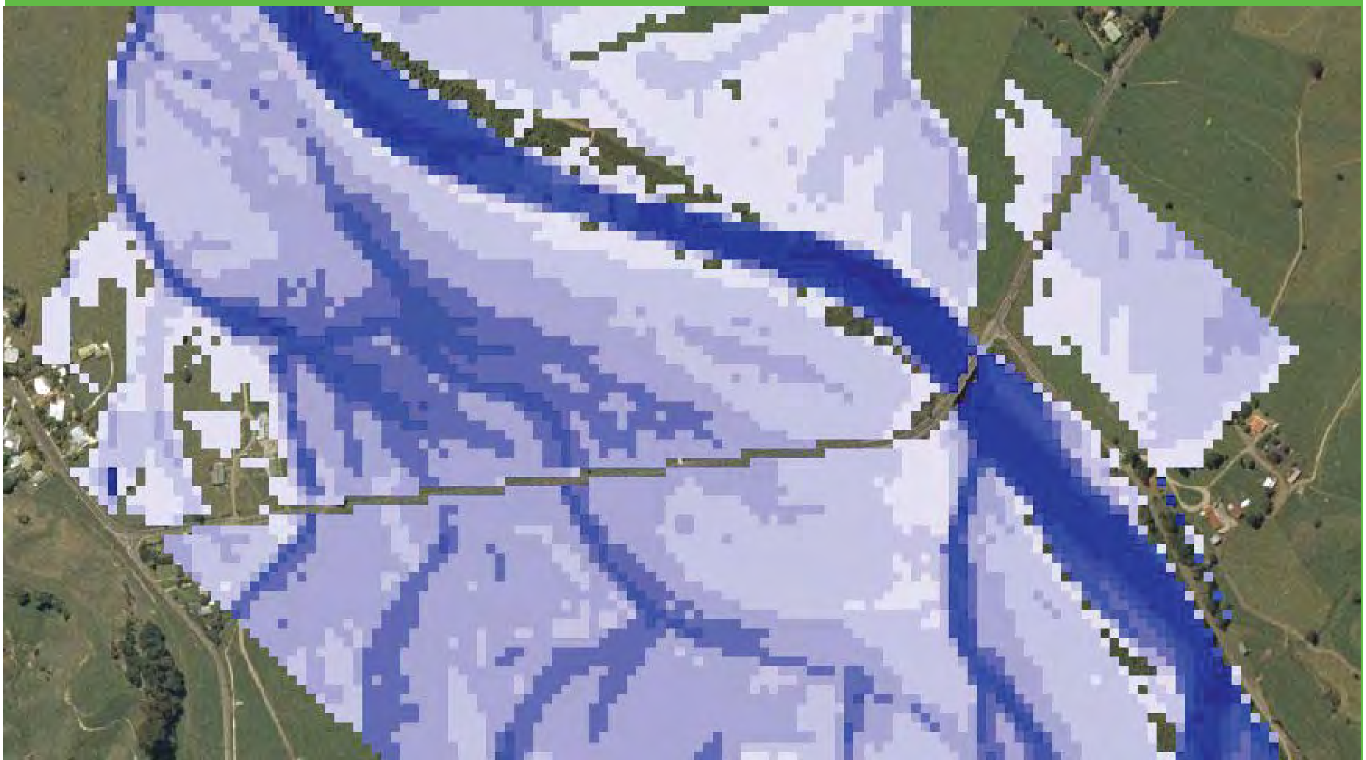
Hydraulic Modelling for the Waimana River and Floodplain

Prepared by Ingrid Pak, Environmental Engineer



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Executive Summary

A steady state computer model was constructed using Mike11 software, to estimate the flood levels for various design flows in the Waimana River upstream of the Waimana Gorge recorder.

The model was calibrated against observed peak levels for the July 2004 flood and verified against the July 1998 flood.

Maps of flood depth were produced for the various design flows, overlaid onto topographical maps for use in conjunction with other work, in the development of a floodplain management strategy for the Whakatane and Waimana Rivers.

Contents

Chapter 1: Introduction

Environment Bay of Plenty manages the Whakatane River Scheme covering the Whakatane and Waimana Rivers and tributaries (Figure 1).

A floodplain management plan is to be prepared for the Whakatane and Waimana floodplains, with the aim of minimising the flood risk. The first stage of this process is a review of the existing hazard.

This report describes the hydraulic modelling of the Waimana River and its floodplain.

There are no stopbanks along the Waimana River, and no hydraulic modelling has been done previously.

The main objectives of producing such a model are:

- To produce flood hazard maps of the floodplain
- To assist with setting minimum floor levels for new development
- To assist in flood warning

Separate models have been developed for the Lower and Upper Whakatane Rivers.

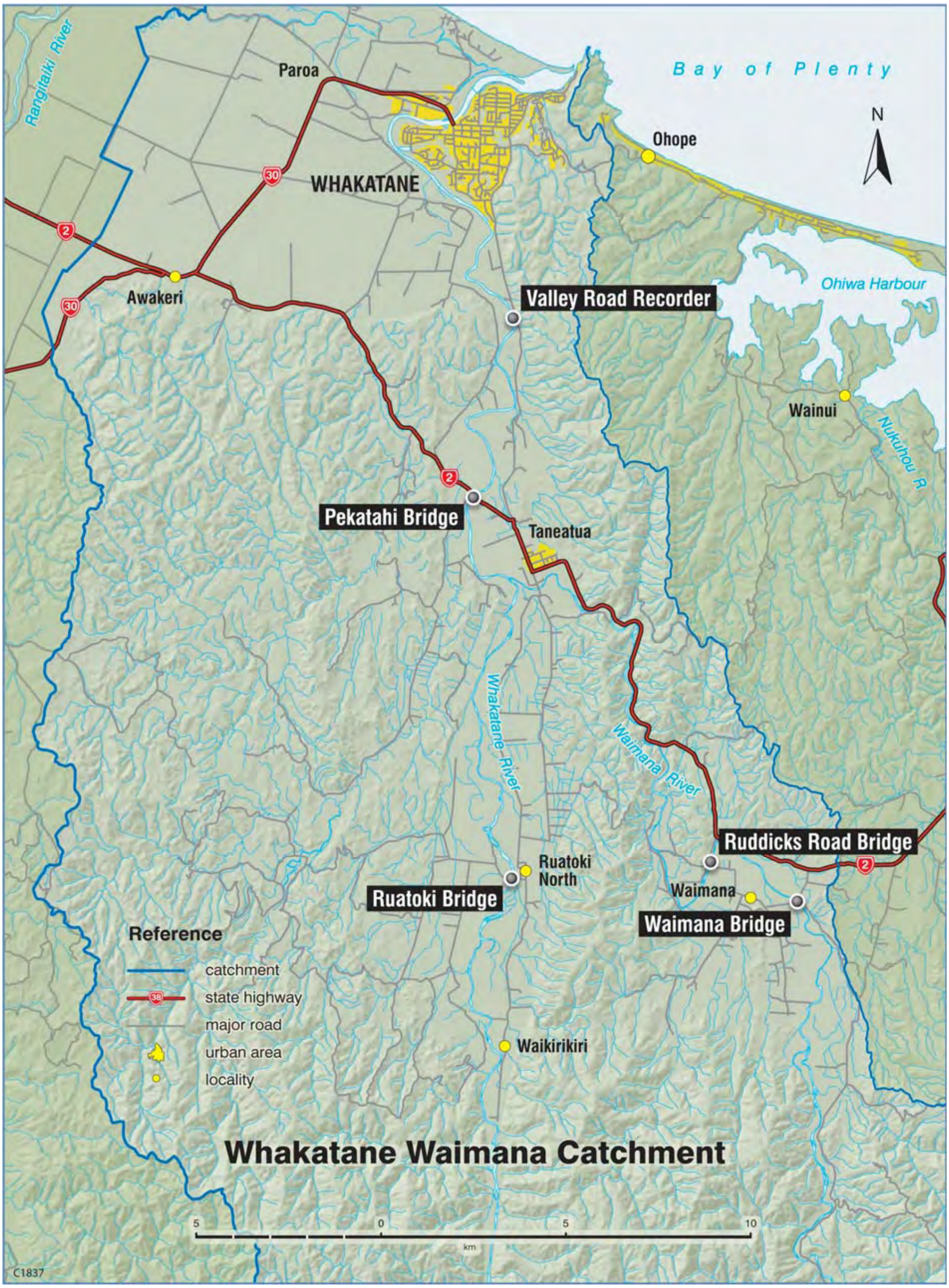


Figure 1 Whakatane Waimana Catchment

Chapter 2: Extent of Model

The model covers the Waimana River from where it leaves the incised valley and comes onto its floodplain down to partly into the Waimana Gorge. The upstream end of the model is at cross-section 33, about 1km upstream of Piripari marae. The downstream end of the model is located at cross-section 10A, just upstream of the Waimana Gorge recorder site.

Only one version of the model has been produced, both for calibration and verification purposes, as well as for prediction scenarios. It includes the main river channel and the wider floodplain, as well as the Parau Stream and Matatere Stream tributaries.

Chapter 3: Model Software

Mike11, a software program developed by DHI, has been used as the principal modelling tool. It has had extensive use around the world, and has been widely used in New Zealand, including by Environment Bay of Plenty, for 15 years.

Mike11 uses the Saint-Venant one-dimensional unsteady flow equations to model open channel flow. It allows branched and looped networks of channels to be modelled and can also thus model flood plains flow in quasi two-dimensional manner. An unsteady model is considered essential for this exercise, due to the storage out of the main channel. Weirs, culverts and other hydraulic structures can also be modelled with Mike11.

Chapter 4: Model Layout

4.1 General

In building the model, extensive use was made of aerial photographs, LIDAR data and various cross-sections. Figure 2 shows the full extent of the model.

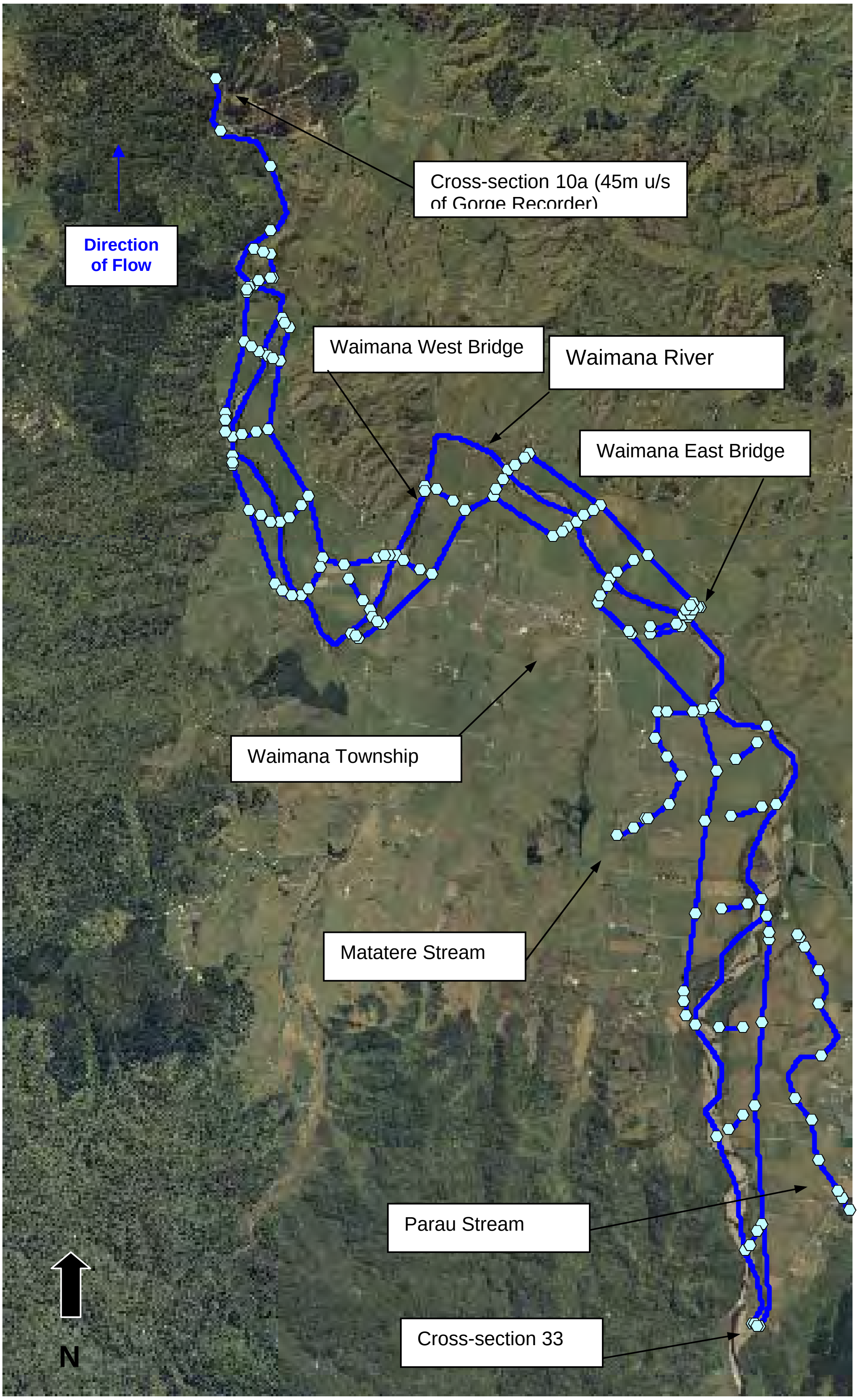


Figure 2 Model layout (Calibration, Verification and Prediction Scenarios)

4.2 Cross-section and Topographical Information

4.2.1 Waimana River and Floodplain

Several sets of river cross-sections have been used for the main channel and the floodplain. The survey dates for each purpose is listed in Table 1.

Table 1 Cross-section dates

Model purpose	Event	Cross-section survey date	Comment
Calibration	July 2004	November 2003	Plus extended cross-sections from 2003
Verification 1	July 1998	November 1996	Plus extended cross-sections from 2003
Verification 2	Feb 2001	November 1999	Plus extended cross-sections from 2003
Prediction Scenarios	-	September 2004	Plus extended cross-sections from 2003

During the July 1998 flood, flooding occurred outside the areas covered by the regular river cross-sections surveys. In order to match the extent of the model to the extent of flooding observed in the 1998 floods and the extent of expected flooding during predictive scenarios, the existing cross-sections have been extended out onto the wider floodplain where required. This survey was carried out in October 2003.

Additional floodplain topography data have been obtained. A LIDAR (Light Detection and Ranging) survey of the Waimana floodplain was undertaken in 2003, covering the area from cross-section 33 (upstream end of model) to cross-section 22 (Figure 3). From the LIDAR data, Mike11 GIS has been used to produce a Digital Terrain Model (DTM) based on a rectangular grid of 10 by 10 metres.

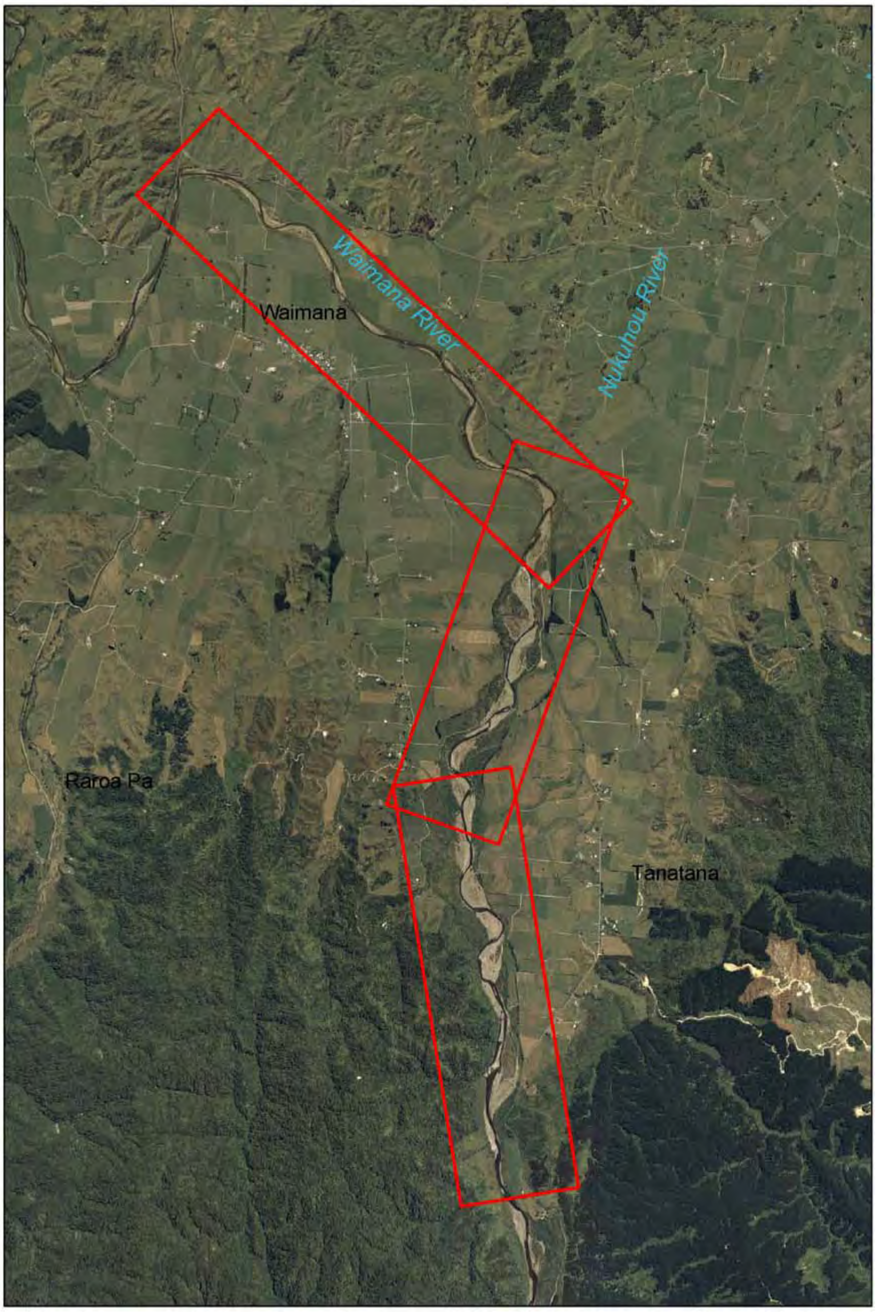


Figure 3 Extent of LIDAR survey/DEM

From the cross-section data and the DTM, a network of one-dimensional floodplain channels or ponding areas (where water was more likely to pond rather than flow) has been schematised. In doing this, some simplifications have been required due to the limitations of the one-dimensional approach.

4.2.2 Parau Stream and Matatere Stream

Cross-sections of the Parau Stream from Matahi Road to the confluence and of the Matatere Stream from upstream of Hodge Road to the confluence have been surveyed in October 2003. Both tributaries have been linked to the Waimana network.

4.2.3 River – Floodplain Connections

Connections between the main river channel and floodplain channels have been treated as Mike11 “link channels”. These treat the connection as a weir. The weir width has been measured from the council GIS, and generally goes to either midway to the next cross-section (where a further link channel is specified if required) or to what is considered to be the end of the length of the overflow weir.

Within the area of LIDAR coverage, the geometry of the overflow weir in the link channels is represented by a bank level profile which has been created from the DTM. These profiles have some “noise” but the points have been accepted as-is. Ground survey could be carried out to check some locations if further checks are required.

As the over-bank flow is controlled by the river levels at cross-sections (where the river-floodplain connection is specified), the bank levels need to be rotated parallel to the water surface levels, to ensure that the correct relative difference between river level and bank level is maintained along each link. To do this, the water surface slope has been taken from preliminary calibration peak water levels from the model.

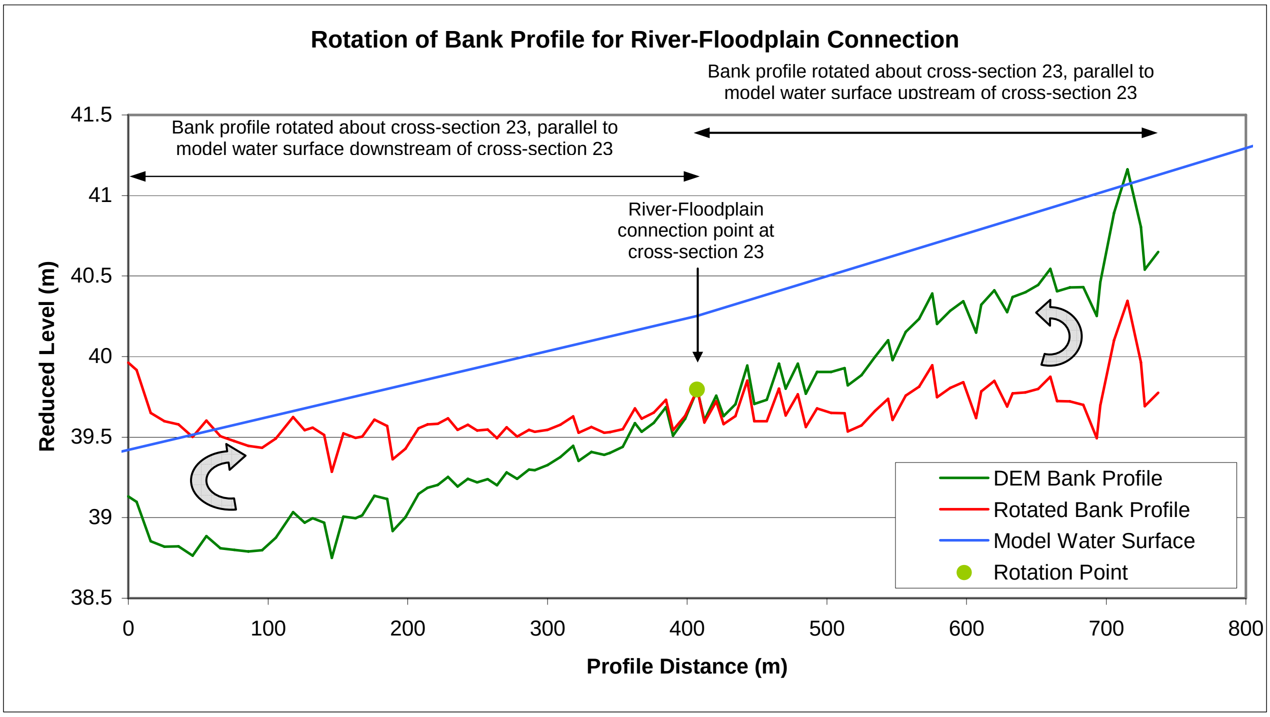


Figure 4 – Example of bank level profile rotation

In the area outside of LIDAR coverage, a simple geometry of all river-floodplain connections has been assumed. This geometry takes the level from the adjacent river cross-section that represents the boundary between the main river and floodplain channel and uses it as the minimum crest or low point of the “weir” (Figure 5).

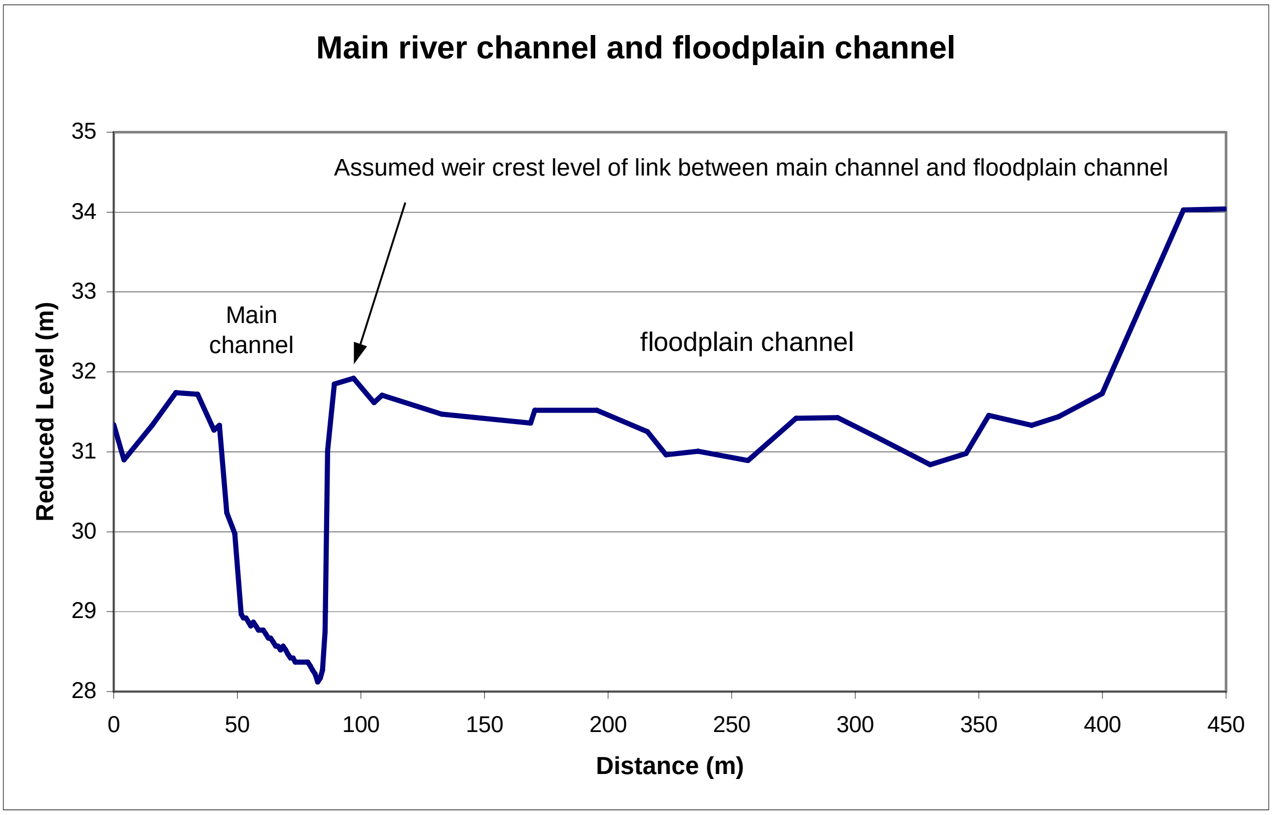


Figure 5 *Example of simple link between parallel channels (Waimana cross-section 18)*

Chapter 5: Calibration

5.1 Calibration Event and Data

Data from the July 2004 flood have been used to calibrate the model.

The Eastern Bay experienced extensive flooding in July 2004. In the Waimana River this flood is regarded to have had the same peak flow as the July 1998 flood at the Gorge recorder and was considered to be an approximately 60 year event. The 2004 flood was chosen over the 1998 flood as calibration event, as more and better flood level data were collected after the 2004 flood.

The data consist of the following:

- Peak flood levels along the river from cross-section 33 to the recorder site
- Recorded water level hydrographs at the Gorge recorder

5.2 Calibration Assumptions

5.2.1 Inflows

(a) Waimana

As the only recorder site upstream of the model (Ranger Station) is not rated, the inflow at the upstream boundary of the model has been based on the flow at the Gorge recorder site (downstream boundary of the model). The method used is based on the "Whakatane River Scheme Middle Reaches Investigation" by B R Titchmarsh (1992). The peak flow at the Gorge recorder site on 18 July 2004 was approx. 1100m^3/s (refer email from Peter Blackwood from 5 November 2004).

Titchmarsh gives the design dominant discharge at each cross-section along the river, depending on the catchment size at each cross-section. From his numbers, the July 2004 discharge at each cross-section has been pro-rated based on the flow at the Gorge recorder site. This not only provides the flow at the upstream boundary condition (913m^3/s) but also lateral inflows at cross-sections to account for tributaries.

The approach described above did not lead to satisfactory calibration results and produced a mismatch of simulated and recorded flow at the downstream boundary. Therefore, as part of the calibration, both the upstream and lateral inflows have been adjusted as follows (Table 2):

Table 2 Inflow adjustments during calibration

Cross-section	Flows as per "Titchmarsh method" (m^3/s)	Inflow (m^3/s)	Adjustment (%)	Adjusted flows (m^3/s)	Comment
33	913	913	70	640	Upstream boundary
32	913	-	70	-	
31	913	-	70	-	
30	913	-	70	-	
29	913	-	70	-	
28	933	20	70	14	Lateral inflow (Parau St)
27	940	7	70	5	Lateral inflow
26	947	7	70	5	Lateral inflow
25	967	20	70	14	Lateral inflow (Matatere St)
24	967	-	70	-	
23	967	-	70	-	
22	977	10	70	7	Lateral inflow
21	977	-	70	-	
20	1027	50	70	35	Lateral inflow
19	1027	-	70	-	
18	1040	13	70	9	Lateral inflow
17	1060	20	70	14	Lateral inflow
16	1063	3	960	28.8	Lateral inflow
15	1067	4	960	38.4	Lateral inflow
14	1067	-	960	-	
13	1070	3	960	28.8	Lateral inflow
12	1080	10	960	96	Lateral inflow
11	1100	30	960	192	Lateral inflow
10a	1100	-	960	-	

The July 2004 storm was unusual in the way the rainfall intensities were centred around the lower parts of the catchments rather than the higher ranges. The above listed adjustments represent this fact and therefore seem justified.

The upstream boundary condition flow hydrograph is plotted in Figure 6.

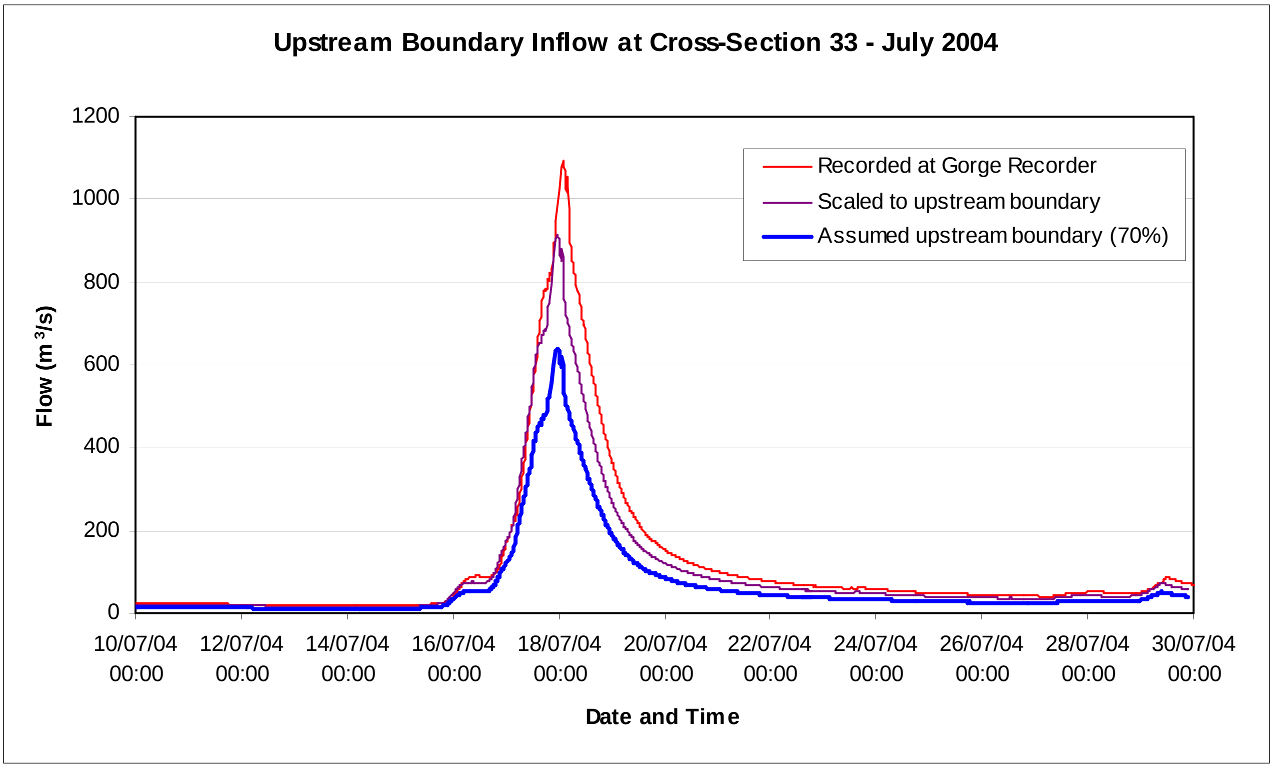


Figure 6 July 2004 flow hydrograph at cross-section 33

The timing of the peak has been shifted by 4 hours backwards to account for travel time from the upstream to the downstream end of the model.

(b) Tributary catchments

The tributary catchments have been accounted for by applying lateral inflows using Titchmarsh' method and adjustments as described above. The hydrographs for lateral inflows are based on the same hydrograph used for the downstream boundary condition (i.e. the hydrograph recorded at the Gorge recorder) and scaled to the individual inflow at each cross-section. The inflows via the Parau and Matatere Streams have been defined the same way, but instead of lateral inflows they become the upstream boundary conditions of each stream branch.

The timing of the lateral inflow hydrographs have been chosen to coincide with the hydrograph at the downstream boundary condition. This assumption has been made to minimise the effort in setting up the lateral inflows. It is considered to be fair, as it is unlikely that all tributaries peak at the same time as the peak moves past their confluence. Also it weights the influence of the downstream tributaries stronger than the upstream tributaries, which reflects the pattern of the 2004 storm being concentrated in the lower parts of the catchment.

5.2.2 Downstream Boundary Condition

As the downstream boundary condition, the water level hydrograph recorded at the Gorge recorder is used (Figure 7). Part of this hydrograph is artificial as the float got stuck during the event and the hydrograph has been adjusted to the debris mark left in the recorder housing. Since the recorder is situated 45 metres downstream of cross-section 10A (downstream end of the model), the hydrograph used as the downstream boundary has been adjusted using the river slope in this reach.

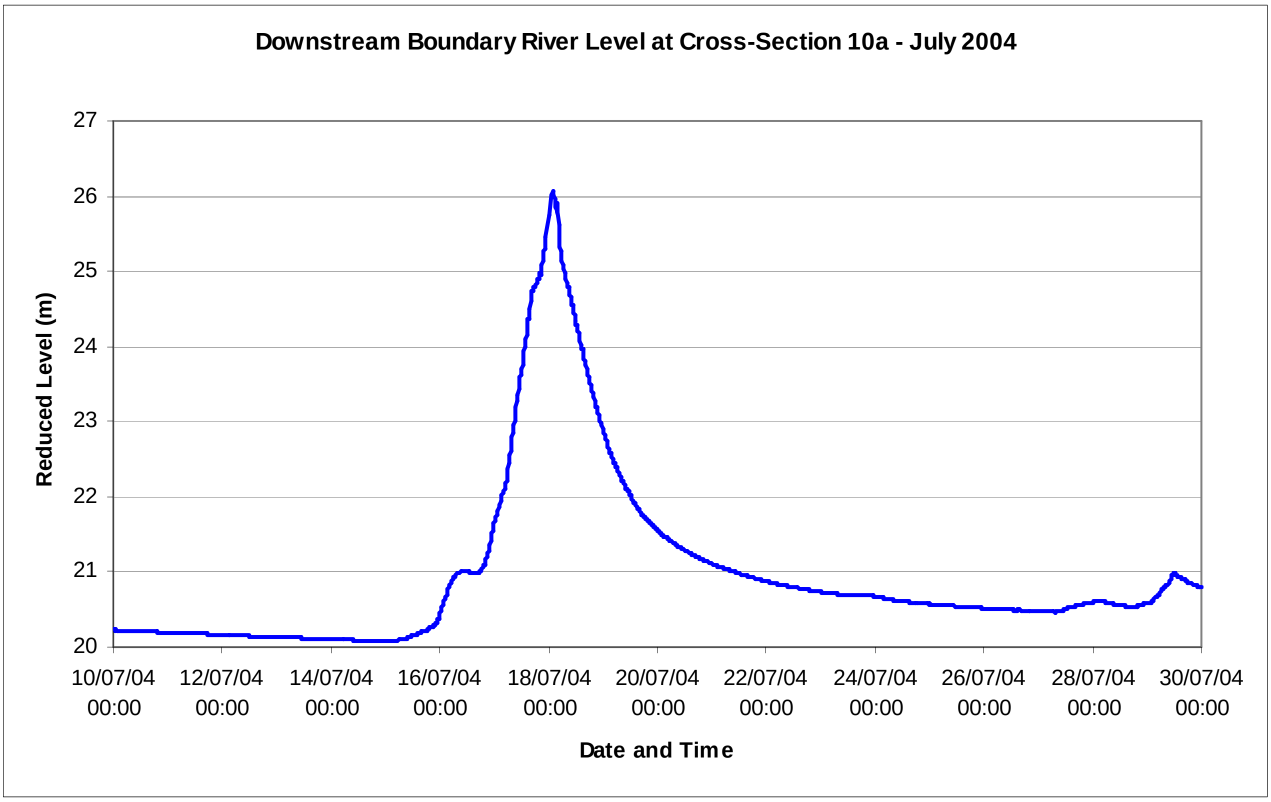


Figure 7 July 2004 stage hydrograph at cross-section 10a

5.2.3 Manning's n

Within each channel, i.e. in the main channel or in a floodplain channel, a uniform Manning's n across a section has been used. Manning's n for each cross-section has first been estimated using Hicks&Mason and the Gary Williams formula ($n=0.104\ s^{0.178}$, where s is the river slope). Some adjustments have been made during the calibration process and the details are given in Appendix A.

5.2.4 Cross-sections

The most recent cross-sections before the July 2004 flood were used for the calibration which were surveyed in November 2003. This is based on the assumption that river cross-section changes tend to occur more on the flood recession rather than earlier, and the pre-flood cross-sections are considered more representative of actual conditions at the peak of the flood.

5.2.5 Bridges

The two bridges within the model reach (Waimana East Bridge and Waimana West Bridge) have not been specifically modelled other than by means of geometry (cross-sections), as instability problems occurred when trying to model them as culverts.

5.3 Results and Discussion

Calibration has been difficult due to the uncertainties at the model boundaries, especially the upstream and lateral inflows.

The calibration achieved an average absolute model error (calculated from 20 data points) of 0.36 m. The model particularly over-predicts the flood levels at cross-section 23 and 19, and under-predicts in the reach from cross-section 16 to 12.

The calibration results, i.e. recorded peak water levels versus simulated peak water levels, are plotted in Figure 8. Table 3 lists the results including the deviation.

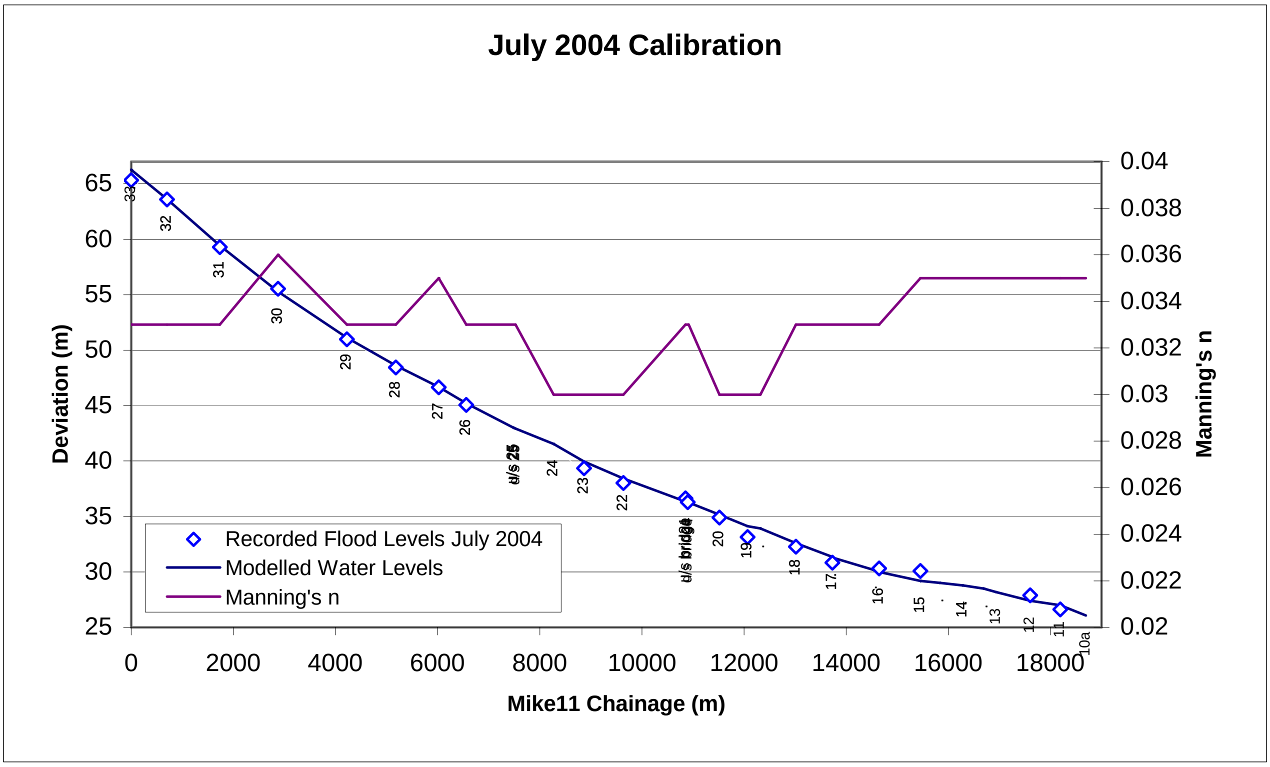


Figure 8 *Peak flood levels (model calibration)*

Table 3 *Calibration results (July 2004)*

Cross-section	Mike11 Chainage	Simulated peak water level (m)	Recorded flood level (m)	Deviation
33	0	66.28	65.34	-0.94
32	700	63.63	63.60	-0.02
31	1735	59.43	59.30	-0.13
30	2875	55.28	55.53	0.26
29	4225	51.13	50.98	-0.15
28	5185	48.62	48.45	-0.17
27	6025	46.69	46.66	-0.03
26	6560	45.22	45.07	-0.15
u/s 25	7485	43.02	-	
25	7505	42.97	-	
d/s 25	7525	42.93	-	
24	8270	41.55	-	
23	8865	39.96	39.34	-0.62

Cross-section	Mike11 Chainage	Simulated peak water level (m)	Recorded flood level (m)	Deviation
22	9640	38.43	38.03	-0.40
21	10855	36.34	-	
u/s bridge	10875	36.33	36.62	0.29
d/s bridge	10915	36.26	36.29	0.03
20	11515	35.16	34.89	-0.27
19	12070	34.12	33.14	-0.98
18	13015	32.59	32.28	-0.31
17	13730	31.28	30.82	-0.46
16	14645	29.99	30.30	0.31
15	15455	29.18	30.08	0.90
14	16280	28.78	-	
13	16940	28.16	-	
12	17600	27.38	27.88	0.50
11	18190	26.99	26.61	-0.38
10a	18690	26.06	-	
		Average Absolute Error:		**0.36**

Chapter 6: Verification

6.1 Verification Events and Data

Data from the July 1998 flood and a smaller flood in February 2001 have been used to verify the model.

The July 1998 flood at the Gorge recorder was considered to be an approximately 60 year event with a peak flow of 1100m^3/s (i.e. approximately the same as the July 2004 flood). The February 2001 event is considered a 6 year flood (peak flow 572m^3/s).

The data consist of the following:

- Peak flood levels along the river from cross-section 33 to the recorder site for both events
- Recorded water level hydrographs at the Gorge recorder for both events

6.2 Verification Assumptions

6.2.1 Inflows

(a) Waimana

The inflow at the upstream boundary of the model (475m^3/s) has been based on the flow at the Gorge recorder site (downstream boundary of the model) and scaled down using the Titchmarsh method as explained for the Calibration model.

This inflow combined with scaled lateral inflows gave a good match of simulated to recorded flows at the downstream boundary, so no adjustment of the flows was necessary (i.e. 100% flows were used). Both these storms seem to follow a more typical storm pattern, i.e. the rain was centred in the higher ranges rather than the lower catchment. Therefore, again the assumption of 100% flows is justified.

The upstream boundary condition flow hydrographs for both events are plotted in Figure 9 and Figure 10.

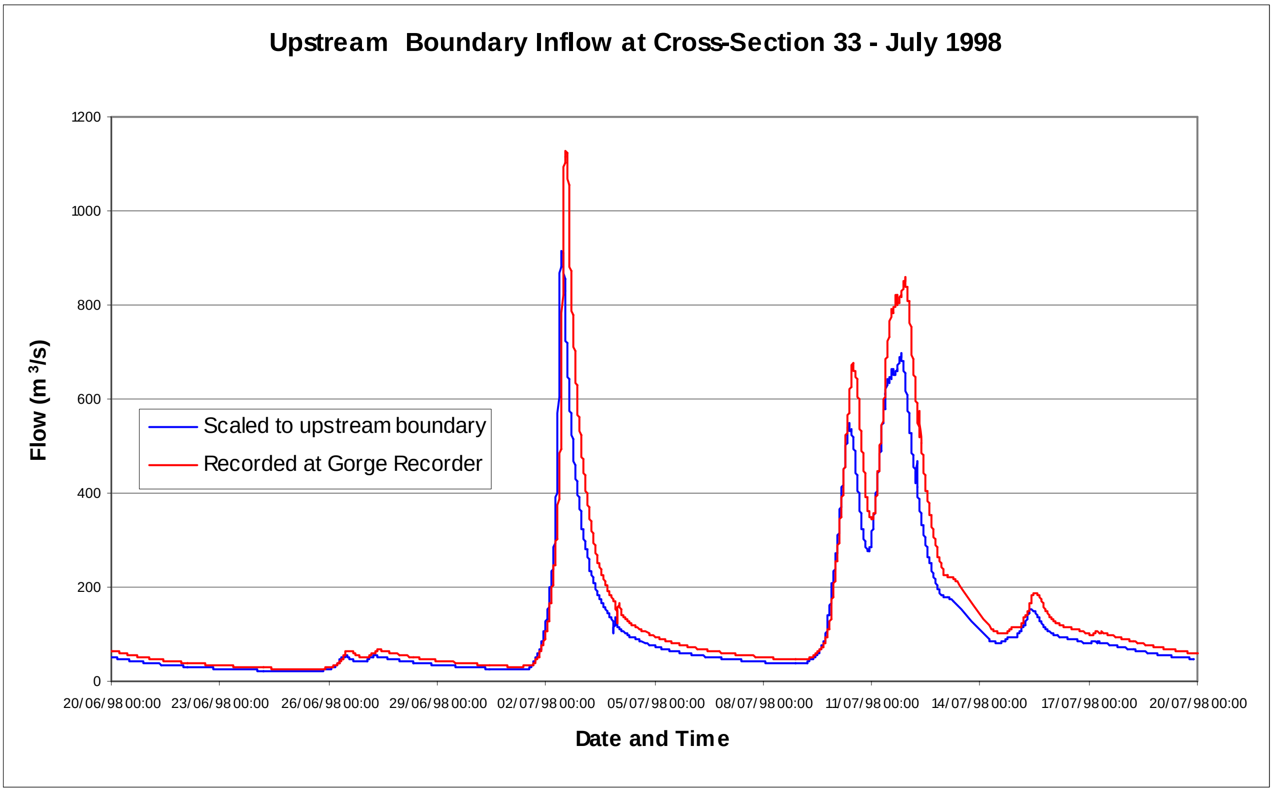


Figure 9 July 1998 flow hydrograph at cross-section 33

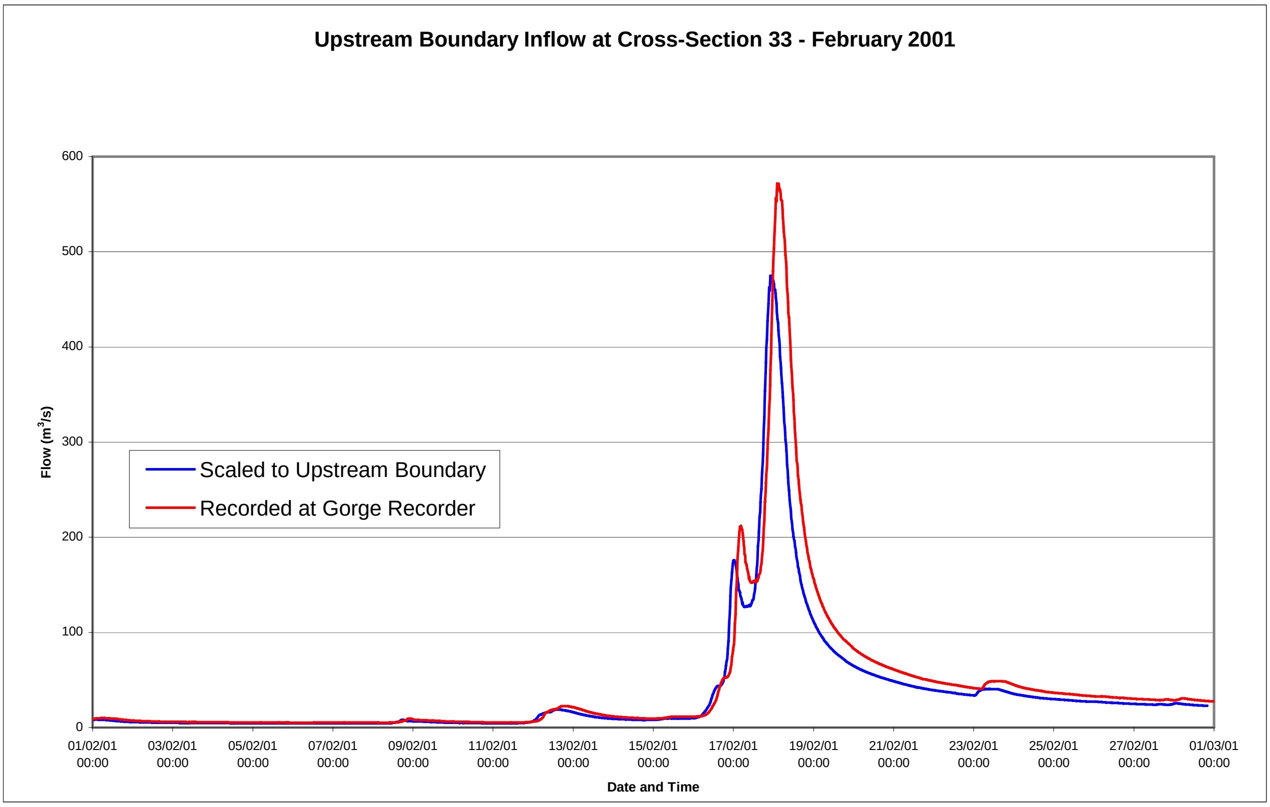


Figure 10 February 2001 flow hydrograph at cross-section 33

As in the calibration model, the timing of the peak at the upstream boundary has been shifted by 4 hours backwards to account for travel time from the upstream to the downstream end of the model.

(b) Tributary catchments

The same assumptions as for the calibration model have been made. All lateral inflows have been taken as 100%.

6.2.2 Downstream Boundary Condition

As the downstream boundary condition for the July 1998 flood, the water level hydrograph recorded at the Gorge recorder is used. Part of this hydrograph is artificial as the recorder had been washed away during the event, and the hydrograph has been adjusted to the debris mark left in the recorder housing.

As the downstream boundary condition for the February 2001 flood, the water level hydrograph recorded at the Gorge recorder is used.

Slight adjustments were required to the levels for use in the model as the recorder is situated 45m downstream from the downstream end of the model at cross-section 10a.

6.2.3 Manning's n

The same Manning's n settings as for the calibration model have been used.

6.2.4 Cross-sections

For the July 1998 verification model, the cross-sections surveyed in 1996 were used, but extended where applicable with the 2003 survey of the wider floodplain.

For the February 2001 verification model, the 1999 cross-sections were used, again extended where applicable with the 2003 survey of the wider floodplain.

6.2.5 Bridges

As for the calibrations model, the Waimana East and Waimana West bridges have not been specifically modelled other than by means of geometry (cross-sections), as instability problems occurred when trying to model them as culverts.

6.3 Results and Discussion

The 1998 verification achieved an average absolute model error (calculated from 13 data points) of 0.48 m. The model particularly under-predicts flood levels in the reach from cross-section 27 to 23.

Generally, the 1998 flood marks are higher than the 2004 flood marks. This would indicate that peak flows in 1998 were higher, which supports the assumption of flow adjustments in the calibration model, while using 100% flow in the verification model. There are some inconsistencies in the 1998 flood marks; for example the flood mark at cross-section 15 is higher than the flood mark upstream at cross-section 16. The flood mark at cross-section 15 has therefore been ignored.

The 2001 verification achieved an average absolute model error (calculated from 20 data points) of 0.31 m. The model particularly over-predicts flood levels at cross-section 25 (Waimana East Bridge) and under-predicts in the reach of cross-section 19 to 16.

The results of both verification runs, i.e. recorded peak water levels versus simulated peak water levels, are plotted in Figure 11. Tables 4 and 5 list the results including the deviations.

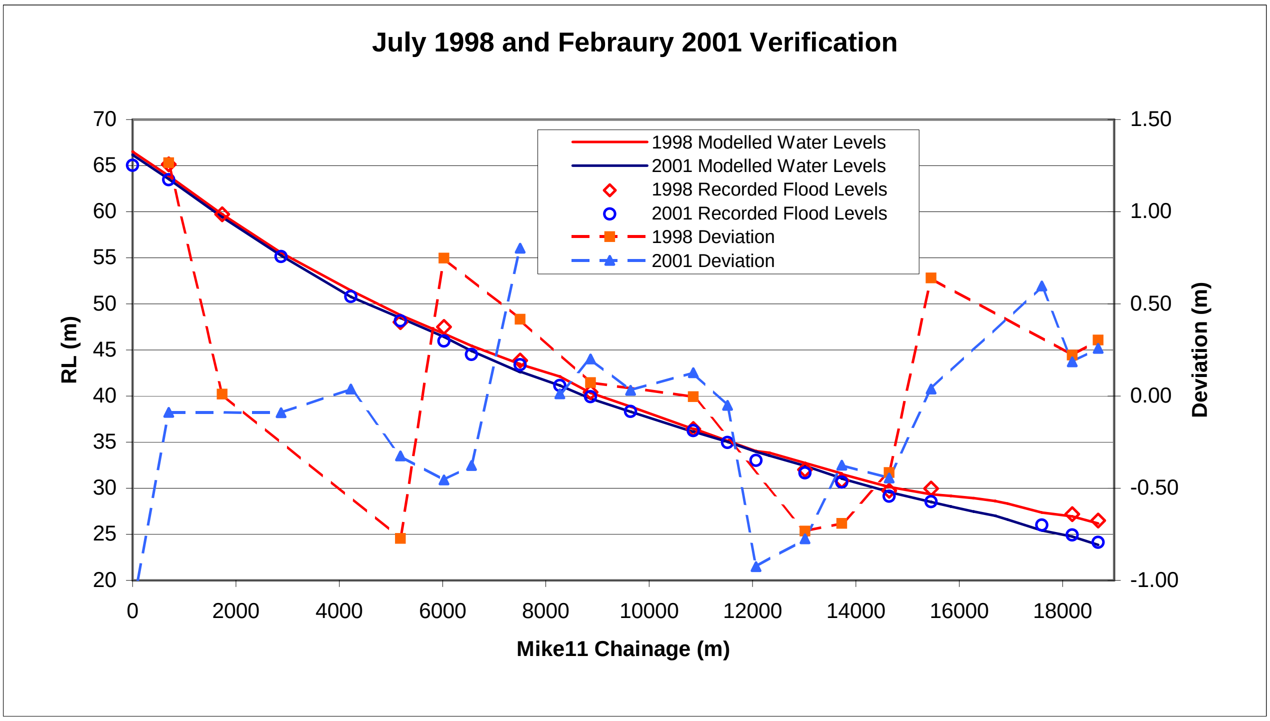


Figure 11 Peak flood levels (1998 and 2001 model verification)

Table 4 1998 verification results

Cross-section	Mike11 chainage	Simulated peak water level (m)	Recorded peak water level (m)	Deviation
33	0	66.53	-	
32	700	63.87	65.14	1.27
31	1735	59.72	59.73	0.01
30	2875	55.56	-	
29	4225	51.45	-	
28	5185	48.78	48.01	-0.77
27	6025	46.76	47.51	0.75
26	6560	45.46	-	
u/s 25	7485	43.49	-	
25	7505	43.42	43.84	0.42
d/s 25	7525	43.39	-	
24	8270	42.11	-	
23	8865	40.34	40.41	0.07
22	9640	38.84	-	
21	10855	36.43	36.43	0.00
u/s bridge	10875	36.42	-	
d/s bridge	10915	36.34	-	
20	11515	35.13	-	
19	12070	34.03	-	
18	13015	32.75	32.02	-0.73

Cross-section	Mike11 chainage	Simulated peak water level (m)	Recorded peak water level (m)	Deviation
17	13730	31.52	30.83	-0.69
16	14645	30.14	29.72	-0.42
15	15455	29.33	29.97	0.64
14	16280	28.91	-	
13	16940	28.33	-	
12	17600	27.35	-	
11	18190	26.96	27.18	0.22
10a	18690	26.19	26.50	0.30
			Average Absolute Error:	**0.48**

Table 5 2001 verification results

Cross-section	Mike11 chainage	Simulated peak water level (m)	Recorded peak water level (m)	Deviation
33	0	66.19	65.04	-1.15
32	700	63.55	63.46	-0.09
31	1735	59.41	-	
30	2875	55.24	55.15	-0.09
29	4225	50.76	50.80	0.04
28	5185	48.48	48.16	-0.32
27	6025	46.44	45.98	-0.46
26	6560	44.90	44.52	-0.38
u/s 25	7485	42.65	-	
25	7505	42.62	43.42	0.80
d/s 25	7525	42.60	-	
24	8270	41.14	41.15	0.01
23	8865	39.74	39.94	0.20
22	9640	38.29	38.32	0.03
21	10855	36.12	36.25	0.13
u/s bridge	10875	36.12	-	
d/s bridge	10915	36.03	-	
20	11515	35.03	34.98	-0.05
19	12070	33.95	33.02	-0.93
18	13015	32.45	31.67	-0.77
17	13730	31.03	30.65	-0.38
16	14645	29.57	29.13	-0.44
15	15455	28.50	28.54	0.04
14	16280	27.48	-	
13	16940	26.60	-	
12	17600	25.42	26.02	0.60
11	18190	24.74	24.93	0.19
10a	18690	23.87	24.13	0.26
			Average Absolute Error:	**0.31**

Chapter 7: Predictive Simulations

7.1 Predictive Hydrological Conditions

The downstream boundary of the model is defined by a stage-flow relationship (rating curve).

The rating curve is based upon historical gaugings performed between 1965 and 1980 and a slope area gauging derived from the 1998 flood event. The 1998 slope area gauging has a derived mean velocity of 2.3m/s which seems plausible when compared with the historical gauging and was used to extend the top end of the last filed rating in July 1978. Be aware that confidence in the slope area gauging is limited (probably closer to +/- 15%). The rating curve has been visually extrapolated further to cater for predictive flows greater than the peak 1998 flow.

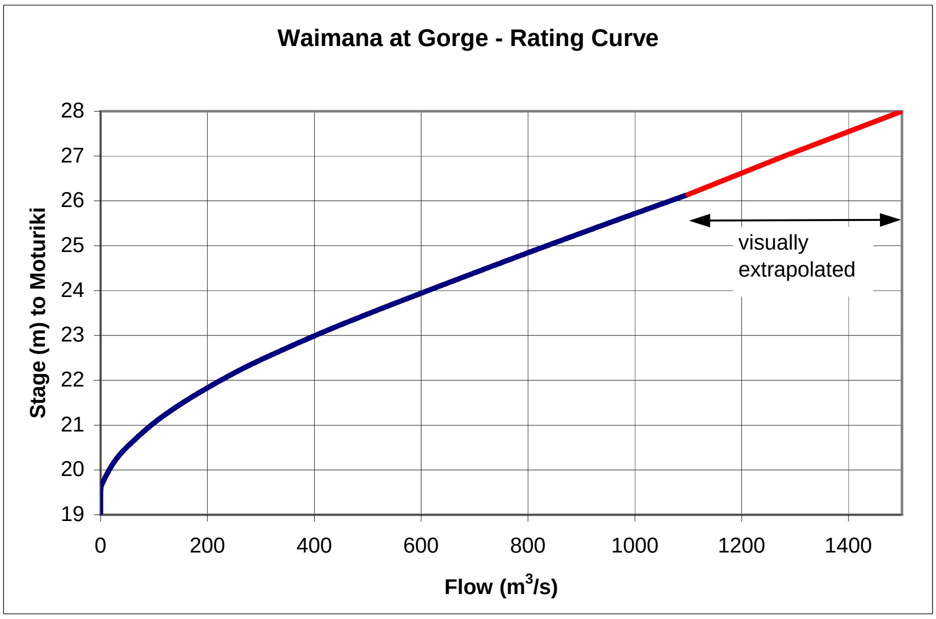


Figure 12 Predictive Downstream Boundary Condition (Rating Curve)

Several predictive inflow hydrographs at the upstream boundary (cross-section 33) have been modelled. These inflows have been based on the design flows at the Gorge recorder site (downstream boundary of the model) and scaled as per the Titchmarsh method described in the Calibration Chapter. In order to achieve a match between the design flows and the simulated flows at the recorder some adjustments were made to all inflows. Details of inflows used are listed in Table 6.

Table 6 Predictive Upstream Boundary Conditions (AEP and peak flows)

Event size	Design flow at Gorge recorder (m^3/s)	Flow at cross-section 33 as per Titchmarsh method (100%) (m^3/s)	Adjustment (%)	Adjusted flow at cross-section 33 (m^3/s)
0.5% AEP (200yr)	1430	1187	109	**1294**
1% AEP (100yr)	1240	1030	108	**1112**
2% AEP (50yr)	1050	872	109	**950**
5% AEP (20yr)	820	681	108	**735**
10% AEP (10yr)	670	556	112	**623**
20% AEP (50yr)	520	432	109	**471**

The shape of the hydrographs assumed is that of the July 1998 flood, as illustrated in Figure 13.

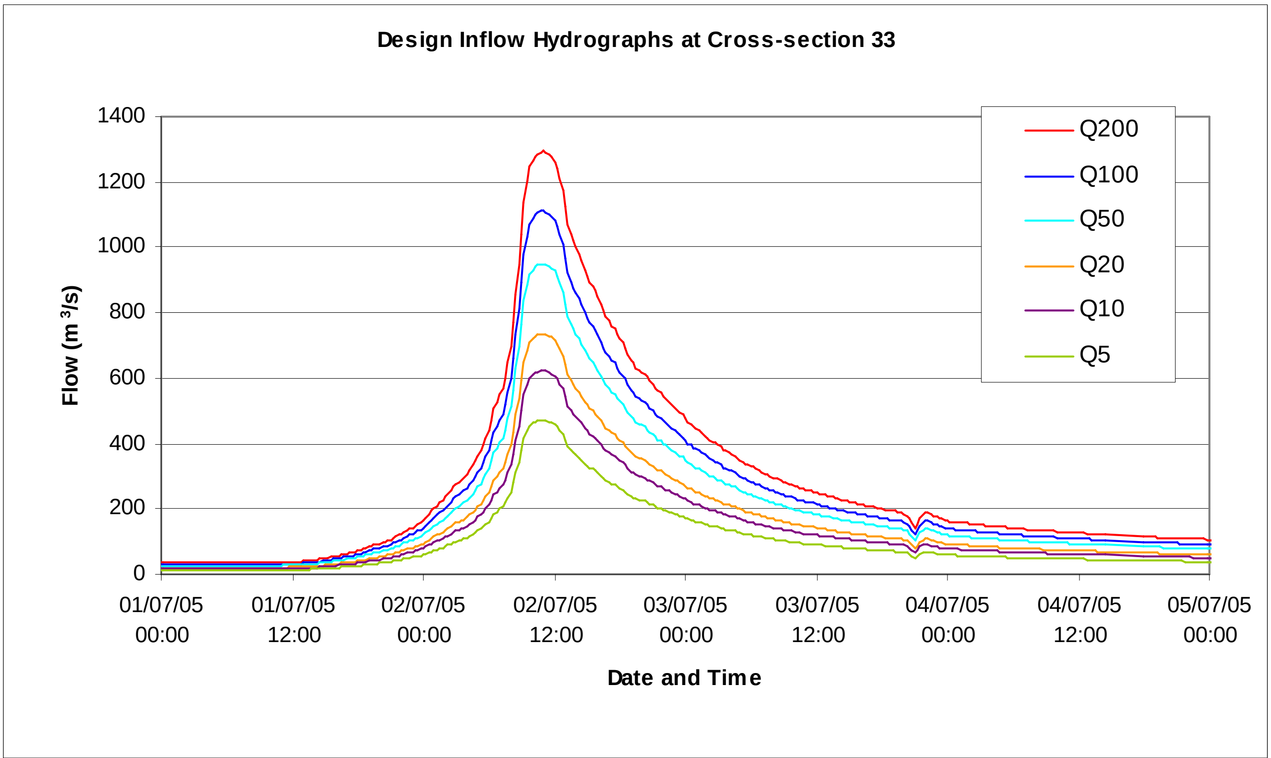


Figure 13 Design Inflow hydrographs

Lateral inflows have been adjusted by the same adjustment as the upstream boundary condition.

7.2 Predictive Model Layout

No changes to the model layout were required for the predictive model runs, apart from at the bridges. Due to the predictive flows being higher than the calibration flows, it is considered necessary to explicitly model the bridges in order to achieve an accurate simulation of water levels upstream of the bridges. Although the nature of both bridges (Waimana West Bridge and Waimana East Bridge) is not seen to cause large head losses, the bridges have been put into the model, with the soffit lowered by 0.6m for debris blockage.

The Waimana East Bridge has been satisfactorily modelled as a culvert.

The Waimana West Bridge has been modelled by increasing the resistance factor at the bridge cross-section at the level at which the soffit (lowered by 0.6m for debris blockage) is reached. A resistance factor of 2 was considered reasonable. This alternative was chosen due to instability issues when modelled as a culvert, and is considered accurate enough since any effect of the bridge to upstream water levels is not crucial to any areas other than the immediate vicinity of the river.

7.3 Predictive Water Level Results

The simulated water level profiles for the predictive scenarios are plotted in Figure 14, and tabulated in Appendix D.

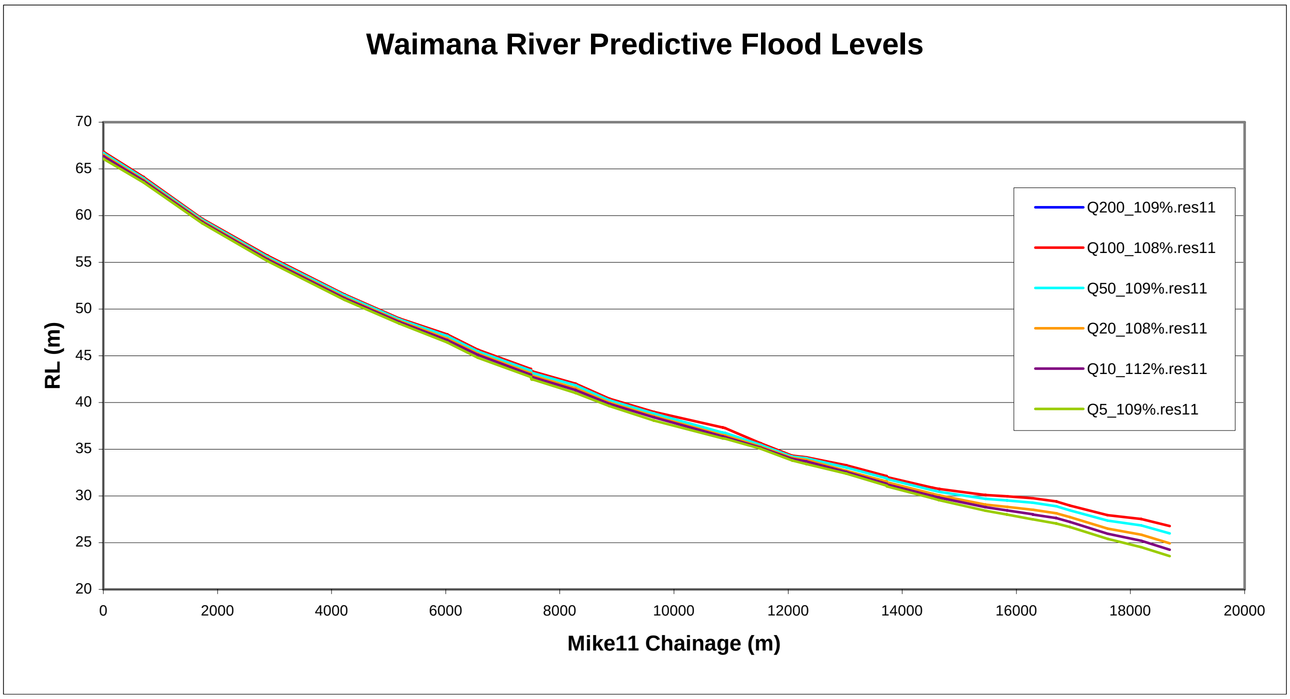


Figure 14 Predictive Flood Levels

For each of the predictive scenarios flood maps have been produced. These are attached in Appendix E.

Note that all water levels given do not include any freeboard, nor do the flood maps.

Chapter 8: Conclusions and Further Investigations

Calibration has been reasonably successful, although some anomalies exist between the observations (flood levels) and the simulations. This can be put down to uncertainties over river flows during the calibration and verification events.

Further investigation is recommended around the bridges by observation and collection of the upstream and downstream levels during a fresh in the future.

Nonetheless, the flood maps produced in this report give an indication of likely flooded areas in the scenarios modelled, allowing further work on estimating potential flood damages to begin and providing useful information for planning preparedness for future disasters and guidelines for future development (floor levels).

8.1 Reporting and Documentation

All models and associated files (e.g. spreadsheets) are stored on the Environmental Bay of Plenty computer network. Appendix F lists the most relevant files, including the Mike11 model and result files.

References

Iremonger, S. & Stringfellow, M. (2000); Environmental Data Summaries. Environment Bay of Plenty Environmental Report 2001/01.

Titchmarsh, B R (1992); Whakatane River Scheme Middle Reaches Investigation, Environment Bay of Plenty

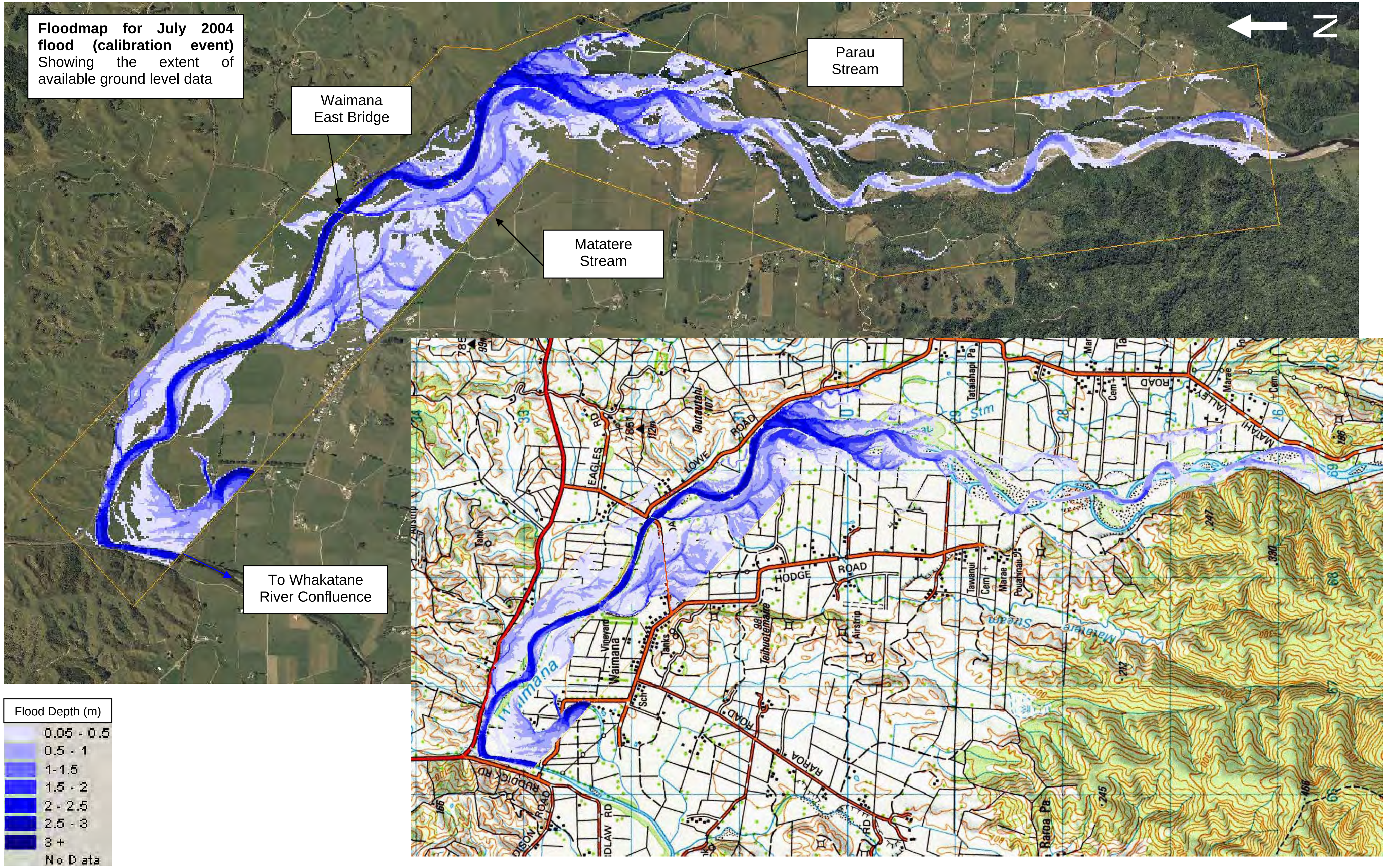
Wallace, P. (2004); Hydraulic Modelling of Lower Whakatane River and Floodplain (Report prepared for Environment Bay of Plenty) – Draft

Appendices

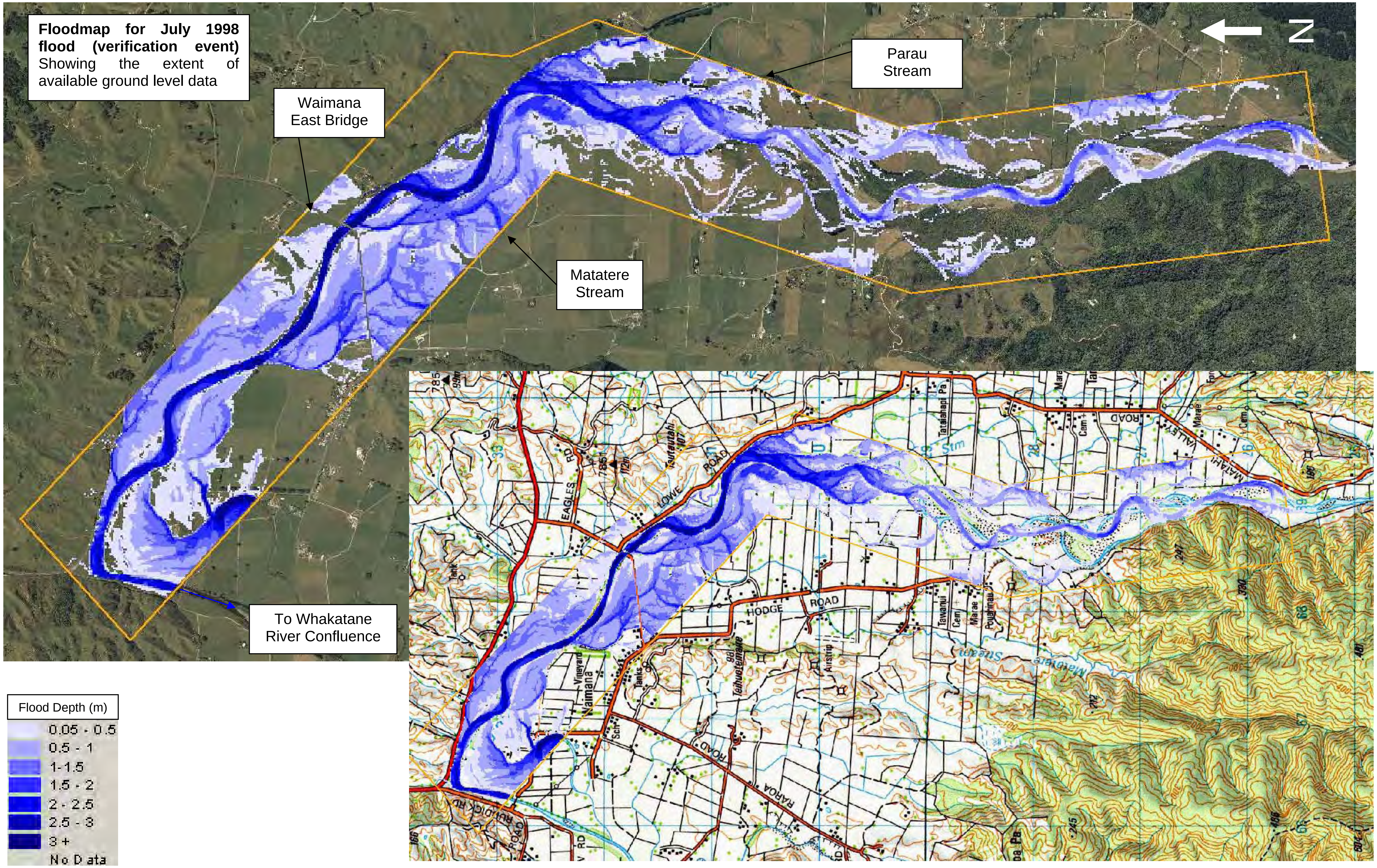
Appendix A – Resistance Values (Manning's n)

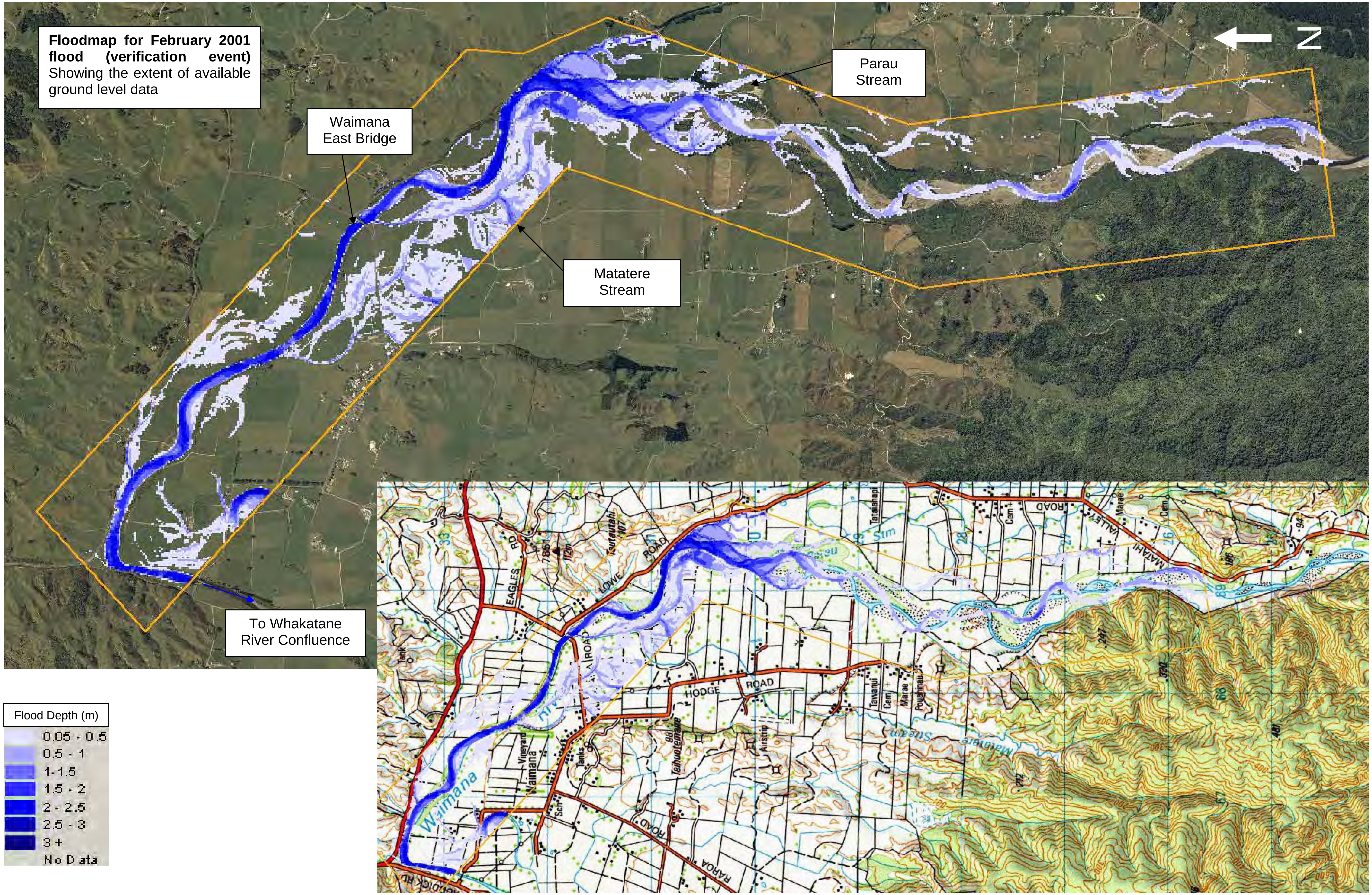
Cross-section	Mike11 chainage	Manning's n
33	0	0.033
32	700	0.033
31	1735	0.033
30	2875	0.036
29	4225	0.033
28	5185	0.033
27	6025	0.035
26	6560	0.033
u/s 25	7485	0.033
25	7505	0.033
d/s 25	7525	0.033
24	8270	0.030
23	8865	0.030
22	9640	0.030
21	10855	0.033
u/s bridge	10875	0.033
d/s bridge	10915	0.033
20	11515	0.030
19	12070	0.030
18	13015	0.033
17	13730	0.033
16	14645	0.033
15	15455	0.035
14	16280	0.035
13	16940	0.035
12	17600	0.035
11	18190	0.035
10a	18690	0.035

Appendix B – Flood Map Calibration



Appendix C – Flood Maps Verifications




Floodmap for February 2001 flood (verification event)
Showing the extent of available ground level data
N
Parau Stream
Waimana East Bridge
Matatere Stream
To Whakatane River Confluence
Flood Depth (m)
0.05 - 0.5
0.5 - 1
1-1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 +
No Data
HODGE ROAD
Waimana

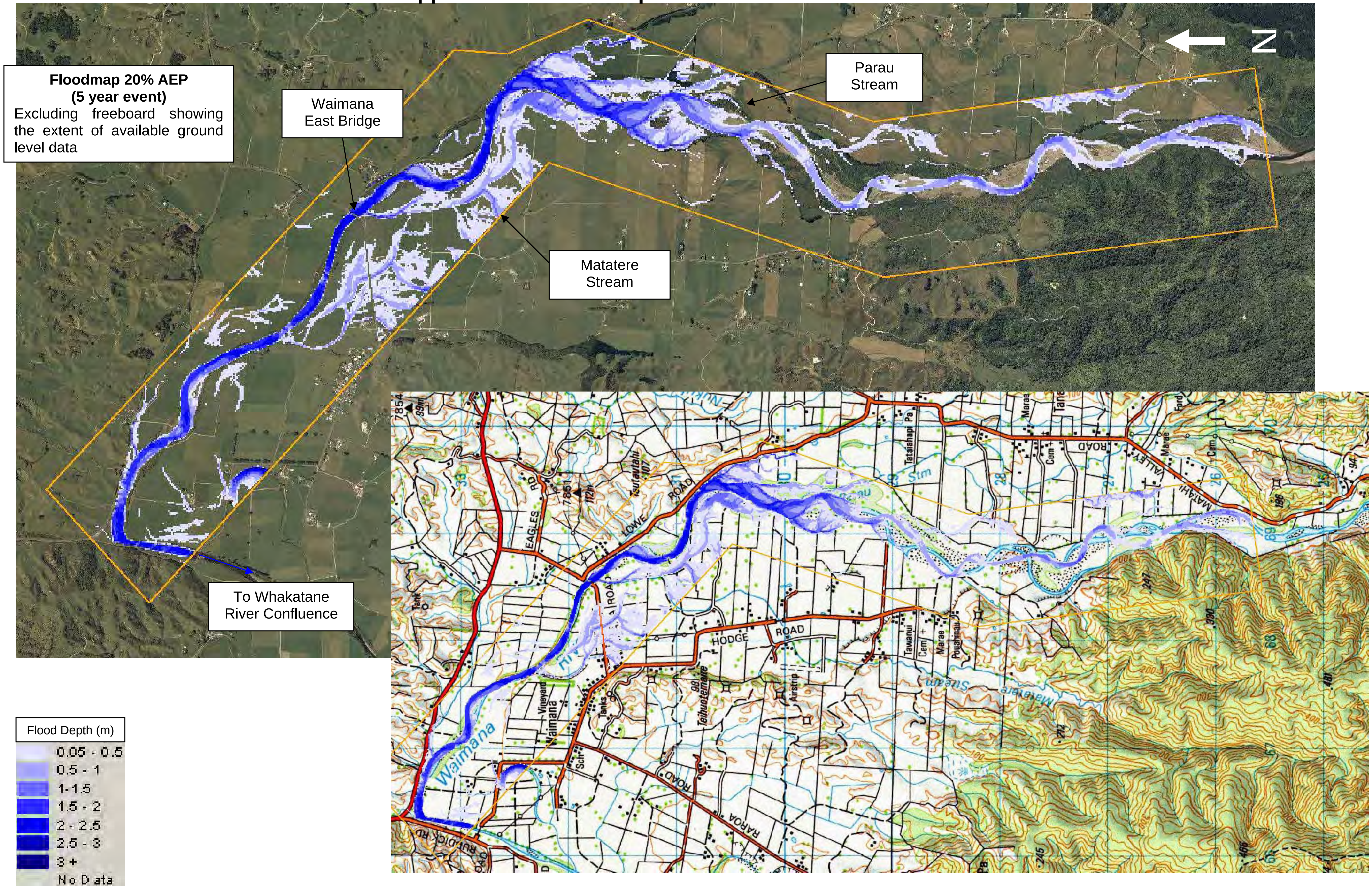
Appendix D – Water Level Results

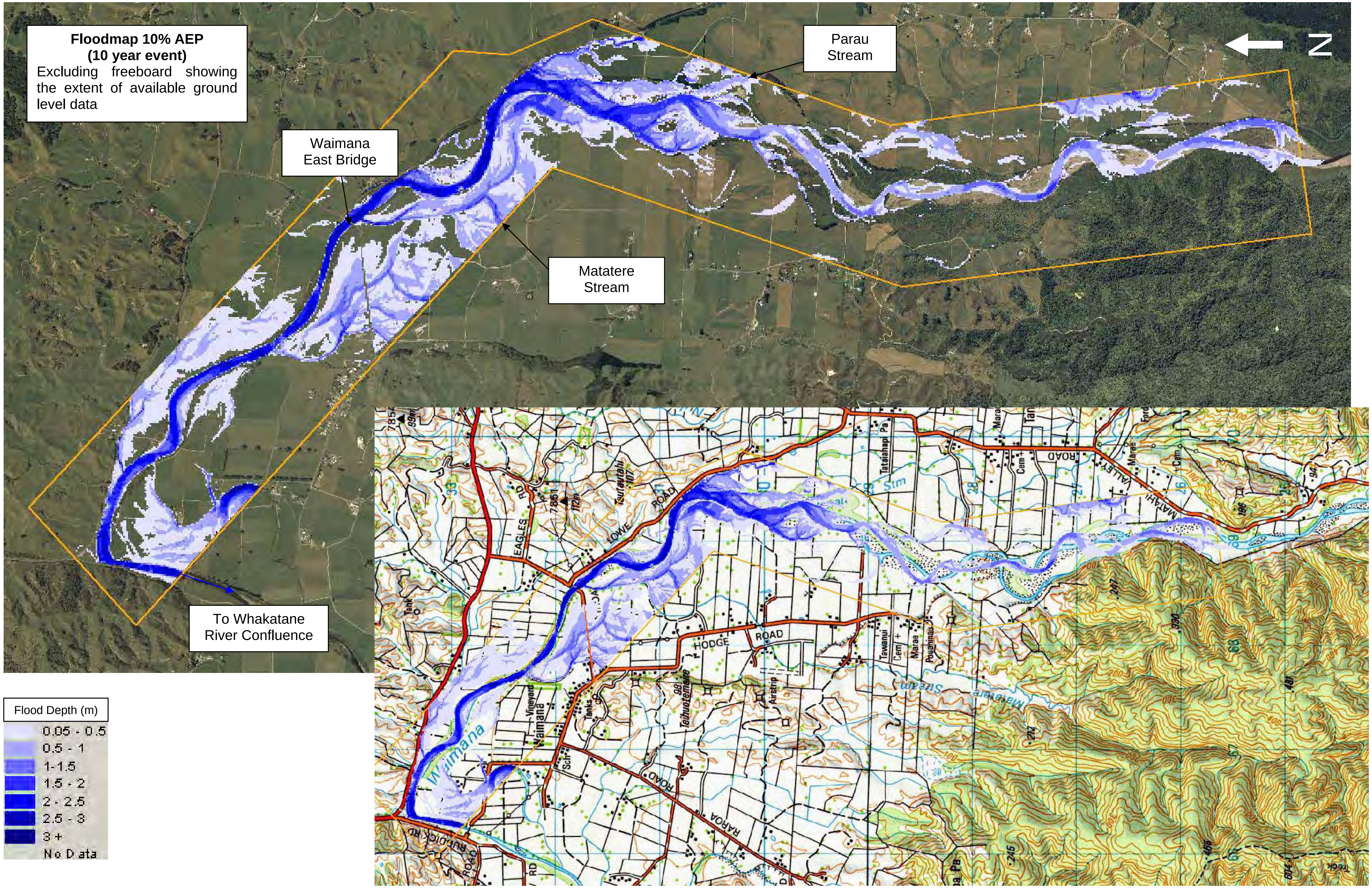
Simulation Results - Predictive Flood Levels (exclusive of freeboard)

Branch	Cross-section	Mike11 Chainage	Q5_109%	Q10_112%	Q20_108%	Q50_109%	Q100_108%	Q200_109%
		(m)	RL (m)	RL (m)	RL (m)	RL (m)	RL (m)	RL (m)
WAIMANA	**33**	0	66.08	66.36	66.51	66.70	66.82	66.95
WAIMANA	**32**	700	63.55	63.72	63.83	64.01	64.13	64.25
WAIMANA	**31**	1735	59.19	59.32	59.40	59.56	59.66	59.76
WAIMANA	**30**	2875	55.14	55.32	55.42	55.59	55.71	55.80
WAIMANA	**29**	4225	51.00	51.16	51.27	51.47	51.58	51.69
WAIMANA	**28**	5185	48.47	48.64	48.75	48.91	49.01	49.11
WAIMANA	**27**	6025	46.43	46.68	46.83	47.11	47.28	47.44
WAIMANA	**26**	6560	44.80	45.09	45.24	45.48	45.64	45.80
WAIMANA	**u/s 25**	7485	42.75	42.99	43.15	43.44	43.60	43.76
WAIMANA	**25 (East Bridge)**	7505	42.46	42.72	42.88	43.16	43.31	43.46
WAIMANA	**d/s 25**	7525	42.46	42.72	42.88	43.16	43.31	43.46
WAIMANA	**24**	8270	41.02	41.35	41.54	41.84	42.01	42.19
WAIMANA	**23**	8865	39.63	39.85	39.99	40.24	40.40	40.57
WAIMANA	**22**	9640	38.08	38.42	38.57	38.82	38.99	39.15
WAIMANA	**21**	10855	36.16	36.36	36.50	36.78	37.32	37.44
WAIMANA	**West Bridge**	10895	36.12	36.32	36.46	36.74	37.27	37.37
WAIMANA	**20**	11515	35.05	35.17	35.28	35.49	35.64	35.79
WAIMANA	**19**	12070	33.79	33.97	34.08	34.23	34.31	34.47
WAIMANA	**18**	13015	32.41	32.56	32.70	33.05	33.28	33.53
WAIMANA	**17**	13730	31.04	31.23	31.46	31.81	32.03	32.28
WAIMANA	**16**	14645	29.54	29.82	30.07	30.46	30.75	31.15
WAIMANA	**15**	15455	28.44	28.79	29.09	29.68	30.10	30.64
WAIMANA	**14**	16280	27.50	28.03	28.54	29.29	29.78	30.38
WAIMANA	**13**	16940	26.68	27.22	27.73	28.47	28.96	29.57
WAIMANA	**12**	17600	25.41	25.97	26.52	27.35	27.94	28.69
WAIMANA	**11**	18190	24.51	25.20	25.86	26.83	27.52	28.38
WAIMANA	**10a**	18690	23.57	24.26	24.94	26.00	26.78	27.71
Parau	**0**		67.72	67.87	67.98	68.13	68.22	68.35
Parau	**u/s 1 (bridge)**		67.58	67.72	67.81	67.95	68.04	68.16
Parau	**d/s 1 (bridge)**		67.53	67.67	67.77	67.91	68.00	68.12
Parau	**2**		66.11	66.22	66.31	66.42	66.48	66.57
Parau	**3**		61.60	61.75	61.86	62.02	62.12	62.26
Parau	**4**		59.84	60.01	60.12	60.28	60.39	60.53
Parau	**5**		57.27	57.42	57.53	57.68	57.78	57.92
Parau	**6**		55.71	55.95	56.13	56.40	56.57	56.81
Parau	**7**		54.42	54.68	54.86	55.11	55.27	55.49
Parau	**8**		53.17	53.37	53.51	53.71	53.84	54.00
Parau	**9**		51.81	51.99	52.11	52.30	52.41	52.51
Matatere	**1**		53.74	57.63	59.83	68.74	68.51	72.04
Matatere	**2**		53.74	57.63	59.83	68.74	68.51	72.04
Matatere	**u/s 3 (culvert)**		53.74	57.63	59.83	68.74	68.51	72.04
Matatere	**d/s 3 (culvert)**		49.60	49.88	50.10	50.67	50.66	50.86

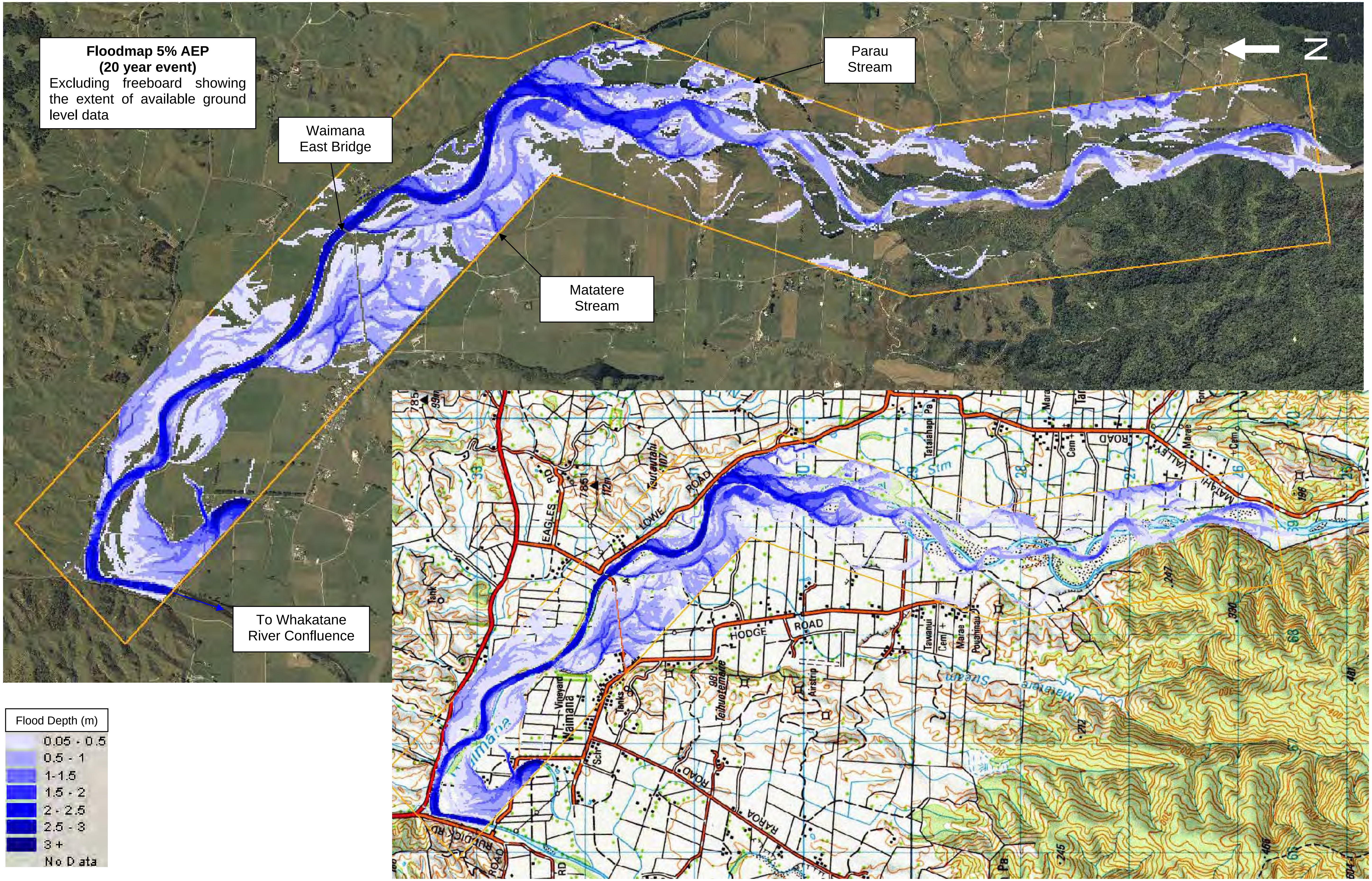
Matatere	**4**	49.15	49.44	49.65	50.17	50.16	50.34
Matatere	**5**	48.55	48.82	49.01	49.44	49.43	49.55
Matatere	**6**	47.69	47.87	47.99	48.31	48.30	48.41
Matatere	**7**	46.45	46.55	46.63	46.81	46.80	46.86
Matatere	**8**	45.28	45.39	45.45	45.54	45.55	45.59
Matatere	**9**	45.28	45.39	45.45	45.54	45.55	45.59

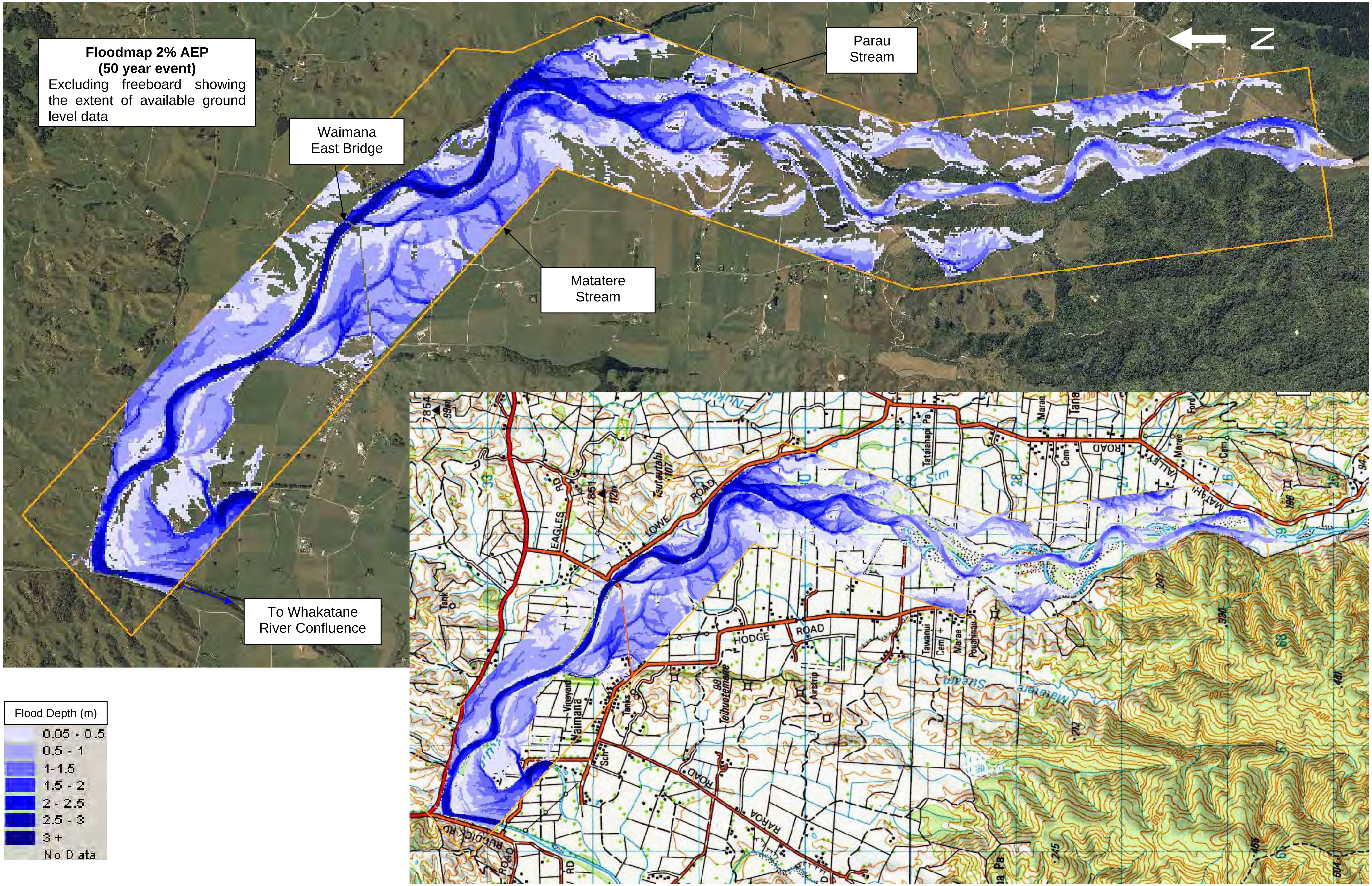
Appendix E – Flood Maps Predictive Scenarios

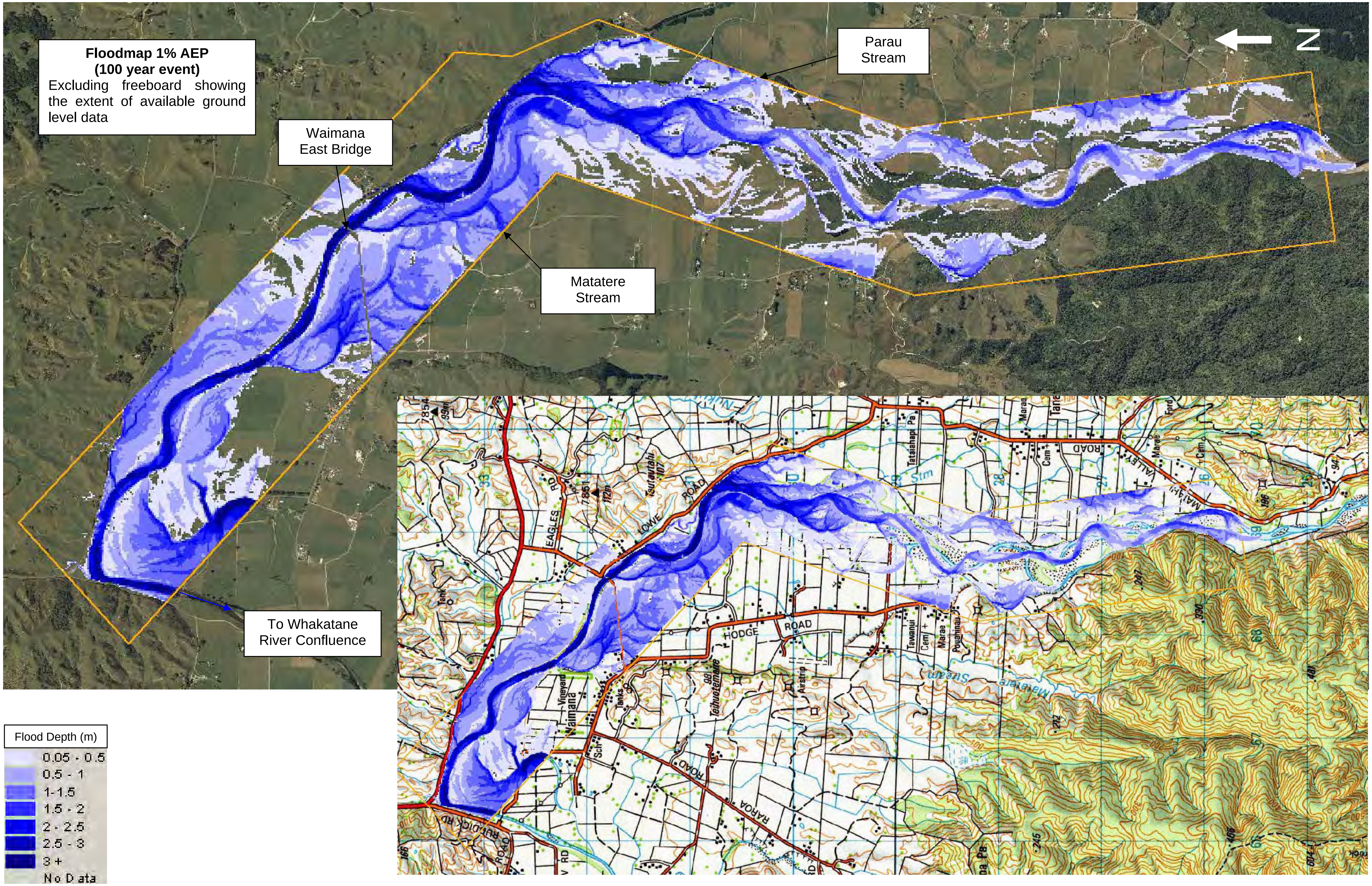


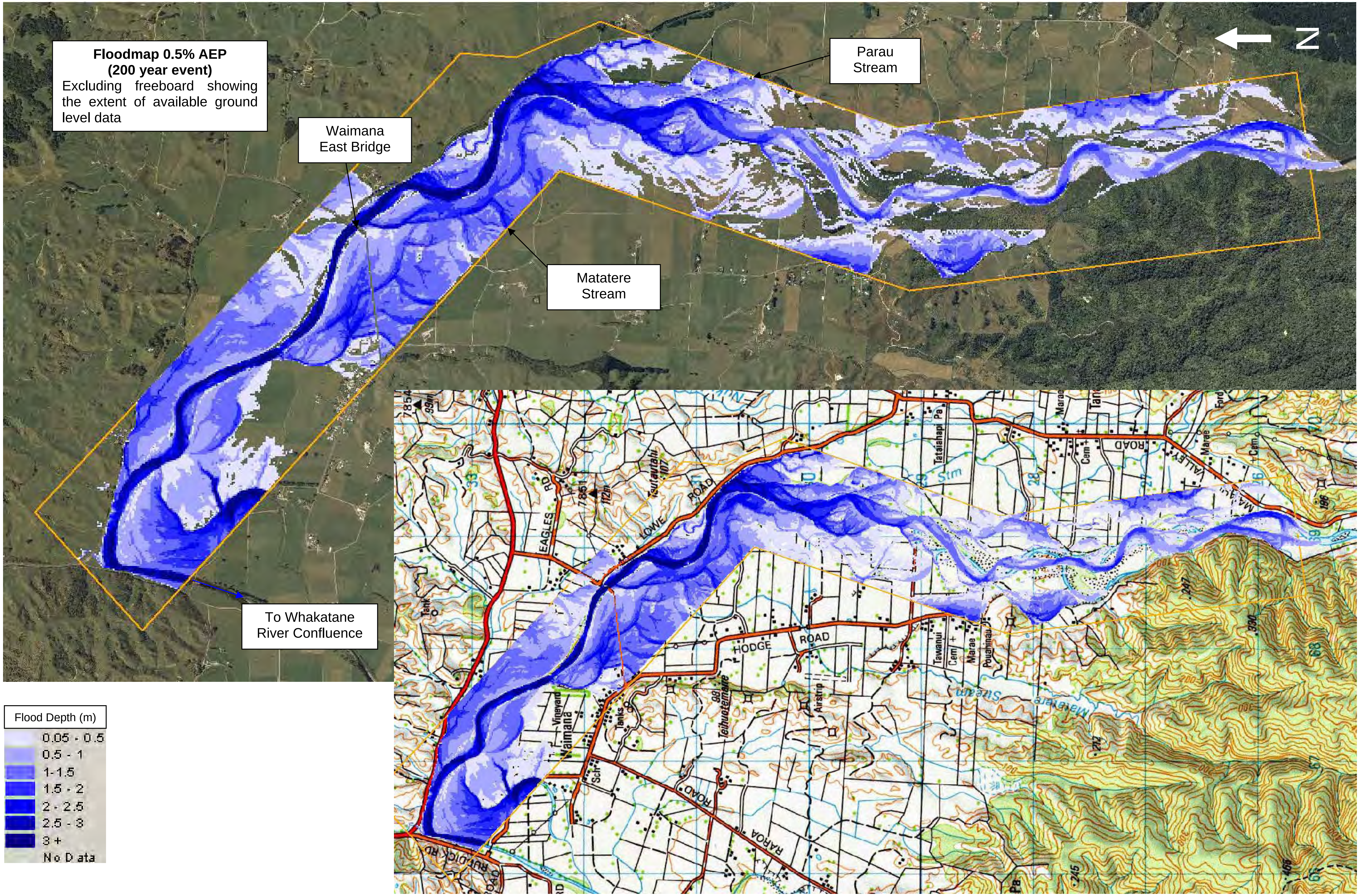


Floodmap 10% AEP (10 year event)
Excluding freeboard showing the extent of available ground level data
Parau Stream
Waimana East Bridge
Matatere Stream
To Whakatane River Confluence
N
Flood Depth (m)
0.05 - 0.5
0.5 - 1
1-1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 +
No Data


Floodmap 5% AEP
(20 year event)
Excluding freeboard showing the extent of available ground level data
Parau Stream
N
Waimana East Bridge
Matatere Stream
To Whakatane River Confluence
Flood Depth (m)
0.05 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 +
No Data


Floodmap 2% AEP
(50 year event)
Excluding freeboard showing the extent of available ground level data
Waimana East Bridge
Parau Stream
Matatere Stream
To Whakatane River Confluence
N
Flood Depth (m)
0.05 - 0.5
0.5 - 1
1-1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 +
No Data
HODGE ROAD
LOWE ROAD
EAGLES RD
RAROA ROAD
RUDDICK RD


Floodmap 1% AEP
(100 year event)
Excluding freeboard showing the extent of available ground level data
Waimana East Bridge
Parau Stream
Matatere Stream
To Whakatane River Confluence
N
Flood Depth (m)
0.05 - 0.5
0.5 - 1
1-1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 +
No Data


Floodmap 0.5% AEP
(200 year event)
Excluding freeboard showing the extent of available ground level data
Waimana East Bridge
Parau Stream
Matatere Stream
To Whakatane River Confluence
N
Flood Depth (m)
0.05 - 0.5
0.5 - 1
1-1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 +
No Data

Appendix F – Files Used

Files used for Waimana model

Mike 11 files

Scenario	.nwk11	.xns11	.bnd11	.HD11	.res11
Calibration 2004	Waimana_2003XS	Waimana	Waimana_2004	Waimana	2004_UPTO960%LATIN FLOW
Verification 1998	Waimana_1996XS	Waimana	Waimana_1998_100%	Waimana	1998_100%FLOW
Verification 2001	Waimana_1999XS	Waimana	Waimana_2001_100%	Waimana	2001_100%FLOW
Predictive 5 year	Waimana_2004XS	Waimana	Q5_109%_	Waimana	Q5_109%
Predictive 10 year	Waimana_2004XS	Waimana	Q10_112%_	Waimana	Q10_112%
Predictive 20 year	Waimana_2004XS	Waimana	Q20_108%_	Waimana	Q20_108%
Predictive 50 year	Waimana_2004XS	Waimana	Q50_109%_	Waimana	Q50_109%
Predictive 100 year	Waimana_2004XS	Waimana	Q100_108%_	Waimana	Q100_108%
Predictive 200 year	Waimana_2004XS	Waimana	Q200_109%_	Waimana	Q200_109%

Associated Files:

Model_Waimana.doc	Detailed day to day notes of model the development

Spreadsheets

Predictive Results.xls	Results from Predictive scenario runs (Q5 to Q200)
Waimana at Gorge 1998&2001&2004Stage.xls	Boundary Conditions (Calibration, Verification, and Predictive)
Waimana Gorge Rating1_adjusted.xls	Rating Curve
Waimana_extendedXS.xls	Cross-section data
Waimana_Floodlevels.xls	Results from Calibration and Verification runs
Bank Profiles for Links from DEM.xls	Bank profiles according to Lidar data, and adjustments (rotation) made for modelling

Arc shape files etc.

10mdem.shp	DEM 10 metre grid
mask.shp	Mask areas
fault.shp	fault lines
unproved10m.inp	Grid specification file
w16_4_1.sid	aerial photo (northern part)
w16_4_2.sid	aerial photo (southern part)