Environment Waikato Technical Report 2004/28

Hydraulic Investigation

Mangaokewa Stream

Te Kuiti Urban Area

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Executive Summary

The Waitomo District Council have asked Environment Waikato to investigate flood levels in the Mangaokewa Stream affecting land parcels in Te Kuiti that are likely to be the subject of future urban development.

Environment Waikato have undertaken this investigation by constructing a one-dimensional hydraulic model of the Mangaokewa Stream extending from a point upstream of the Te Kuiti Township (at cross section 376A) to a point approximately 4 km downstream of the Te Kumi Station Bridge (at cross section 328A).

The 1 in 5, 10, 20, 50 and 500 year flood flows used in the hydraulic model were taken from a flood frequency analysis completed using data recorded by the Environment Waikato Water Level/flow Recorder at Te Kuiti. The 1 in 100 year flood flow used in the hydraulic model was conservatively taken from the 1983 review of the LWWCS. The results from the hydraulic model were calibrated using the stream flow rating table produced for the channel cross section at the Recorder site.

The results from the investigation include a set of flood level profiles for different flood events in the Mangaokewa Stream within the Te Kuiti urban area, with particular focus on the parcels of land identified by Waitomo District Council.

It is recommended that these levels be adopted for identifying the flood hazard areas when considering future development. It should be noted that further hydraulic assessments will be required if flood protection works are proposed by way of stopbanks or filling (raising ground levels) the flood plains, as these will change the flood profiles upstream and downstream of the works.

It is also recommended that topographic surveys of each land parcel are completed to allow the full translation of the flood level profiles into flood extent plans.

1 Introduction

1.1 Background

The Waitomo District Council have identified the following land parcels within the Te Kuiti urban area that will be subject to future urban development:

Map 1 Western third of the land parcel at the southern end of the airport (Lot 2 DP 7392)

Map 2 72 Te Kumi Rd plus the land parcel on either side (Lots 1, 2 and 3 DPS 41089).

Map 3 16 to 30 Te Kumi Rd (Pt Lot 3 DPS 12403, Lots 1 and 2 DPS 23629 and Pt Lot 2 DPS 4302).

These land parcels are adjacent to the Mangaokewa Stream and are therefore potentially subject to inundation during significant flood events.

The Waitomo District Council have asked Environment Waikato to undertake a hydraulic investigation and determine the flood levels of different size events in the vicinity of these land parcels.

1.2 Purpose of report

The purpose of this report is to outline the methodology that Environment Waikato has followed during this investigation and to provide the Waitomo District Council with the flood level at the specified land parcels for different flood events. This will assist the District Council to establish the design floods criteria for development of these properties.

1.3 Level datum

All levels quoted in this report are in terms of the Moturiki mean sea level datum unless otherwise specified.

2 Investigation

2.1 Information collection

Environment Waikato has collected the following information as part of this investigation:

- Channel cross sections surveyed by Harrison Grierson Consultants Ltd during December 2001-March 2002 (refer to Environment Waikato Contract 2001/2).

- Channel cross sections surveyed by Harrison Grierson Consultants Ltd during September and October 2004 (refer to Environment Waikato Contract 2004/5 – 10).

  Note: A plan of the cross sections used in this investigation is presented in Appendix A.

- A frequency analysis of flood events in the Mangaokewa Stream based on data collected by the Environment Waikato Water Level Recorder located in the vicinity of the Waitomo District Council Water Treatment Pumping Station at Te Kuiti.

- A stream flow rating table produced by Environment Waikato for the Mangaokewa channel at the recorder site.

2.2 Catchment hydrology

2.2.1 Methodology

The hydrology of the Mangaokewa Stream catchment has been derived using represented by the flood frequency analysis completed using data from the Environment Waikato Te Kuiti water level recorder.

The results of the flood frequency analysis were also compared to the original scheme design information compiled during 1959 and the scheme review information compiled during 1983 (refer to Waikato Valley Authority Technical Report 25).

2.2.2 Results

The design peak flood flows for the Mangaokewa Stream based on data from the Environment Waikato Te Kuiti water level recorder are presented in the following table.

Return period	Peak flood flow
5 years	85 m^3/s
10 years	101 m^3/s
20 years	116 m^3/s
50 years	135 m^3/s
100 years	150 m^3/s
500 years*	188 m^3/s

*Derived by direct extrapolation from the flood frequency analysis

The initial design of the LWWCS estimated that the peak flow during the 1 in 100 year flood event was 8600 ft^3/s (245 m^3/s). However, the review of the LWWCS completed in 1983 concluded that this estimate was conservative and that a more reasonable estimate was 159 m^3/s (derived using the Unit Hydrograph Method).

It should be noted that it was decided that for the purpose of this investigation the 1983 estimate of 159 m^3/s should be adopted for the design 1 in 100 year flow through the Te Kuiti urban area. This is a conservative assumption based on the fact that the flood frequency analysis supports this estimate but does not provide enough certainty to use the lower value of 150 m^3/s.

As a matter of interest, the highest flood flow recorded during the last twenty-two years was 135 m^3/s in February 2004.

2.3 Stream hydraulics

2.3.1 Methodology

The hydraulic behaviour of the Mangaokewa Stream channel was investigated by constructing a one-dimensional hydraulic model using the MIKE 11 software programme.

The hydraulic model extended from cross section 376A (the upstream edge of the Te Kuiti urban area) to cross section 328A (around 4 km downstream of the Te Kumi Station bridge). This extent was selected to ensure that the downstream boundary would not directly affect the model results at the most downstream point of interest (as demonstrated by the chart presented in Appendix B).

The geometry of the Mangaokewa Stream was represented by the cross sections that were surveyed by Harrison Grierson Consultants Ltd during December 2001-March 2002 and September/October 2004.

The flow in the Mangaokewa Stream was assumed to be steady, with the magnitude governed by the flood frequency analysis at the recorder site.

The hydraulic model was used to complete steady state simulations of the 1 in 5, 10, 20, 50 and 100 year flood events in the Mangaokewa Stream.

2.3.2 Results

A long section showing the design peak flood levels for the entire reach of the Mangaokewa Stream covered by this investigation is presented in Appendix C.

The design peak flood levels for the Mangaokewa Stream at the points of interest are summarised on the following table.

	Design peak flood level					
Land Parcel*	**1 in 5Y**	**1 in 10Y**	**1 in 20Y**	**1 in 50Y**	**1 in 100Y**	**1 in 500Y**
1 (upstream)	47.55 m	47.81 m	47.86 m	47.91 m	47.96 m	48.04 m
1 (downstream)	47.26 m	47.33 m	47.38 m	47.44 m	47.50 m	47.61 m
2 (upstream)	49.67 m	49.97 m	50.18 m	50.41 m	50.78 m	51.37 m
2 (downstream)	49.58 m	49.88 m	50.09 m	50.31 m	50.68 m	51.26 m
3 (upstream)	50.07 m	50.38 m	50.62 m	50.87 m	51.21 m	52.07 m
3 (downstream)	49.99 m	50.29 m	50.52 m	50.77 m	51.10 m	51.98 m

* Land parcel 1: Western third of the land parcel at the southern end of the airport (Lot 2 DP 7392)
Land parcel 2: 72 Te Kumi Rd plus the land parcel on either side (Lots 1, 2 and 3 DPS 41089)
Land parcel 3: 16 to 30 Te Kumi Rd (Pt Lot 3 DPS 12403, Lots 1 and 2 DPS 23629 and Pt Lot 2 DPS 4302)

Long sections showing the design peak flood levels for each land parcel are presented in Appendix D.

Cross sections located in the vicinity of each land parcel (and referred to on the long sections contained in Appendix D) are presented in Appendix E.

2.4 Calibration of stream hydraulics

2.4.1 Methodology

Calibration of the hydraulic model was undertaken by comparing the water level produced by each simulation with the water level given by the stream flow rating table produced for the Water Level Recorder at Te Kuiti. Any discrepancies between the two water levels were eliminated or minimised by adjusting the hydraulic roughness (Manning's n) of the stream channel.

2.4.2 Results

The hydraulic roughness (Manning's n) for the Mangaokewa Stream channel through the Te Kuiti urban area is summarised in the following table.

Return period	Hydraulic roughness
5 years	n = 0.03400
10 years	n = 0.03450
20 years	n = 0.03550
50 years	n = 0.03500
100 years	n = 0.03475
500 years	n = 0.0380

A comparison between the calibrated water levels produced by the hydraulic model and water levels indicated by the stream flow rating table is summarised in the following table.

		Water level		
Return period	**Peak flood flow**	**Hydraulic model**	**Rating table**	**+ / -**
5 years	85 m^3/s	51.85 m	51.840 m	+ 0.01 m
10 years	101 m^3/s	52.17 m	52.165 m	+ 0.01 m
20 years	116 m^3/s	52.46 m	52.459 m	+ 0.01 m
50 years	135 m^3/s	52.83 m	52.823 m	+ 0.01 m
100 years	150 m^3/s	53.30 m	53.267 m	+ 0.03 m
500 years	188 m^3/s	53.78 m	53.780 m	+ 0.00 m

This comparison is also presented in Appendix F.

3 Discussion

3.1 Information collection

- The cross section information collected for this investigation spanned 3 years. To ensure that it was appropriate to combine the information collection during 2001 with the information collected 2004, the 2004 survey included the re-survey of cross section 345A. This re-survey showed that cross section 345A had not varied significantly since 2001 and that it was therefore appropriate to combine the two sets of information.

  A comparison of the 2001 and 2004 survey of cross section 345A is presented in Appendix B.

3.2 Catchment hydrology

- Given that the Mangaokewa Stream catchment is 172.3 km^2 above the Te Kuiti urban area, the use of observed data to determine appropriate design flood flows is considered appropriate. It should however be noted that the data record used to produce the flood frequency analysis was only 21 years. Therefore the 1 in 50 year, 100 year and 500 year flood flow estimates should be treated cautiously.

- The 1 in 100 year peak flood flow produced by the flood frequency analysis (150 m^3/s) compares well to the assessment of the 1 in 100 year peak flood flow completed as part of the LWWCS review in 1983 using to Unit Hydrograph Method (159 m^3/s). It is therefore considered appropriately conservative to adopt 159 m^3/s as the 1 in 100 year design peak flood flow.

3.3 Stream hydraulics

- Although the hydraulic model achieved steady state for all simulations, there were some minor fluctuations in the water level during the initial stages of the simulation. To avoid these fluctuations, the outputs from the hydraulic model were taken from the last time step of each simulation.

- The 1 in 100 year water level at cross section 331A (Te Kumi Station Road bridge) was 47.94 m. This is below the soffet of the Te Kumi Station Road bridge (49.85 m). Therefore, the bridge structure has not been included in the hydraulic model.

- The adjustment of the downstream boundary condition to an extreme value of 46.0 m had a significant effect on the water level produced by the hydraulic model. However, as this effect did not propagate beyond chainage 6,200 m, it is concluded that the downstream boundary condition does not have a significant effect on the design flood levels at the land parcels that are of interest. Therefore, it was assumed that it was appropriate to maintain the downstream boundary condition at a constant value for all simulations. A comparison between these two scenarios is presented in Appendix G.

- The variation between the 1 in 5 year water level and the 1 in 100 year water level varies between 1.52 m (cross section 358A) and 0.20 m (cross section 332A). This is mainly because the Mangaokewa Stream is well incised within the Te Kuiti urban area, but opens out onto a wide floodplain downstream of cross section 335A.

3.4 Calibration of stream hydraulics

- Calibration of the hydraulic model resulted in the Mangaokewa Stream gave a hydraulic roughness (Manning's n) that varied between 0.03400 (1 in 5 year flood event) and 0.03550 (1 in 20 year flood event). The reason for this variation is not certain, however is likely to be because of the following:

    a. As the water level increases, the flood flow encounters sections of stream bank that have a higher hydraulic roughness (e.g. trees and grass).

    b. As the water velocity increases, the stream bed becomes mobile and the hydraulic roughness is reduced (i.e. this might explain the decrease in hydraulic roughness observed for the 1 in 50 and 100 year simulations).

- The variation in hydraulic roughness (Manning's n) required to calibrate the hydraulic model was small and therefore could also be attributed to errors in the stream flow rating table.

- The hydraulic roughness (Manning's n) values that were assumed for each simulation were within the range of 0.03 to 0.04 that was expected for an open channel such as the Mangaokewa Stream.

4 Summary

- The Waitomo District Council have asked Environment Waikato to investigate flood levels in the Mangaokewa Stream affecting land parcels in Te Kuiti that are likely to be the subject of future urban development.

- Environment Waikato have undertaken this investigation by constructing a one-dimensional hydraulic model of the Mangaokewa Stream extending from a point upstream of the Te Kuiti Township (at cross section 376A) to a point approximately 4 km downstream of the Te Kumi Station Bridge (at cross section 328A).

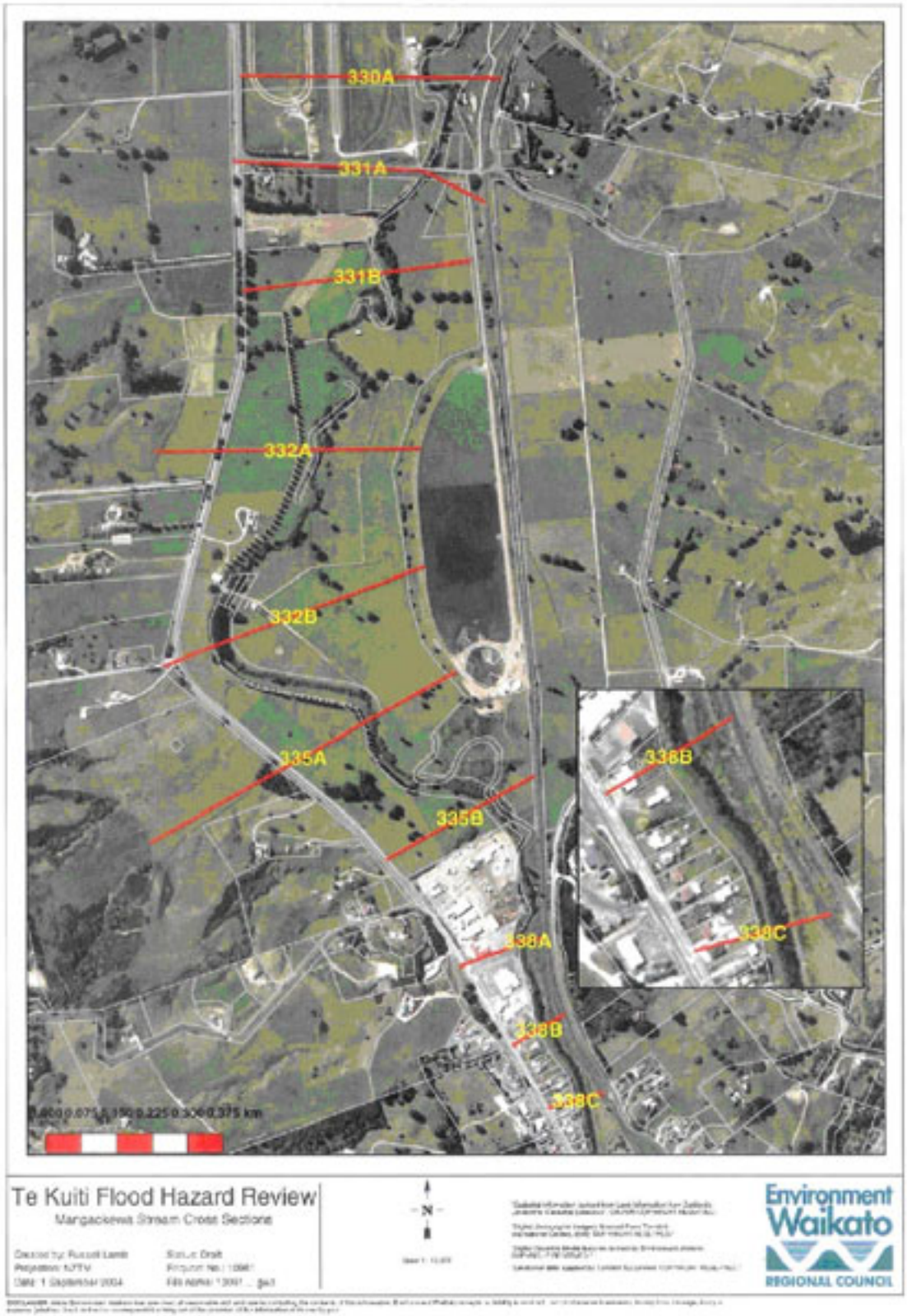
- The 1 in 5, 10, 20, 50 and 500 year flood flows used in the hydraulic model were taken from a flood frequency analysis completed using data recorded by the Environment Waikato Water Level/flow Recorder at Te Kuiti. The 1 in 100 year flood flow used in the hydraulic model was conservatively taken from the 1983 review of the LWWCS. The results from the hydraulic model were calibrated using the stream flow rating table produced for the channel cross section at the Recorder site.

- The results from the investigation include a set of flood level profiles for different flood events in the Mangaokewa Stream within the Te Kuiti urban area, with particular focus on the parcels of land identified by Waitomo District Council.

- It is recommended that these levels be adopted for identifying the flood hazard areas when considering future development. It should be noted that further hydraulic assessments will be required if flood protection works are proposed by way of stopbanks or filling (raising ground levels) the flood plains, as these will change the flood profiles upstream and downstream of the works.

- It is also recommended that topographic surveys of each land parcel are completed to allow the full translation of the flood level profiles into flood extent plans.

Appendix A Cross section location plans



Te Kuiti Flood Hazard Review

Mangaokewa Stream Cross Sections

Created by: Russell Lamb
Project nr: NZTM
Date: 1 September 2004

Status: Draft
Request No.: 10951
File name: 10951_gis1

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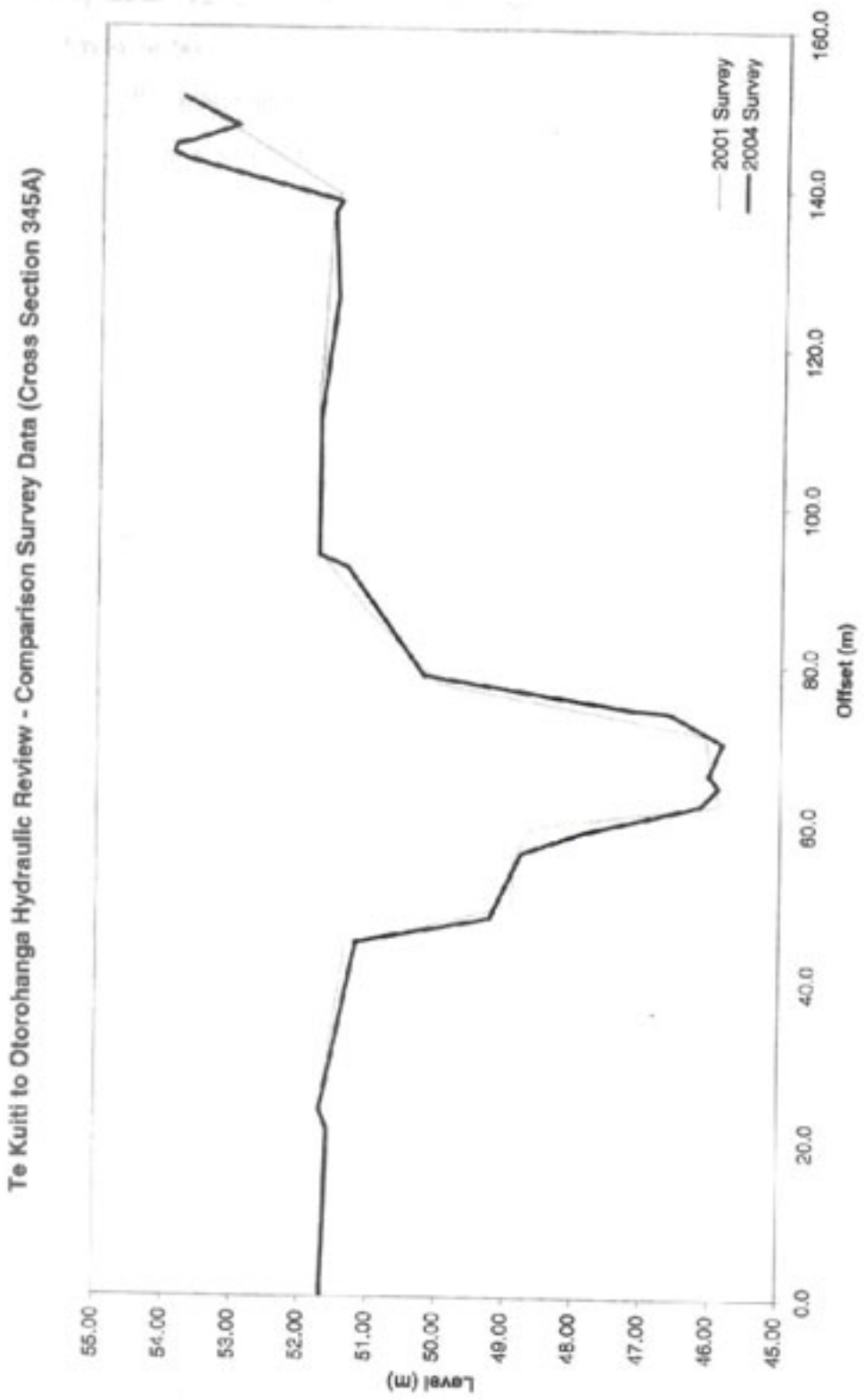
Appendix B Comparison of cross section 345A (December 2001-March 2002 and September/October 2004)



Appendix C Long section of entire reach covered by investigation

Key to symbols

○ 1 in 5 year flood level

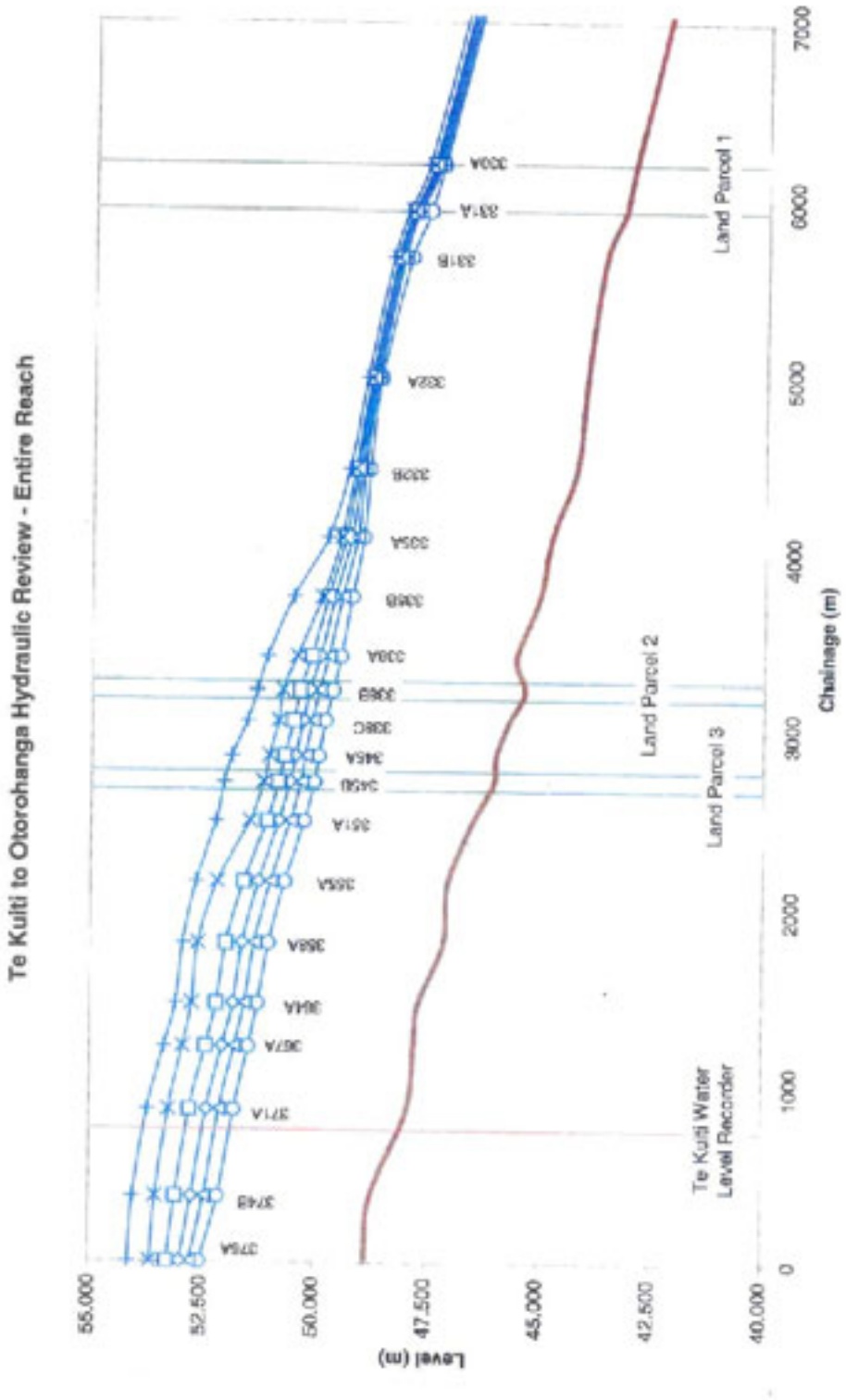
□ 1 in 50 year flood level

△ 1 in 10 year flood level

× 1 in 100 year flood level

◊ 1 in 20 year flood level

\+ 1 in 500 year flood level



Appendix D Long section in the vicinity of each land parcel of interest

Key to symbols

○ 1 in 5 year flood level

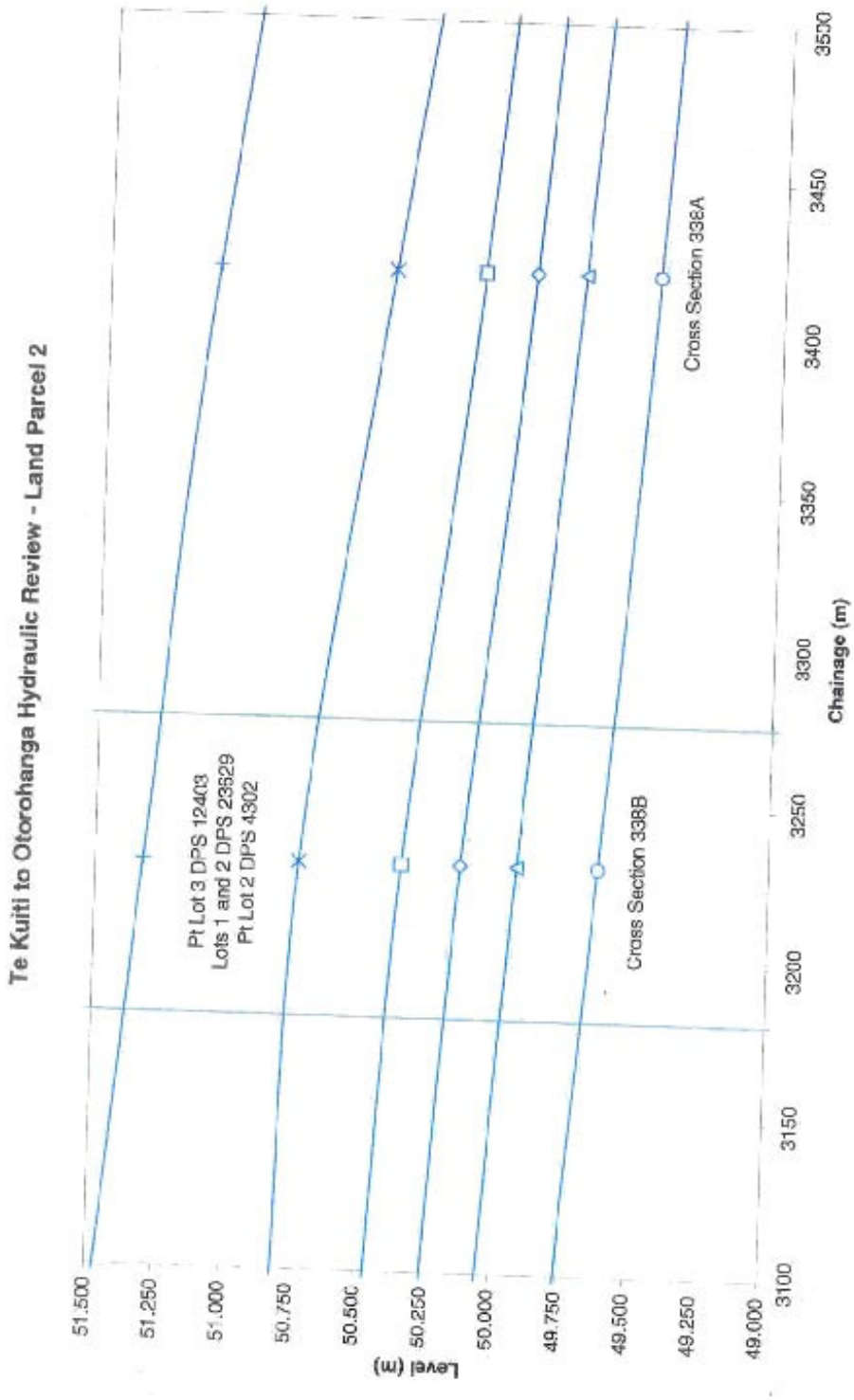
△ 1 in 10 year flood level

◇ 1 in 20 year flood level

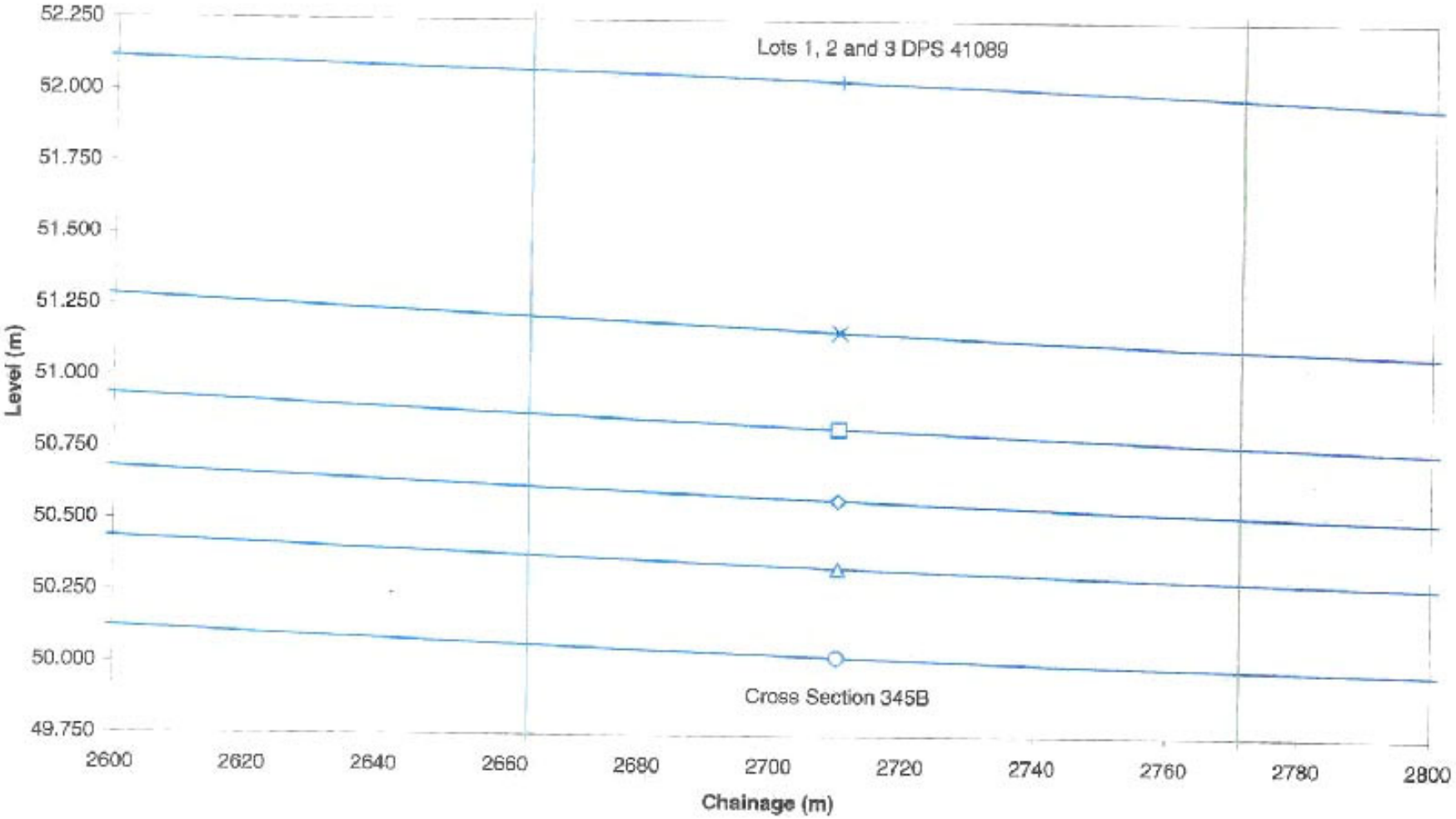
+ 1 in 500 year flood level

□ 1 in 50 year flood level

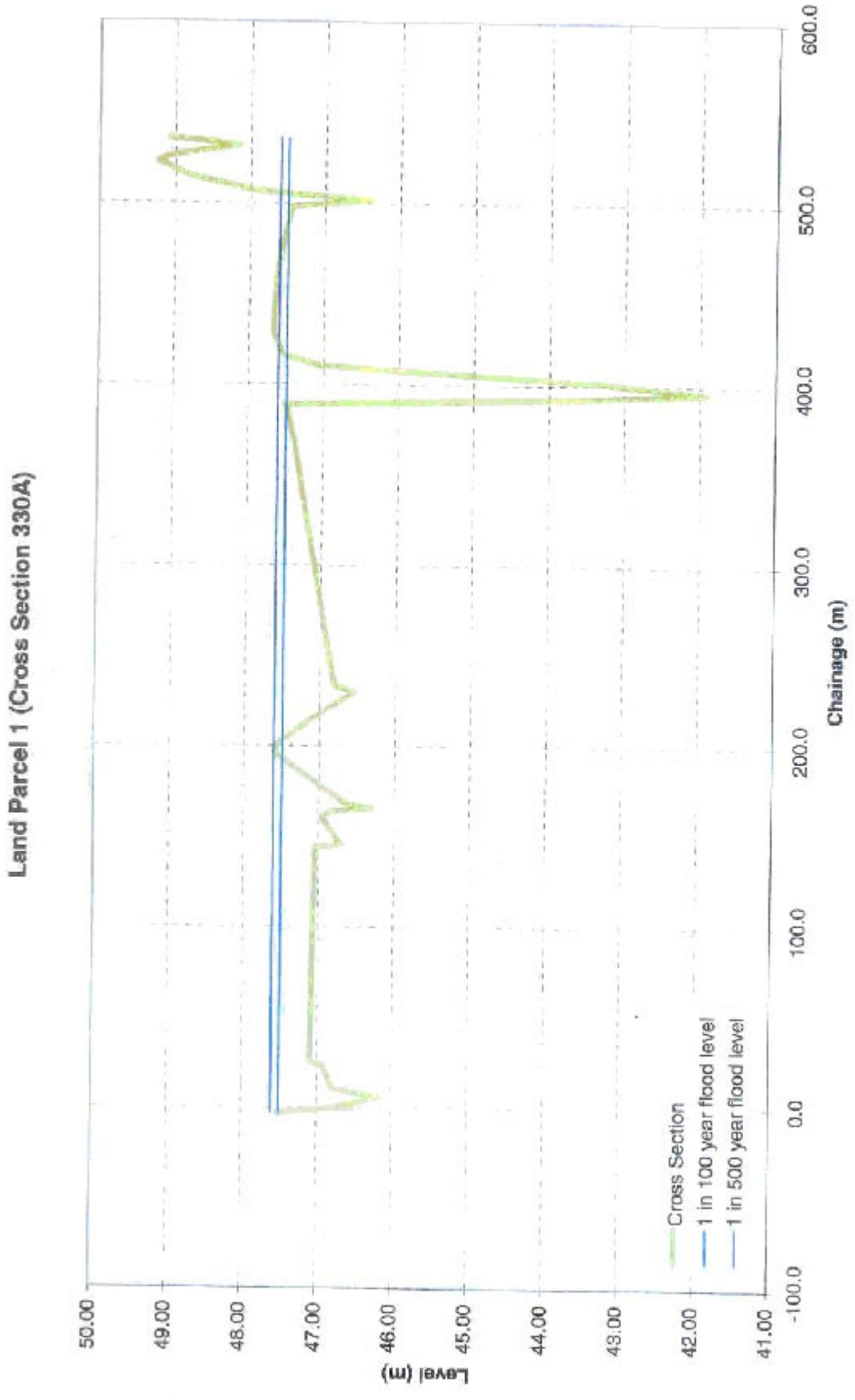
× 1 in 100 year flood level

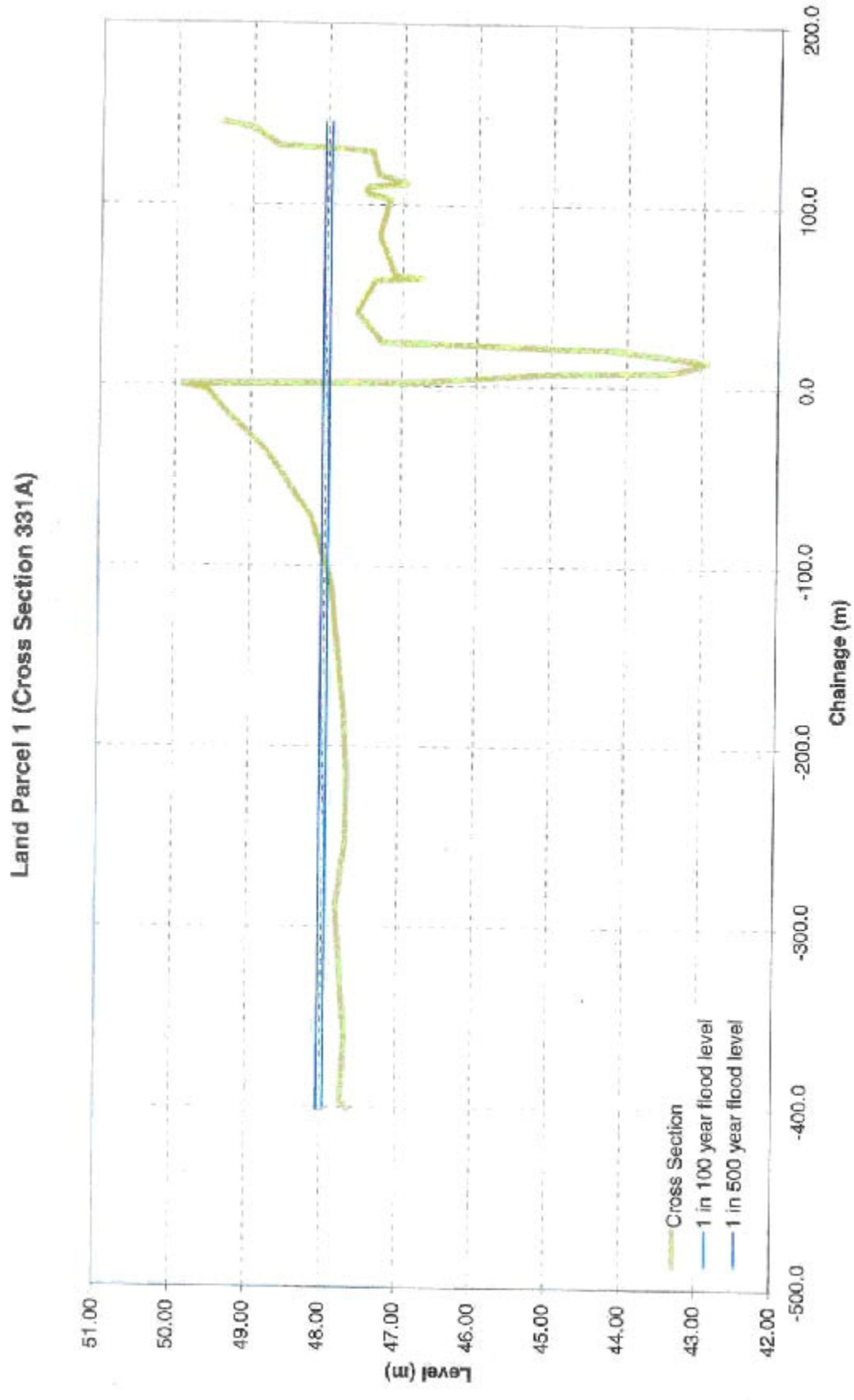


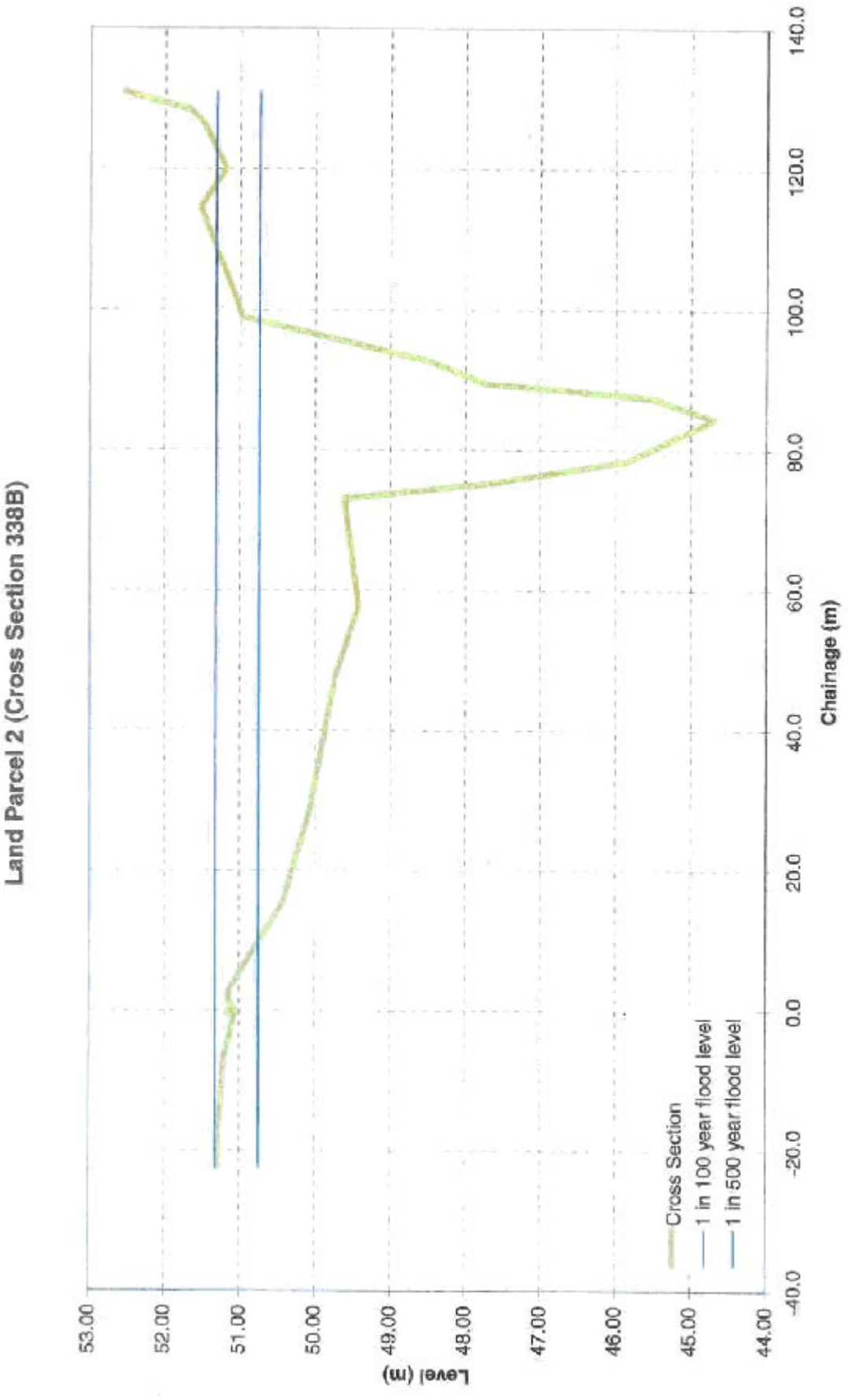
Te Kuiti to Otorohanga Hydraulic Review - Land Parcel 3

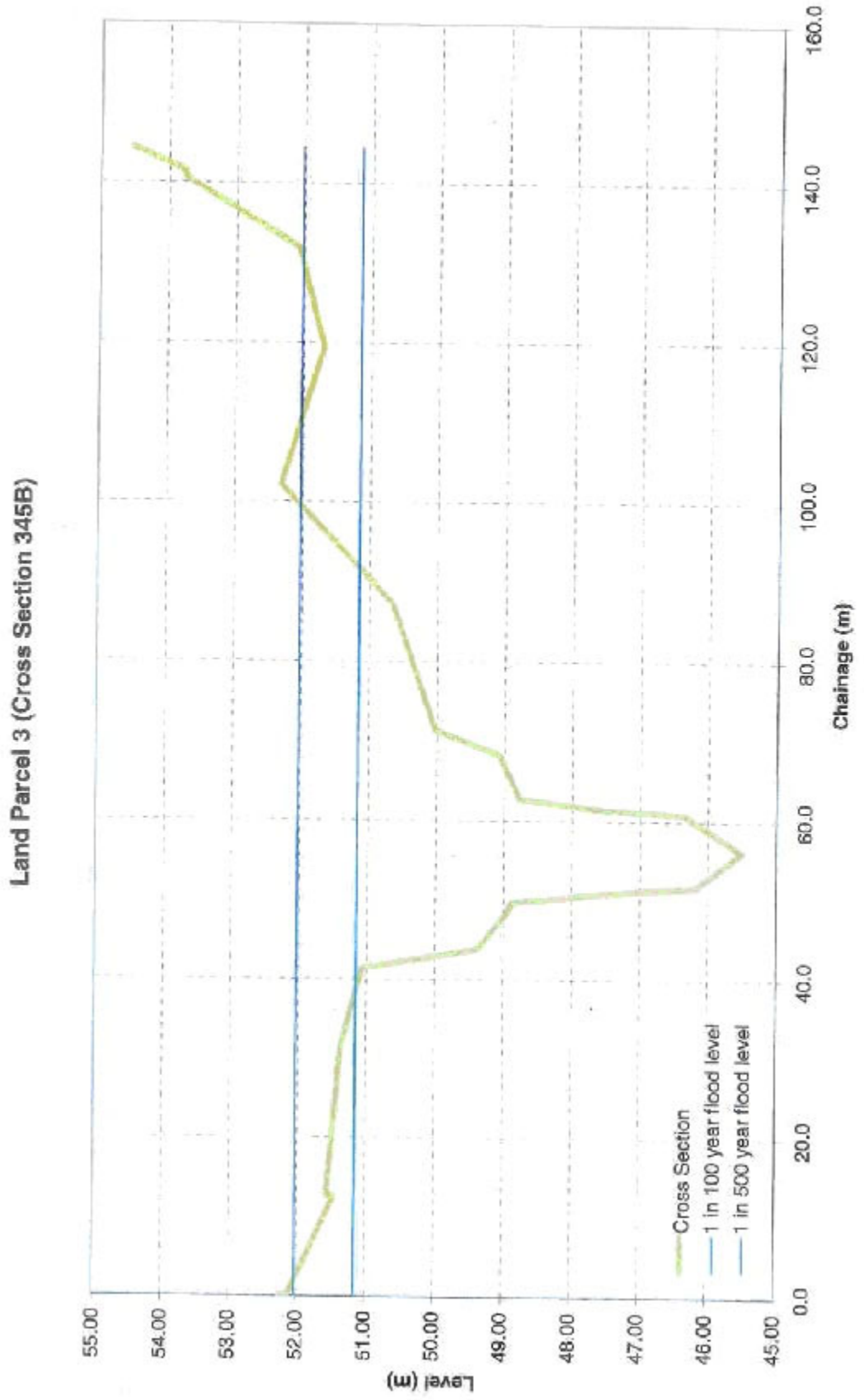


Appendix E Cross sections in the vicinity of each land parcel of interest



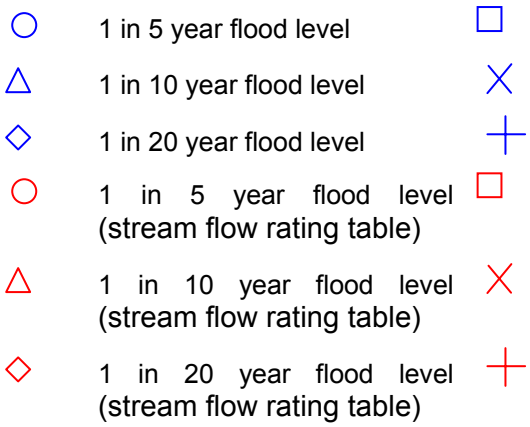

Land Parcel 1 (Cross Section 331A)
Level (m)
51.00
50.00
49.00
48.00
47.00
46.00
45.00
44.00
43.00
42.00
-500.0
-400.0
-300.0
-200.0
-100.0
0.0
100.0
200.0
Chainage (m)
Cross Section
1 in 100 year flood level
1 in 500 year flood level


Land Parcel 2 (Cross Section 338B)
Level (m)
53.00
52.00
51.00
50.00
49.00
48.00
47.00
46.00
45.00
44.00
-40.0
-20.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
Chainage (m)
Cross Section
1 in 100 year flood level
1 in 500 year flood level


Land Parcel 3 (Cross Section 345B)
Level (m)
55.00
54.00
53.00
52.00
51.00
50.00
49.00
48.00
47.00
46.00
45.00
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
Chainage (m)
Cross Section
1 in 100 year flood level
1 in 500 year flood level

Appendix F Long section in the vicinity of the Environment Waikato Water Level Recorder at Te Kuiti

Key to symbols



1 in 5 year flood level

1 in 10 year flood level

1 in 20 year flood level

1 in 5 year flood level (stream flow rating table)

1 in 10 year flood level (stream flow rating table)

1 in 20 year flood level (stream flow rating table)

1 in 50 year flood level

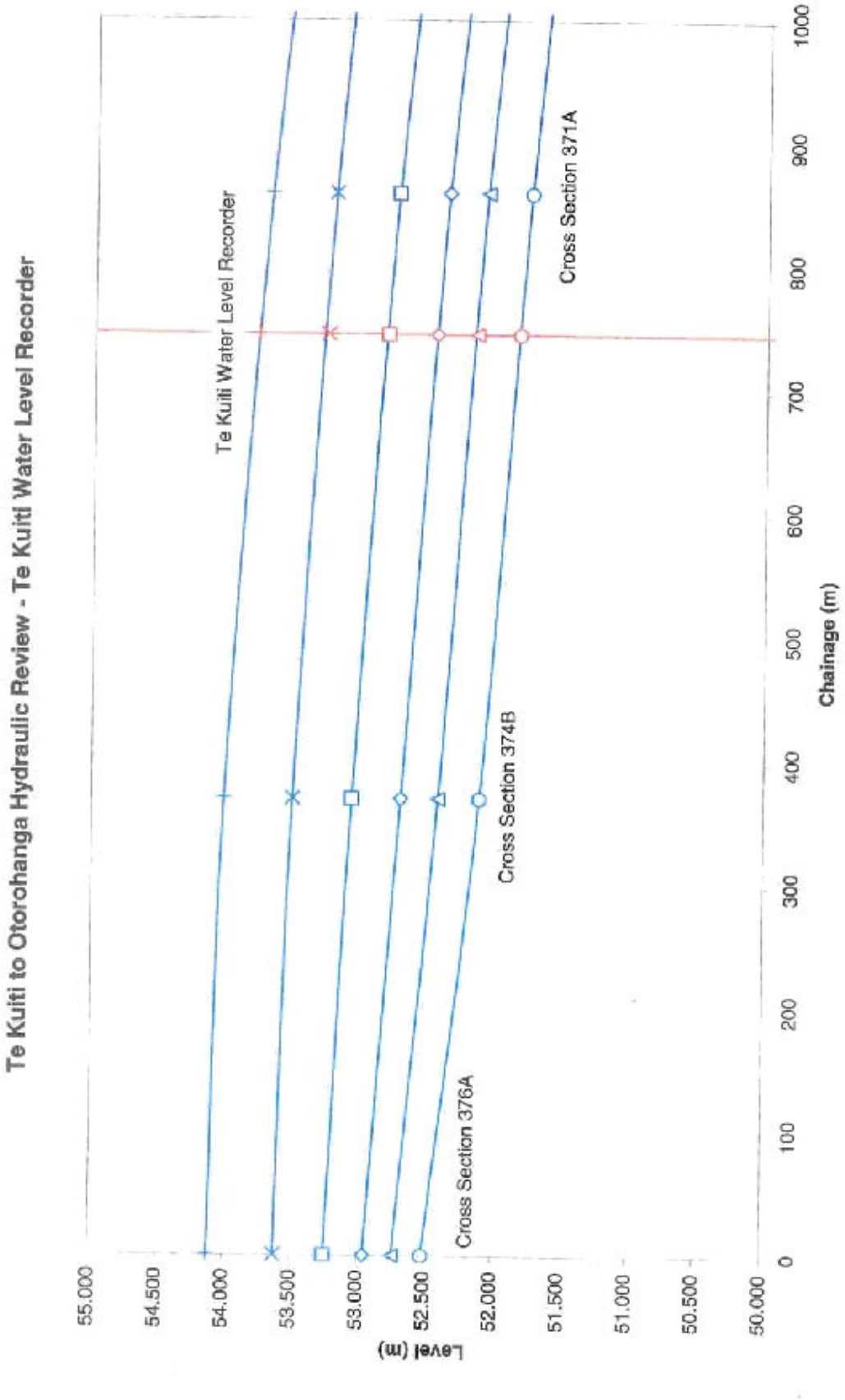
1 in 100 year flood level

1 in 500 year flood level

1 in 50 year flood level (stream flow rating table)

1 in 100 year flood level (stream flow rating table)

1 in 500 year flood level (stream flow rating table)


Te Kuiti to Otorohanga Hydraulic Review - Te Kuiti Water Level Recorder
Te Kuiti Water Level Recorder
Cross Section 371A
Cross Section 374B
Cross Section 376A
Level (m)
55.000
54.500
54.000
53.500
53.000
52.500
52.000
51.500
51.000
50.500
50.000
0
100
200
300
400
500
600
700
800
900
1000
Chainage (m)

Appendix G Comparison of water level profile following variation of downstream boundary condition