of Makiekis Coall Creek (upstream of YMCA Camp).
- Inflow Pt. 5 - Pohangina River at confluence of Ohinetapu Stream.
- Inflow Pt. 6 - Pohangina River at confluence of Tokeawa Stream.
- Inflow Pt. 7 - Pohangina River at confluence of Maungatukurangi Stream.
- Inflow Pt. 8 - Pohangina River at Ashurst.

3.6 Hydraulic Structures

The bridge openings and weirs representing flow at bridges were based on combining the 2008 cross section survey with the LiDAR data. An example of how the data sets were combined at Raumai Bridge is shown in Appendix B.

Table 3-1 shows the bridges within the model extent and defines where they incorporated into the MIKE FLOOD model.

Table 3-1 Pohangina River Bridges Included in MIKE 11 Model

Bridge	MIKE 11 Chainage (m)	Comment
Totara Reserve Bridge	8050	Bridge opening based on 20 Nov 2008 survey and LiDAR.
Raumai Bridge	24559	Bridge opening based on 20 Nov 2008 survey and LiDAR.
Saddle Road Bridge	35010	Bridge opening based on 20 Nov 2008 survey and LiDAR.
Railway Bridge	36965	Bridge opening based on 20 Nov 2008 survey and LiDAR.

3.7 Roughness and Manning's Values

The Manning's n value for the Pohangina River was taken 0.028 to 0.03 for upstream reach (from top of MIKE 11 model to Awahau North) and 0.04 to 0.05 for downstream reach (Awahou North to the confluence of the Manawatu River) and was adopted during the model calibration process to enable a match with HRC's observed flood levels and extents.

The roughness and equivalent Manning's n values for the MIKE 21 grid were based on land use information provided by HRC. The adopted values are shown in Table 3-2 These values have been successfully used for similar flood mapping projects on the Manawatu, Rangitikei, Mangatainoka and Whanganui Rivers.

Table 3-2 MIKE 21 Roughness and Manning's Values

Land Type	Roughness	Equivalent Manning's 'n' (1/Roughness)
Built up Areas	6	0.167
Dense Vegetation	15	0.067
Open Space	27	0.037
Waterways	35	0.029
Roads	56	0.018

3.8 Link Structures

117 lateral links were set-up for transfer of flow between the MIKE 11 cross sections and the MIKE 21 grid. The link structure type used for all the links is summarized in Table 3-3 below.

Table 3-3: Link Structure Details (Common for all 117 links)

Parameter	Value	Comment
Method	Cell to cell	
Type	Weir 1	$Q = W \cdot C \cdot (H_{us} - H_w)^k \cdot \left[1 - \left(\frac{H_{ds} - H_w}{H_{us} - H_w}\right)^k\right]^{0,385}$ Refer to MIKE 11 reference manual for details.
Source	M21 and HGH	At the upstream reach from top of MIKE 11 model to Awahau North) of the river, M21 grid cell levels at lateral links are used as invert level for the link. At the downstream reach (Awahou North to the confluence of the Manawatu River) of the river, HGH grid cell levels are used as invert of lateral links to avoid instability in the model.
Depth Tolerance	0.1m	For model stability.
Weir C	1.838	Default discharge coefficient.
Manning's n	0.05	Adopted value.

3.9 Other Parameters

Other critical parameters for the MIKE FLOOD model are provided below:

- Calculation time-step: 2 seconds.
- Flooding and drying enabled:
  - Drying depth: 0.02m.

- o Flooding depth: 0.03m.

- Eddy viscosity: 0.10m^2/s.

3.10 Downstream Model Boundary

The downstream model boundary is located on the Manawatu River just downstream of the confluence of the Pohangina River. A discharge vs depth (Q/H) rating was developed for this site as the downstream boundary condition using the existing MIKE 11 model (Ashurst-Palmerston Nth developed by HRC) of the Manawatu River which is currently being used in the Manawatu River real-time flood forecasting model. The model was modified to include a cross-section at the exact location of the MIKE FLOOD model boundary.

The February 2004 flood was run through the modified MIKE 11 model and a Q/H relationship exctracted at the location of the MIKE FLOOD model boundary. The Q/H relationship used in the Pohangina MIKE FLOOD model is provided in Figure 3-4 below.

The above method of estimating the downstream MIKE FLOOD boundary condition was agreed to by HRC.

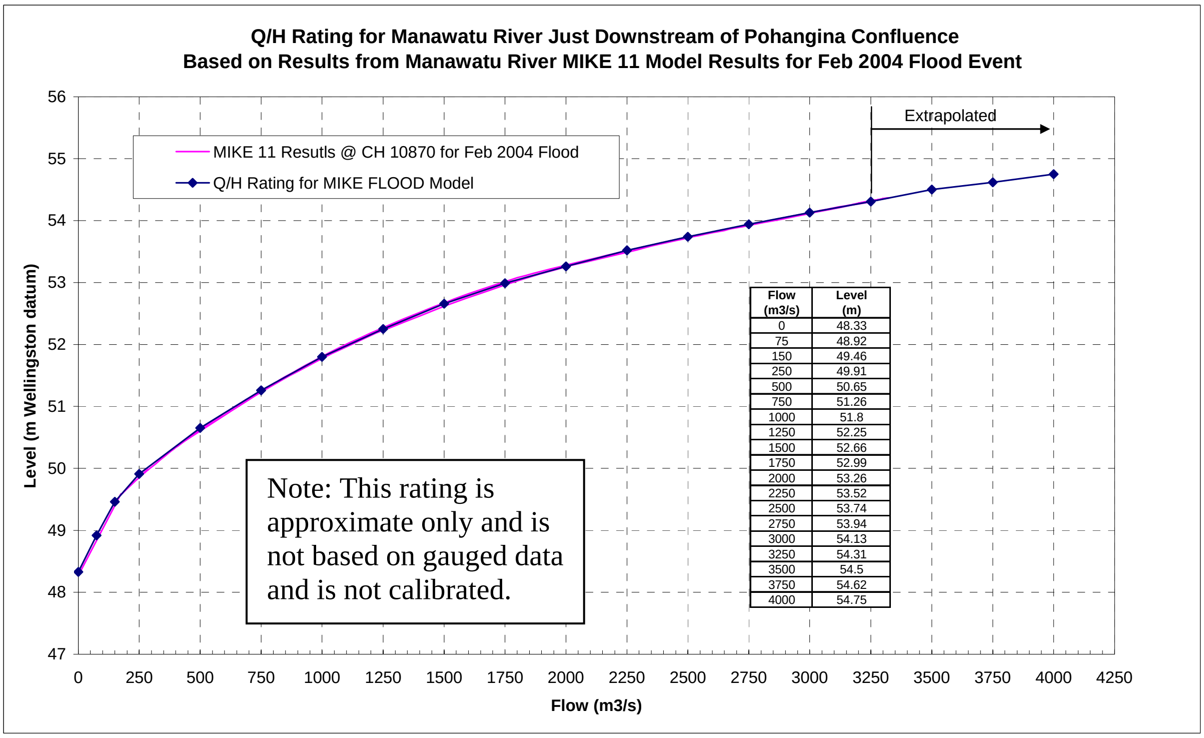

Figure 3-4 Q/H relationship at MIKE FLOOD Model Boundary

3.11 Model Datum

The modelling was carried out in Wellington Vertical Datum.

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4. Model Calibration

A model calibration was required to provide confidence that the outputs of the hydraulic model were reasonable. The hydraulic model was calibrated for the February 2004 Flood event by comparing:

- Modelled and measured discharges at Mais Reach of Pohangina River.
- Modelled flood extents against observed flood extents using a flood extent map (Arc GIS shape file) and available flood photographs provided by HRC.

The inflow hydrographs for February 2004 flood event are provided in Appendix A.

The modelled MIKE FLOOD hydrograph at Mais Reach of the Pohangina River and the observed hydrograph at that location are shown in Figure 4-1 below. This shows that the modelled flood duration along with the timing of peak discharge compares well with the observed hydrograph, although the peak of the modelled hydrograph is slightly lower than the peak of the observed hydrograph.

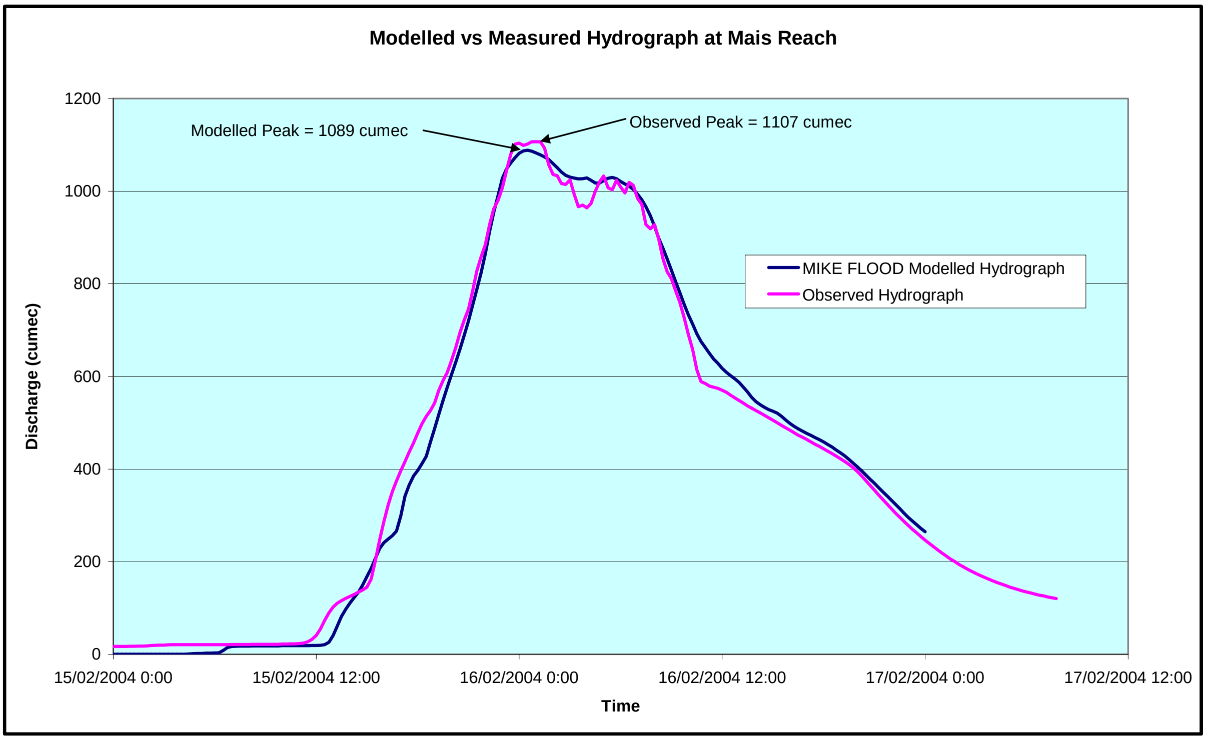

Figure 4-1 Observed vs Modelled Discharge at Mais Reach for February 2004 Flood

The modelled peak flood levels of the February 2004 flood event were plotted and the inundation map is shown in Figure 4-2. The indicative flood extent during February 2004 food event provided by HRC (based on observations of actual flooding that occurred) is also shown in Figure 4-2. The modelled flood extent map compares well with the indicative flood extent.

HRC provided photographs of flooding that occurred during the February 2004 event. It is assumed that these photos show the peak of the flood. The locations of these photos are also shown on Figure 4-2. A selection of the photographs are shown in Figure 4-3 to Figure 4-9. The extent of inundation from the MIKE FLOOD modelling shown in Figure 4-3, 4-4, 4-7 and 4-8 compares well with the flooding around Saddle Bridge, Raumai Birdge and Pohangina Valley as shown in the photos.

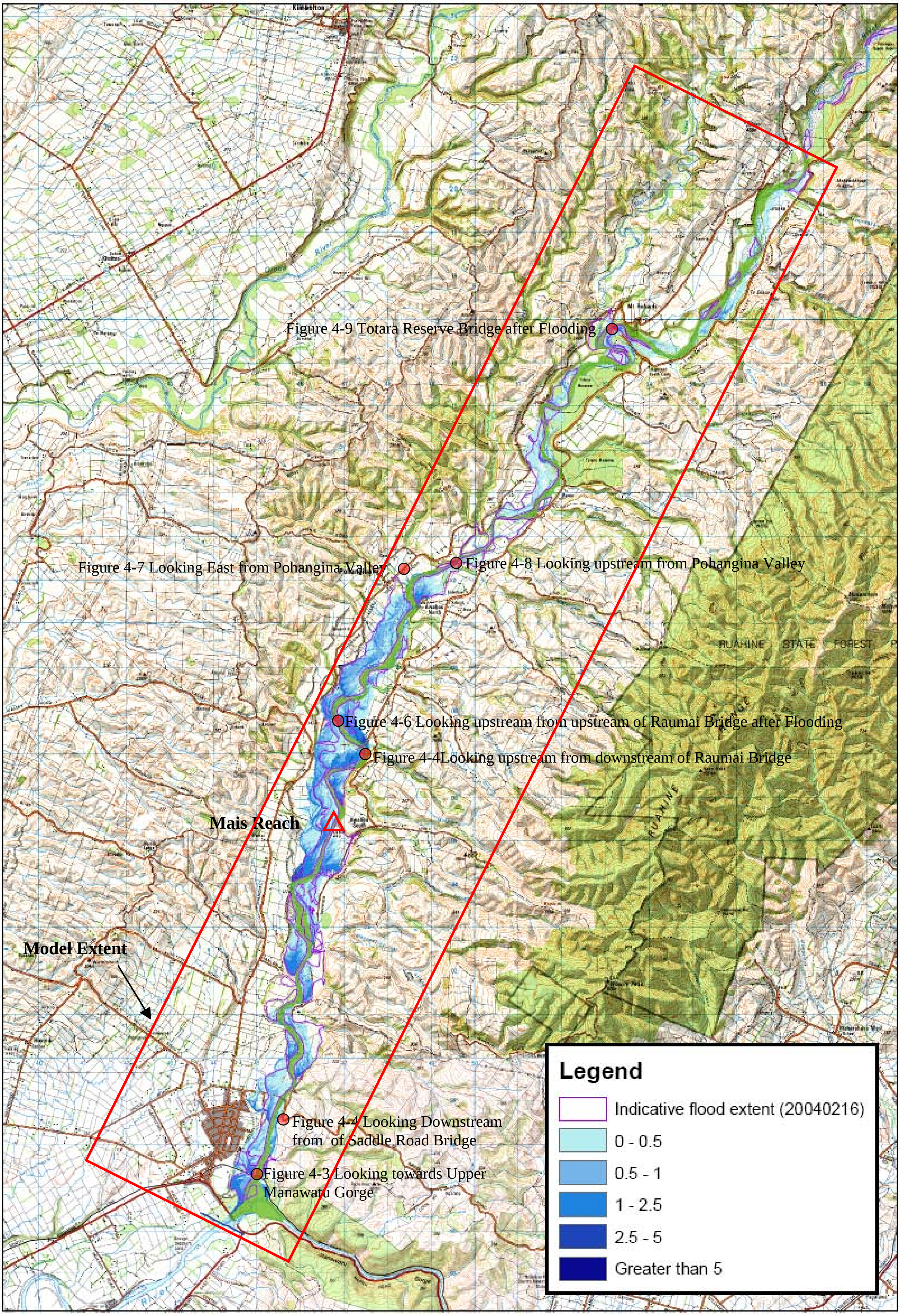

Figure 4-2Flood Inundation Map of February 2004 Flood

Figure 4-3 Looking towards Upper Manawatu Gorge

Figure 4-4 Looking Downstream from Upstream of Saddle Road Bridge

Figure 4-5 Looking Upstream from Downstream of Raumai Bridge

Figure 4-6 Looking Upstream from Upstream of Raumai Bridge after Flooding

Figure 4-7 Looking East from Pohangina Village

Figure 4-8 Looking Upstream from Pohangina Valley

Figure 4-9 Totara Reserve Bridge

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5. Design Model Runs

The MIKE FLOOD model was used to develop a set of electronic flood extent depth and hazard maps for the 1 in 100 AEP and 1 in 200 AEP flood discharges as measured at Mais Reach in Pohangina River. Flood frequency results at this location were provided by HRC and are shown in Table 5-1.

Table 5-1: Flood Frequency Result

Flood AEP	Discharge (m^3/s)
1:100	1300
1:200	1450

The February 2004 flood event hydrograph was used as the basis of the design runs and the inflow hydrographs to the MIKE FLOOD model for this event were scaled so that the peak discharge at the Mais Reach gauge site matched the required peak flow for the 1 in 100 and 1 in 200 AEP design events.

The hydrographs used for design runs are provided in Appendix A.

5.1 Flood Extent Maps

Flood extent maps for the 1 in 100 and 1 in 200 AEP design flood events were prepared using the results form MIKE FLOOD model run for those flood events. Those maps were provided to HRC electronically in ARC GIS format. Plots of the flood 1 in 100 AEP and 1 in 200 AEP extents are shown in Figure 5-1 and Figure 5-2.

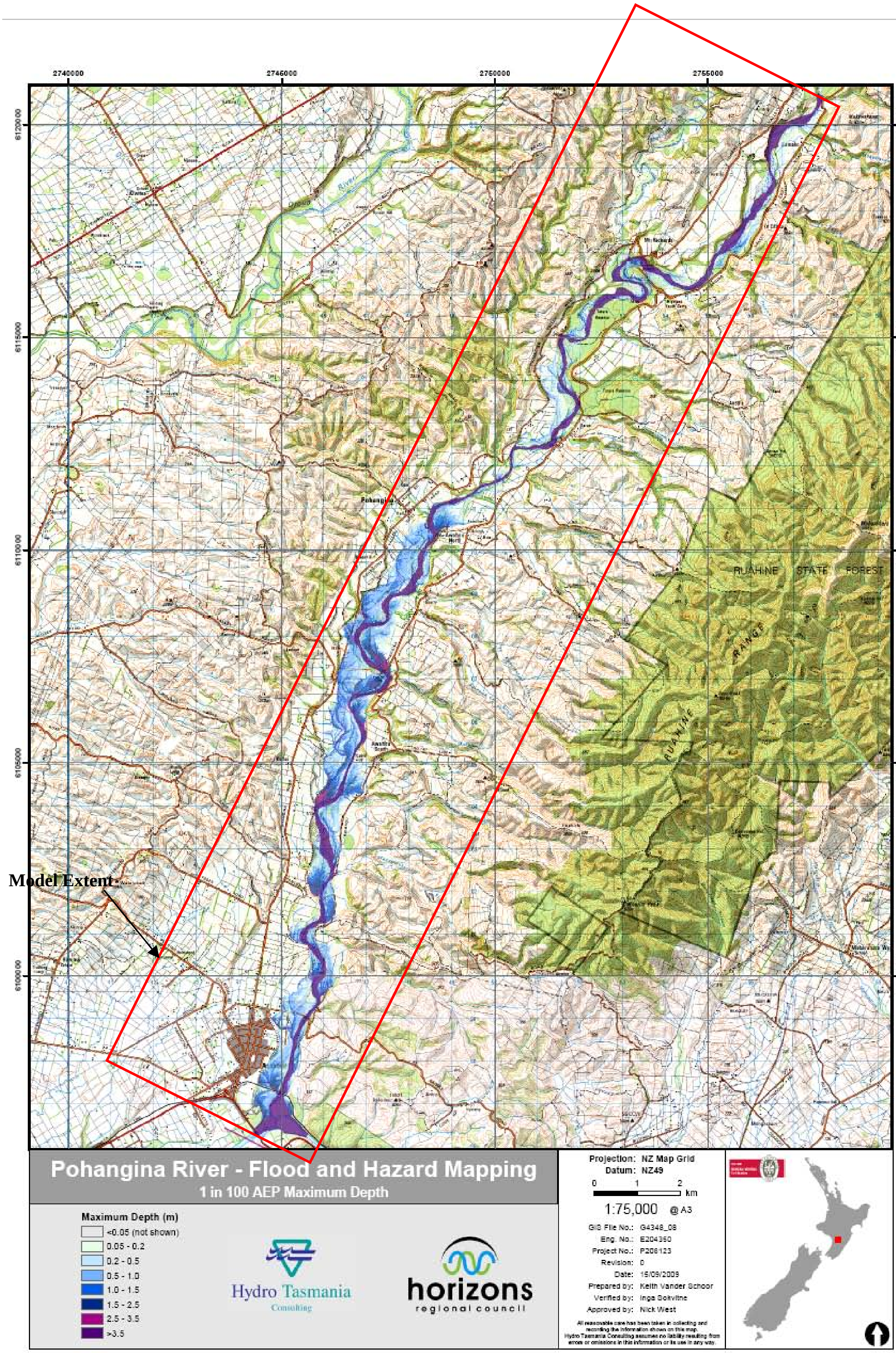

Figure 5-1 1 in 100 AEP Flood Extent

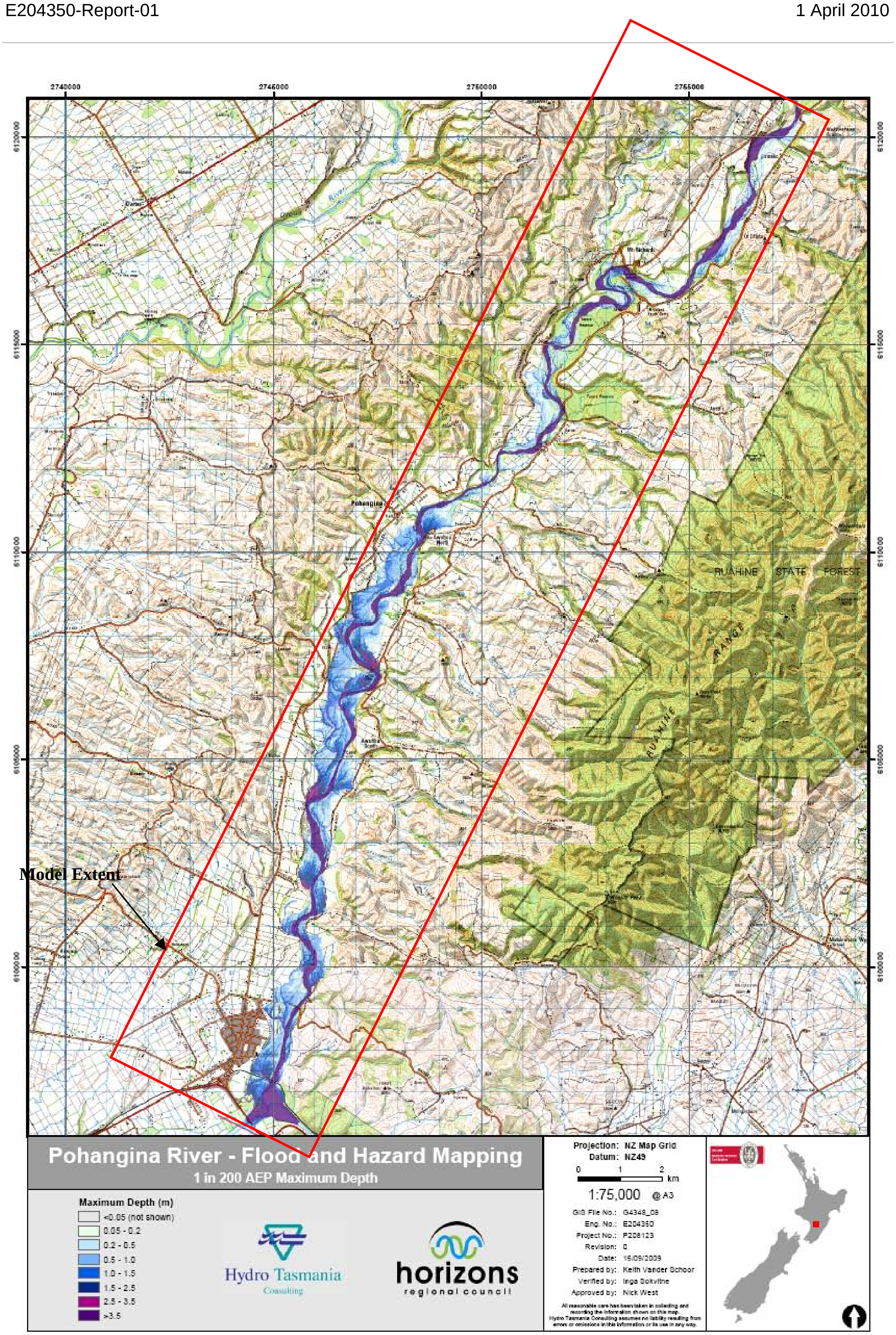

Figure 5-2 1 in 200 AEP Flood Extent

5.2 Flood Hazard Maps

From the MIKE FLOOD Model results of 1 in 100 AEP and 1 in 200 AEP flood events, hazard grid file were generated which were used to prepare Flood Hazard Maps to show the flood hazard categories based on CSIRO Flood Hazard Guideline. According to this guideline, the flood hazard is categorized into four degrees of hazards, namely ‘Low’, ‘Medium’, ‘High’ and ‘Extreme Hazard’. The maps thus prepared were provided to HRC electronically in ARC GIS format. Plots of 1 in 100 AEP and 1 in 200 AEP flood hazards are shown in Figure 5-3 and Figure 5-4.

5.3 Flood Hazard Animation

Animations of changing flood hazard were developed for the 1 in 100 and 1 in 200 AEP flood events. The hazard animations are based on 15 minute time steps and were provided to HRC in ArcGIS format.

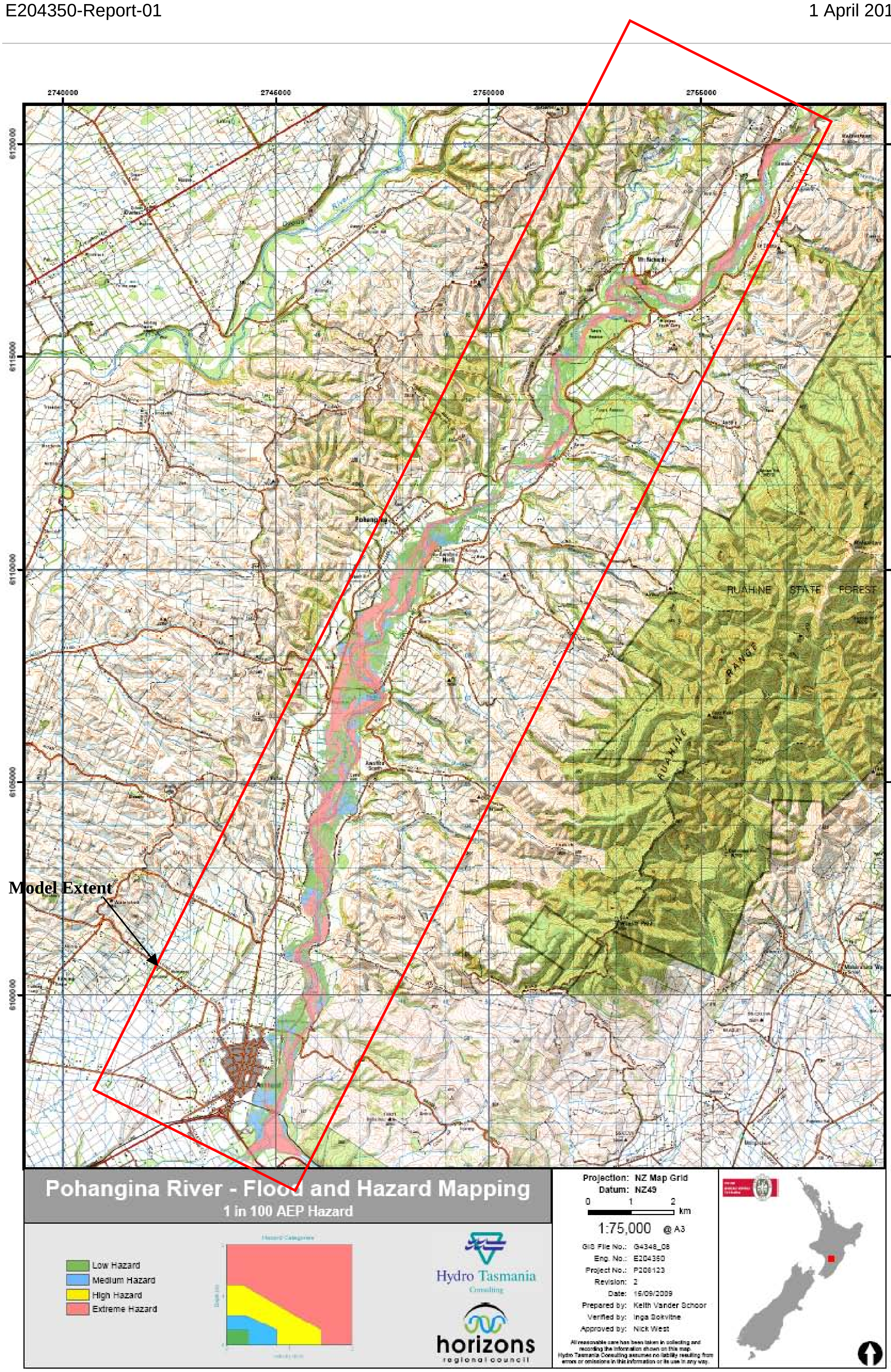

Figure 5-3 1in 100 AEP Flood Hazard Map

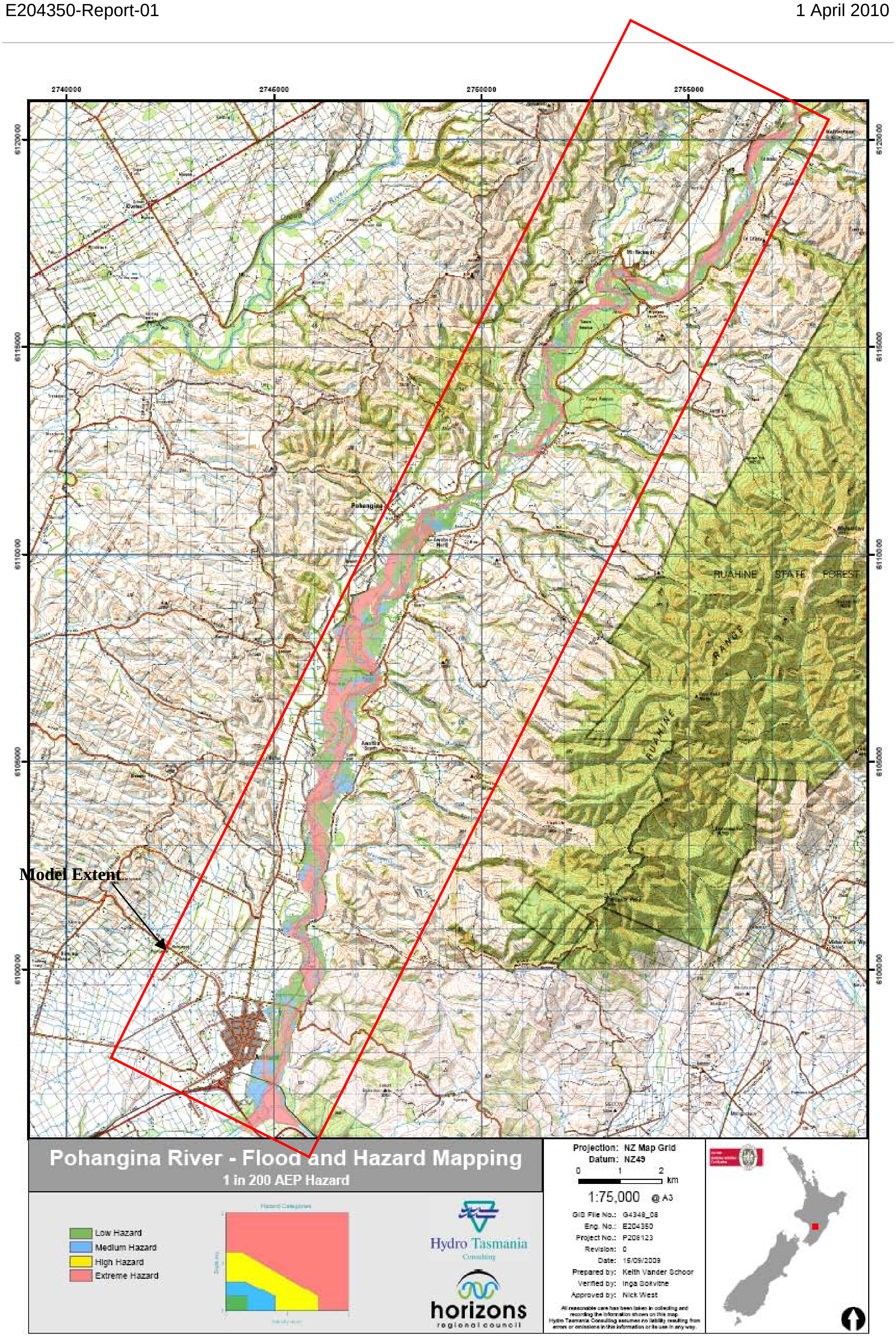

Figure 5-4 1 in 200 AEP Flood Hazard Map

6. Intermediate Flood Runs

A series of intermediate floods between the breakout flow for the river (approximately 300m^3/s) and the 1 in 100 AEP peak discharge were run through the Pohangina River MIKE FLOOD model to provide HRC with a series of raw results files. These results files will be used in the waterRIDE software package to view real-time estimates of flood extents based on output from the flood warning system of the river that was previously developed by HTC.

The February 2004 flood hydrograph was used as the basis of the intermediate floods and the inflow hydrographs to the MIKE FLOOD model for these events were scaled so that the peak discharges at the Mai's Reach gauge site matched the required peak flows as outlined in Table 6-1.

The raw results files were provided to Worley Parsons on behalf of HRC.

Table 6-1: Peak discharge at Mai's Reach for intermediate floods

Intermediate Flood	Peak Discharge at Mai's Reach (m^3/s)	Peak Discharge top end of model (m^3/s)	Gauge Height at Mai's Reach (m)
1	300	308	2.8
2	350	365	3.0
3	400	483	3.2
4	450	589	3.4
5	500	699	3.6
6	550	797	3.8
7	650	909	4.0
8	750	1012	4.2
9	875	1120	4.4
10	1050	1211	4.6

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7. References

Hydro Tasmania Consulting, *Horizons Regional Council Flood Forecasting System – Upper Manawatu Catchment Operating Manual*, 121040-Report-03, November 2008.

CSIRO, 2000, *Floodplain Management in Australia: Best Practice principals and Guidelines*, SCARM Report 73

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Appendices

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Appendix A Flood Hydrographs

Flood hydrographs used for Model Calibration.

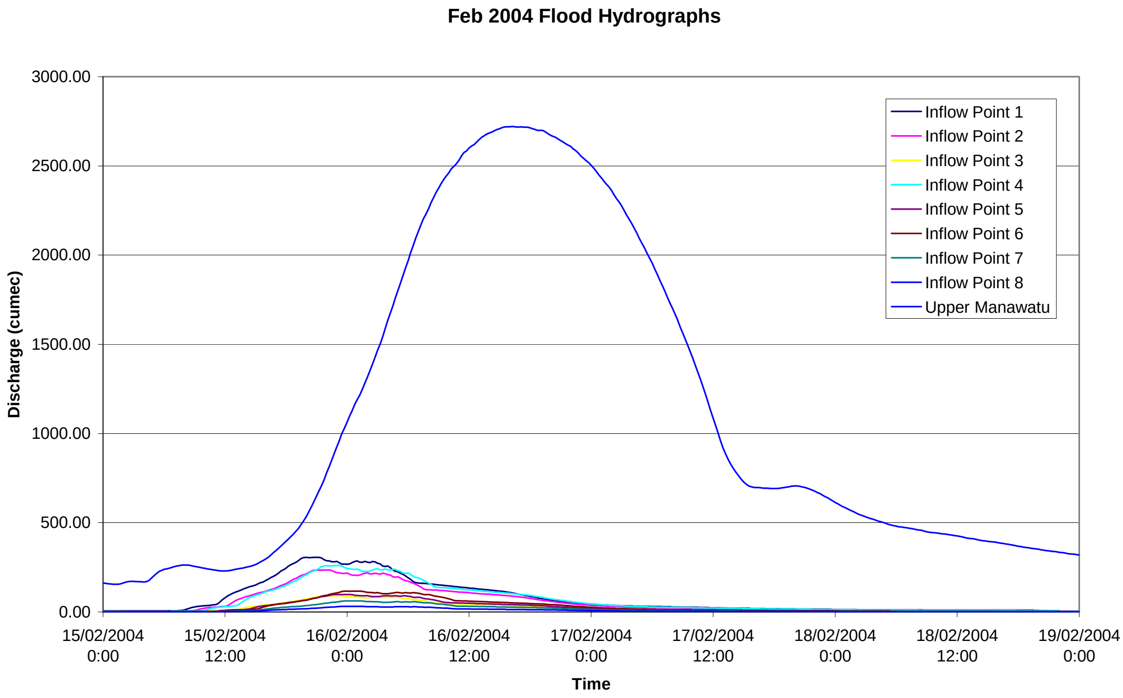

Figure A-1: February 2004 Flood Hydrographs

Flood hydrographs used for Designed Model Run.

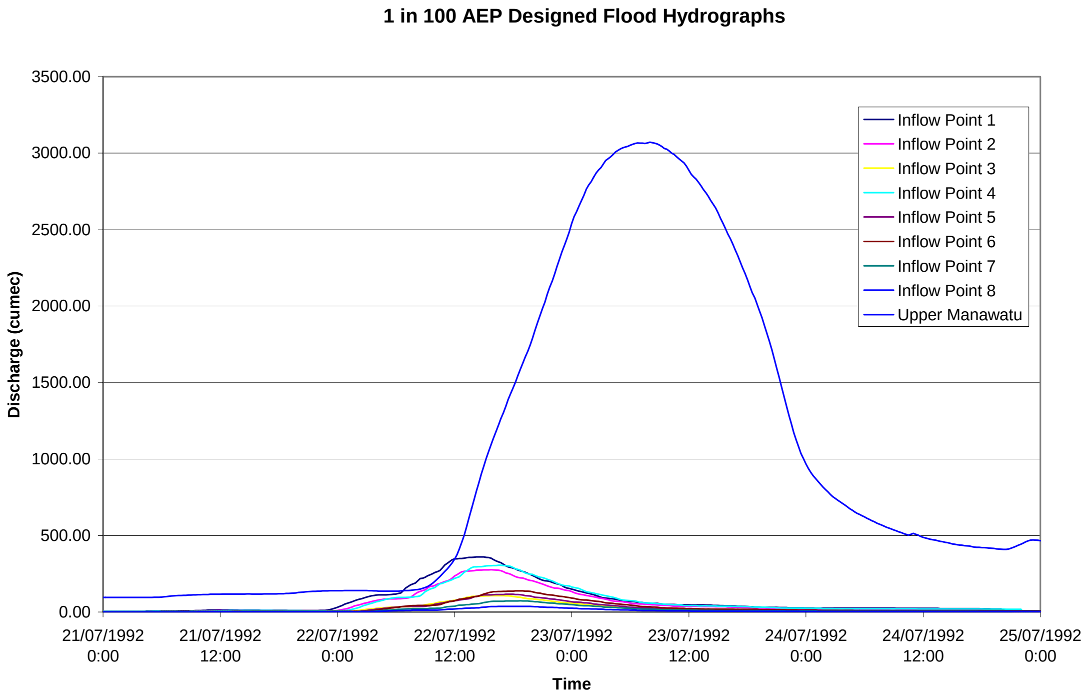

Figure A-2: 1 in 100 AEP Designed Flood Hydrographs

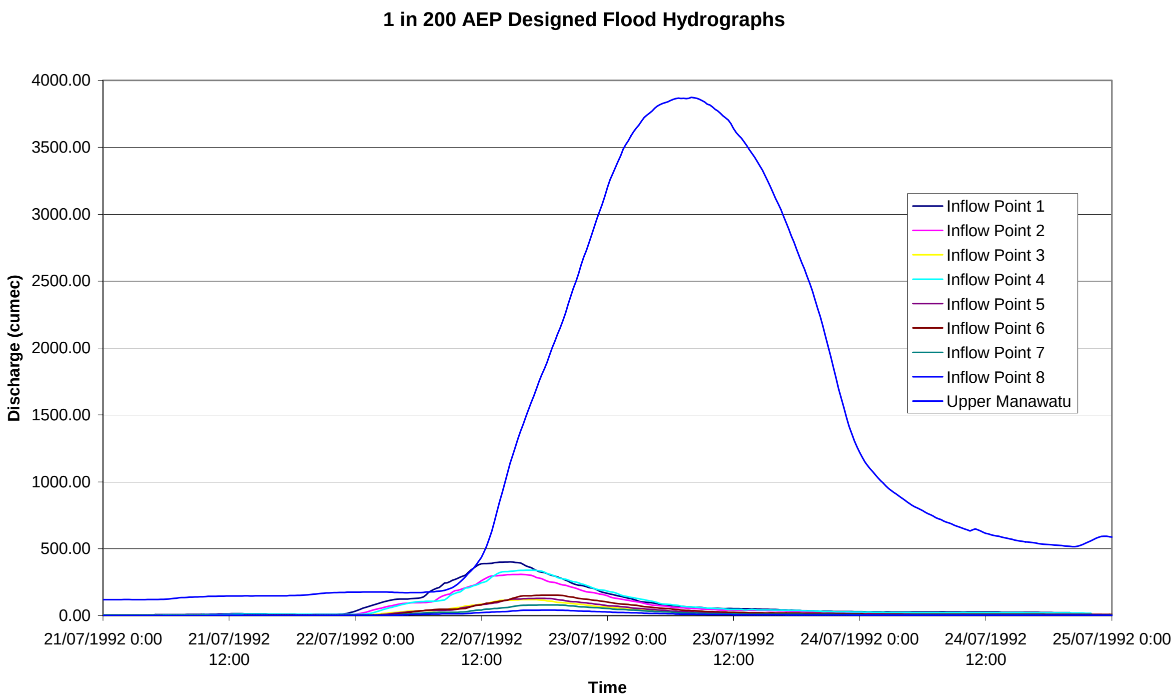

Figure A-3: 1 in 200 AEP Designed Flood Hydrographs

Appendix B Typical Cross Section of Bridge

Survey Provided by HRC

Offset(m)	Wellington Vertical (m)	
0.000	101.156	
0.369	99.585	Bridge soffit RL
1.419	97.562	
2.327	97.337	
4.153	96.433	
6.175	96.035	
7.438	95.174	
8.832	93.959	
10.717	94.516	
15.490	94.695	
21.201	94.699	
24.109	94.387	
26.093	94.116	
28.672	93.845	
30.342	93.630	
32.492	93.547	
34.645	93.700	
37.164	93.877	
40.221	94.714	
42.777	94.904	
45.463	95.263	
55.327	95.062	
63.204	95.065	
69.306	95.149	
74.070	95.788	
80.264	96.154	
84.148	97.144	
85.530	97.239	
86.365	99.550	Bridge soffit RL
86.699	101.156