Wainui te Whara Stream flow estimation for 2014 Easter storm event

Bay of Plenty Regional Council
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5 Quay Street
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NEW ZEALAND

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BAY OF PLENTY REGIONAL COUNCIL
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Executive summary

The Wainui te Whara Stream has a catchment size of 5.75 km^2. The upper catchment consists of steep hillside of which 64% is forest and bush and 35% is farmland. The remaining 5% is located at the outlet of the catchment and made up of residential and commercial land use. Through the town, the Wainui te Whara Stream follows a highly modified course before it exits into Awatapu Lagoon which is a modified reach of the Whakatāne River. The modified stream through town no longer follows its natural watercourse, instead it has been straightened and canalised with stopbanks. Town development butts up hard against the stopbanks.

The purpose of this report is to undertake hydraulic analysis of the peak flow measured at the stream gauge during the flooding at Easter 2014 (18-20 April). Confidence in the upper end of the rating curve is low and the hydraulic analysis of this event is being used to verify the confidence level. A secondary purpose of the report is to determine peak flows from the Easter event to enable others to calibrate the hydrology at an upstream potential detention dam site.

Two methods were used to estimate flow values at five sites on the stream. Critical flow analysis was used for Site 3 (stream gauge site) and Site 1 (further downstream). Slope-area method analysis was used for Sites 4 and 5 near the potential detention dam site and Site 2 (located between Sites 3 and 1).

The critical flow analysis produced flow estimates for Site 3 (33.1 m^3/s) and Site 1 (31.2 m^3/s) with an assumed accuracy of ±10%. It is considered likely due to the nature of the channel at Site 3, that waves could push up the debris making the debris levels 100 mm higher than the effective water level, so that the flow was more like that of Site 1. Therefore, the flow at Site 3 was determined to be 31.2 m^3/s ±10%. With the existing rating curve (22 August 2013) giving a flow of 28.7 m^3/s for the peak flow at the gauge on 18 April 2014 at 22:30:00, it is recommended that the rating curve is updated at the upper end. Values for the upper end of the rating curve are included.

There is a lot less confidence in the results from the slope-area method analysis with the upstream Site 5 (11.2 m^3/s) being estimated with a greater flow than the downstream Site 4 (7.0 m^3/s). It is recommended that results at Sites 4 and 5 are not used to calibrate the hydrologic model at the detention dam site. Slope-area analysis at Site 2 gave a flow value (119 m^3/s) that is not consistent with the Sites 3 and 1 above and below and is considered an anomaly.

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Part 1: Background

1.1 Introduction

The purpose of this report is to undertake hydraulic analysis of the peak flow at the stream gauge during the flooding in the lower reaches of the Wainui te Whara Catchment at Easter 2014 (18-20 April). Due to a shortage of high level gaugings, confidence in the upper end of the rating curve at the gauging site is low and the hydraulic analysis of this event is being used to verify the confidence level. A secondary purpose of the report is to determine peak flows to enable others to calibrate the hydrology at an upstream potential detention dam site. Analysis of the probable maximum flood is included in this report.

1.2 Catchment

The Wainui te Whara Stream has a catchment size of 5.75 km^2. The upper catchment consists of steep hillside of which 64% is forest and bush and 35% is farmland. The upper catchment includes Te Rununga o Ngāti Awa (TRoNA) forestry land, privately owned regrowth and grazed pasture, and the Mokorua and Ōhope Scenic Reserve. The remaining 5% is located at the outlet of the catchment and made up of residential and commercial land use. The catchment and the gauge location are shown in Figure 1.

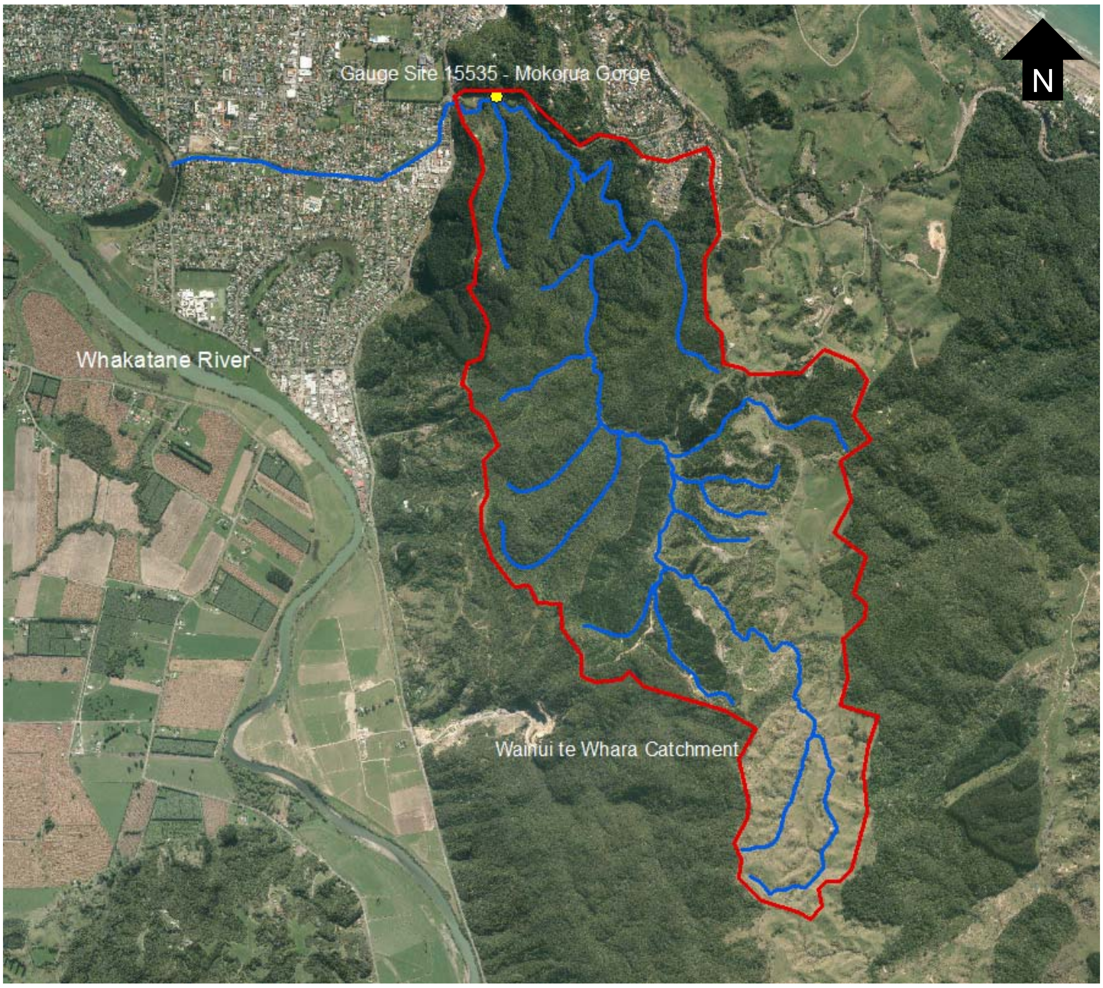

Figure 1 Wainui Te Whara Catchment.

Through the town, the Wainui te Whara Stream follows a highly modified course before it exits into Awatapu Lagoon which is a modified reach of the Whakatāne River. The modified stream through town no longer follows its natural watercourse, instead it has been straightened and canalised with stopbanks.

1.3 Stream gauge

The Wainui te Whara water level and flow recorder located in the Mokorua Gorge has been in operation since November 2006. The catchment above the Mokorua Gorge is 5.08 km^2. The Bay of Plenty Regional Council manages the operation of the recorder (Figure 2). It has a bubble-up type sensor. The hydraulic control at the gauge is a tight solid rock section at the head of a series of sharp drops. At the gauging site, the stream is free-flowing, has good hydraulic control and is not impacted by backwater effects.

Figure 2 Looking downstream towards the gauge in Mokorua Gorge.

1.3.1 **Rating curve**

The stream gauge at the Mokoroa Gorge has not been in service for long. Consequently there is very little data available to define the high end of a level/flow rating at the gauge. Figure 3 shows the most recent rating curve (22 August 2013) and the physical gaugings for the Wainui te Whara at the Mokorua Gorge site. The level of confidence in the upper end of the rating curve is low as there has only been one physical gauging done at high flow (June 2010). This gauging was by a flow velocity estimation method (float-and-stopwatch) in darkness, with a stream cross section survey the next day (Ellery, 2010).

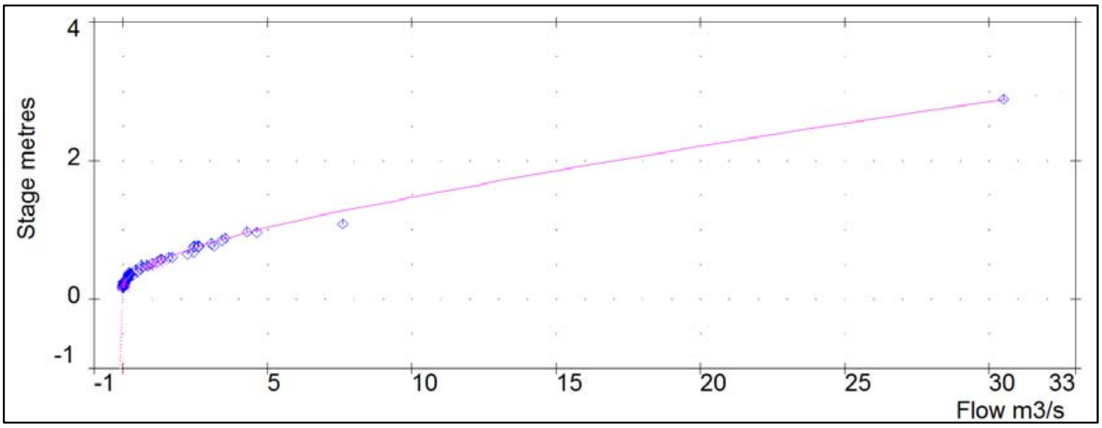

Figure 3 Wainui te Whara rating curve and physical gaugings.

Figure 4 shows the gauge record for the Wainui te Whara; the highest peak recorded by the gauge has been 2.894 m on 1 June 2010 at 19:00:00.

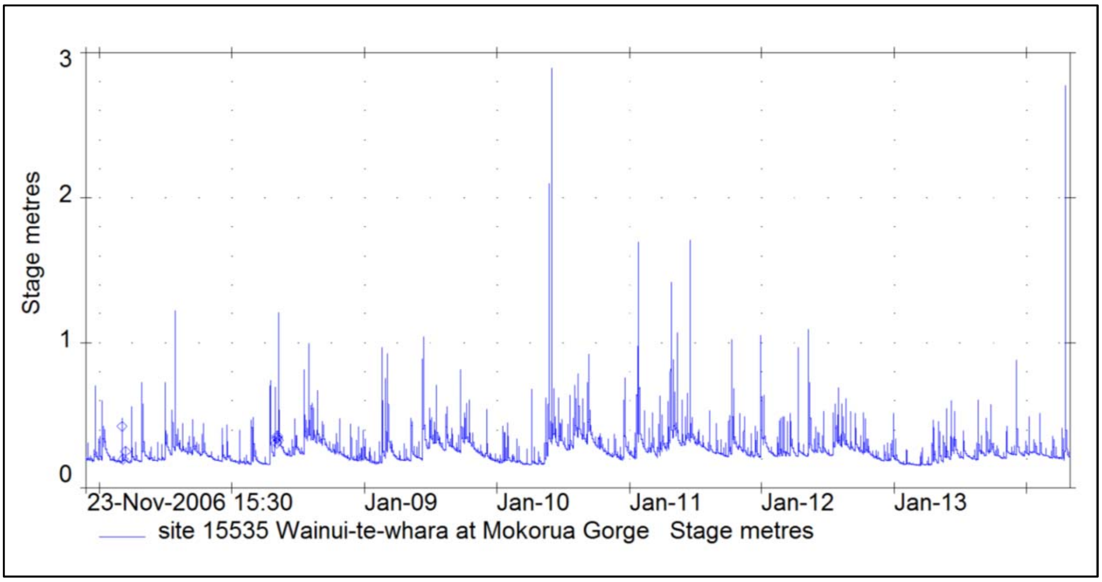

Figure 4 Stage record for Wainui te Whara gauge 23 November 2006-30 April 2014.

1.4 The 18-20 April 2014 event

Figure 5 shows the Wainui te Whara stage record for the 2014 Easter flood from the Tideda Software.

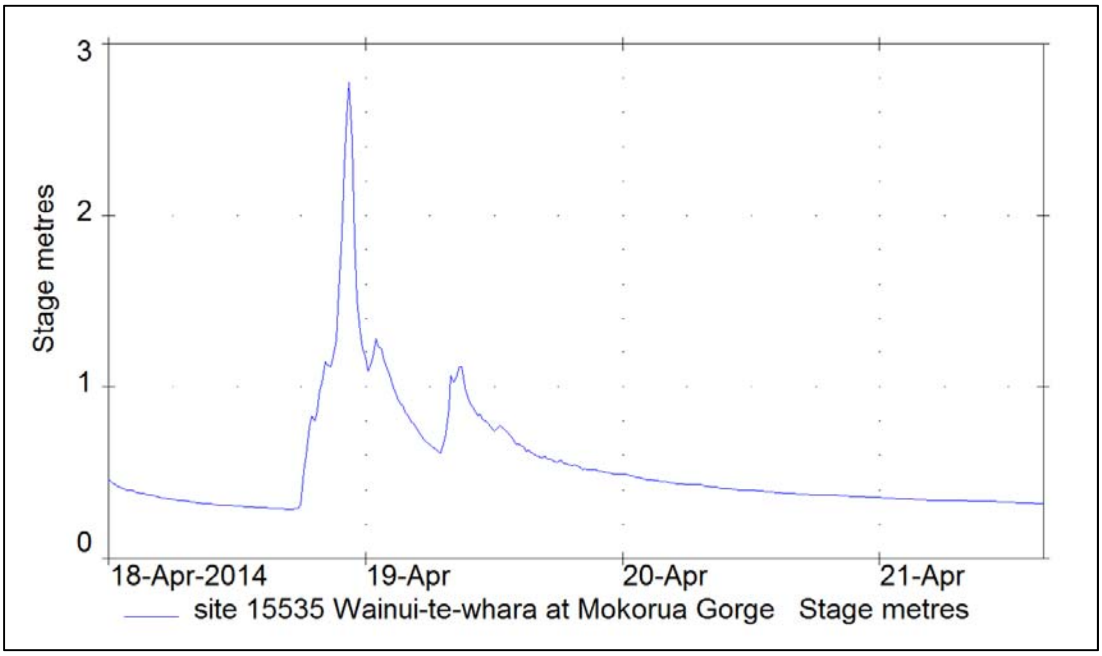

Figure 5 Stage record for Easter flood at Wainui te Whara Stream.

The peak stage record measured by the gauge was 2.774 m on 18 April 2014 at 22:30:00. Using the most recent rating curve (22 August 2013, prior to the analysis included in this report) in the Tideda Software, the corresponding flow at the gauge on the 18 April 2014 at 22:30:00 would be assessed as 28.7 m^3/s.

Part 2: Method

2.1 Survey sites

Five sites were chosen for hydraulic analysis with the main site being at the water level and flow recorder site in the Mokorua Gorge (Site 3 in Figure 6). Figure 6 shows the location of the sites:

- The footbridge (Site 1).
- Straight section above the footbridge (Site 2).
- Gauging site (Site 3).
- Scenic Reserve below potential detention dam site (Site 4).
- Above tributary near potential detention dam site (Site 5).

Figure 6 Location of hydraulic analysis sites on Wainui te Whara Stream.

The sites were surveyed for cross sections, thalweg long sections and debris levels by the Bay of Plenty Regional Council (BOPRC) survey team on 3 and 4 June 2014. Further surveying was done on 23 and 30 July 2014 to gather additional data. It should be noted that a period of six weeks (or longer) after the event is not ideal for surveying debris levels, but the best attempt was made at locating debris levels and confidence levels are given. Appendix 2 shows plots of these survey sections with debris levels.

2.2 Analysis methods

The sites used for each method are listed below.

2.2.1 Critical flow weir analysis

The critical flow weir analysis method was used for Sites 1 and 3 (Figure 7).

Figure 7 Two critical flow weir analysis sites.

The details for the critical flow weir analysis method can be found in Appendix 1.

2.2.2 Slope area method

The slope area method (Manning's Equation) was used for Sites 2, 4 and 5 (Figure 8).

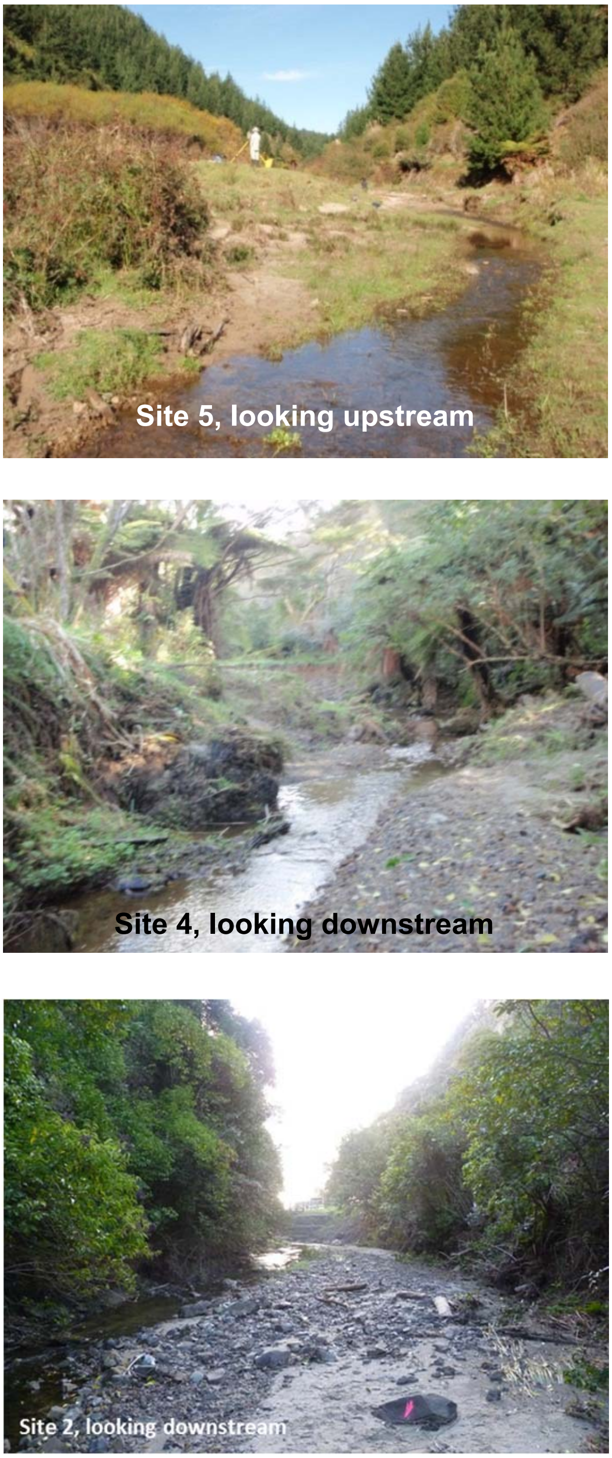

Figure 8 Slope area method sites.

For the application of the slope area method, ideal channel conditions are as follows (Hicks & Mason, 1998):

- Straight channel section.
- The reach has a length >five-times its width.
- The reach has cross sections that are uniform or converging.
- The reach has its flow fully contained within the channel without overflow.
- The reach has a straight entrance and exit condition, with no backwater effects.

The Manning's equation $Q = \frac{AR^{\frac{2}{3}}S^{\frac{1}{2}}}{n}$ is used where A is area of the wetted cross section, R is the hydraulic radius, S the slope of the riverbed and n is the Manning's roughness coefficient.

Manning's n values were considered by reviewing the descriptions of natural streams and their values in Table 3-1(see Appendix 3) in the HEC RAS manual (US Army Corps of Engineers, 2010) and reviewing similar reaches from Hicks & Mason (1998). This information was used to estimate a value for n based on the flow for the similar reach. The Manning's n values chosen are shown in Table 1.

Table 1 Manning's roughness coefficients for selected sites; also with notes on reference reaches from Hicks & Mason 1998.

Wainui te Whara Site	Reference reach from Hicks & Mason	Appendix 2 description	Estimated Manning's n value	Comment
5	30516: Mill Creek at Papanui (Page 282). (Other site considered 37503: Kapaaiaia at Lighthouse Page 278).	Clear winding, some pools and shoals, more shoals.	0.05	H & M site was chosen as banks are grass covered and extend out part of the way on to paddock on both sides before changing to steep banks and bush.
4	46609: Mangere at Kara Weir (Page 310). (Other site considered 47627: Opahi at Pond Page 306).	Clear winding, some pools and shoals.	0.04	H & M site was chosen because has similar overhanging vegetation, slope and sediment type to Site 4.
2	58301: Collins at Drop Structure (Page 294). (Other sites considered 90605: Butchers Creek at Lake Kaniere Road Page 290).	Clear winding, some pools and shoals but some weeds and stones.	0.045	Reference reach has a lower slope than Site 2. Both have a bed with gravel and cobbles and overhanging trees.

Part 3: Results

3.1 Critical flow weir analysis

A summary of the critical flow weir analysis results are shown in Table 2. Full results are shown in Appendix 4. The top cross section at both sites were used to determine the upstream water level. The gauge is currently situated at the middle cross section at Site 3. It was decided the top cross section was a better representation of the water level as it was not constrained like the middle cross section. The bottom cross section was used for Site 3 because it was the most constrained section.

Table 2 Critical flow weir analysis results.

Cross section	Upstream water level (m)	Surface breadth (m)	Velocity (m/s)	Contraction head loss (m)	Flow (m^3/s)
Site 3 bottom	21.03	4.61	4.1	0.07	33.1
Site 1 mid	14.98	5.78	3.8	0.04	31.2

3.2 Slope area method analysis

A summary of the results for the slope area method are shown in Table 3. Full results for Site 2 mid cross section are shown in Appendix 4.

Table 3 Slope area method results.

Cross section	Water surface slope (m/m)	Wetted Area (m^2)	Hydraulic Radius (m)	Mean velocity (m/s)	Manning's n	Energy line slope (m/m)	Flow (m^3/s)
5 mid	0.01	7.5	0.65	1.5	0.05	0.010	11.2
4 mid	0.002	7.7	0.90	0.9	0.04	0.002	7.0
2 mid	0.03	22.6	1.60	5.3	0.045	0.042	118.8

3.3 Confidence levels

The parameters used in the critical flow analysis are the cross section area, surface width and the coefficient of contraction. The coefficient of contraction for a change in channel area varies from 0.1 for a gradual contraction to 0.6 for an abrupt contraction (US Army Corps of Engineers, 2010). The coefficient of contraction was chosen with high confidence as 0.1 for both sites as the selected sites are not abrupt contractions.

There is high confidence in the cross section and long sections surveying for Sites 1 and 3. The debris levels above these two sites were more easily identifiable due to clear lines of debris levels caught on the gabion baskets. The debris levels are used to determine the cross-sectional area and the surface width. The estimated flows for Sites 1 and 3 (31.2 and 33.1 m^3/s) are similar, giving additional confidence in the results.

The confidence interval for the critical flow sites was tested by re-running the analysis with appropriate changes in the main sensitive parameters. Upstream water level was tested at ± 100 mm from surveyed. Surface breadth was tested at ± 5% of surveyed. This indicated a confidence interval of ±2 m3/s (6.4 %). It would be prudent to allow a confidence level of 10% (±3.2 m3/s).

For the slope area method analysis, the parameters are area and shape of cross section, energy slope, manning's n and water level. The surveyed debris levels contribute to the cross section area, slope and water level. Manning's n is estimated from literature tables and from pictures of the similar reference sites. With a higher flow for Site 5 (11.2 m3/s) than the downstream Site 4 (7.0 m3/s) there is low confidence in both flow estimates.

For Site 2, the estimated flow using the slope area method is 119 m3/s. There is almost no confidence in this value being correct due to the sites either side (1 and 3) having estimated flows of 31.2 and 33.1 m3/s respectively. The downstream flood effects observed in the protected urban zone below the three sites, do not support the higher value of 119 m3/s estimated by the Site 2 analysis.

Part 4: Discussion

4.1 Results

Critical flow weir analysis at Site 3 estimates a flow of 33.1 m^3/s for the peak flow in the Mokorua Gorge of the Wainui te Whara Stream during the 18-20 April 2014 storm. With a 10% confidence level the range is 29.8 m^3/s to 36.4 m^3/s. A similar critical flow weir site (Site 1) further downstream also gives a similar result of 31.2 m^3/s for the peak flow. For Site 3, it is considered likely due to the nature of the channel at this location, that due to waves pushing up the debris, the debris levels recorded could be up to 100 mm higher than the effective water level, and that the flow was more like that of Site 1 (31.2 m^3/s). Also, when the Site 3 analysis was re-done using the section at the gauge (middle cross section) and the recorded peak level, the result was 31.1 m^3/s. Taking these various considerations into account, 31.2 m^3/s was judged the most appropriate estimate of peak discharge at Site 3 during the 2014 Easter flood event.

Site 2 has a small tributary entering just above the top cross section but this was assumed to not have a large effect on the flows in the Site 2 cross sections, or at Site 1 (located downstream) due to the tributary catchment's size of 0.3 km^2 relative to the whole catchment size of 5.75 km^2.

Slope area method analysis of Site 2 estimates a flow of 119 m^3/s which is about four times the flow estimated by the Site 3 and Site 1 analyses. Suggestions for the high debris level lines are:

a) A blockage due to logs at the footbridge (Site 1) could cause water to back up above Site 1 raising the water level in Site 2.

b) A large transient slug of sediment (approximately 600 m^3 would be required) deposited at Site 2 could result in the raised debris levels during the peak of the flood.

c) A transient wave of floodwaters due to short-lived dam and break-out event immediately upstream in the gorge.

Approximately 180 m^3 of sediment was removed from the sediment traps downstream of Sites 1 and 2 which makes b) unlikely. Logs are known to have caused blockages at bridges on the stream during the Easter storm, but this has been discounted as a cause of the high debris levels at Site 2 because the water surface profile along the reach (see Appendix 2) was too steep, and therefore is not consistent with that situation. Site 1 is immediately downstream of Site 2. The possibility of a large (short-lived) wave of water at Site 2 is not supported by the results at Site 1. An explanation for the large flow estimated at Site 2 using the Slope Method has not been uncovered.

Flow estimation at Site 4 is very difficult due to a very flat surveyed energy slope. Likewise, the surveyed debris levels at Site 5 do not provide sufficient resolution of the energy slope. There is low confidence in these results and it is not recommended they are used for calibration at the detention dam site.

4.2 Rating curve

The most recent rating curve (22 August 2013) gives the peak flow at the gauge on the 18 April 2014 at 22:30:00 as 28.7 m^3/s. The estimate from the study has a likely value of 31.2 m^3/s for the peak flow from the critical flow analysis.

It is recommended that the high end of the rating curve is updated to reflect this estimate. A recommended rating curve was constructed using the weir calculation spreadsheet developed to analyse the Easter flood flows at Site 3. The recommended rating curve is tabulated in Table 4.

Table 4 Stage discharge relationship.

Discharge (m^3/s)	Stage (m) - Moturiki datum	Stage (m)
33.6	20.69	2.894
31.2	20.57	2.774
25.6	20.3	2.504
21.7	20.1	2.304
18.1	19.9	2.104
14.7	19.7	1.904
11.6	19.5	1.704
9.0	19.3	1.504
6.7	19.1	1.304
4.7	18.9	1.104

Figure 9 shows the previous rating curve (22 August 2013), the physical gaugings that have been done, and the new recommended high end of the rating curve.

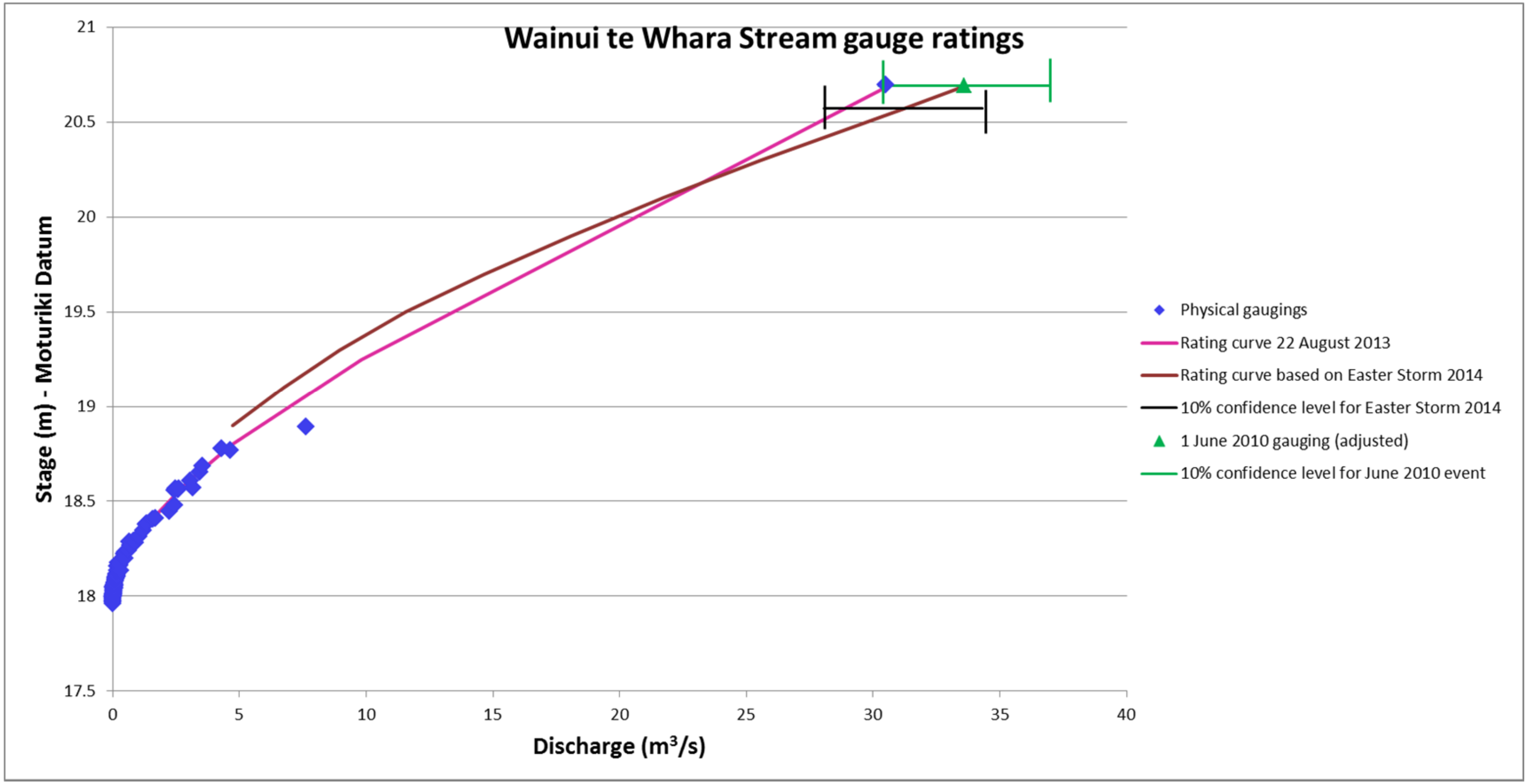

Figure 9 Wainui te Whara Stream gauge ratings.

Part 5: Conclusion and recommendations

- Flow estimation has been carried out at five sites in the Wainui te Whara Stream following the large flow event at Easter 2014.
- At three of these sites, remaining evidence of the flood (debris and channel form) is insufficient to provide reasonable confidence in the estimates.
- At two sites (Site 1 and Site 3) a reasonably high estimated confidence (+/-10%) was achievable due to weir-type features in the stream channel and the high definition of peak flood levels in appropriate locations.
- The resulting estimate of peak flow from the hydraulic analysis of the 18-20 April 2014 storm at the Wainui te Whara Stream gauge is 31.2 m^3/s +/-3.2 m^3/s.
- It is recommended to change the gauge's rating curve at the high flows end to reflect this estimated peak flow value. A new rating curve has been generated for high flows.
- Based on this new rating curve, the peak flow for the 1 June 2010 at 19:00:00 storm is estimated at 33.6 m^3/s (Table 4).
- It is recommended that the results from Site 4 and 5 are not used for calibration of the detention dam site.

Part 6: Bibliography

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Hicks, D., & Mason, P. D. (1998). *Roughness Characteristics of New Zealand Rivers.*

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US Army Corps of Engineers. (2010). *HEC-RAS River Analysis System - Hydraulic Reference Manual.*

Appendices

Appendix 1 – Critical flow weir analysis method

Critical flow weir analysis

The energy equation for an open channel is $= z + y + \frac{V^2}{2g}$. Using the principle of Conservation of Energy for steady flow, the total energy at cross section 1 equals the total energy at cross section 2 plus the energy loss between the two cross sections (Refer Figure 10).

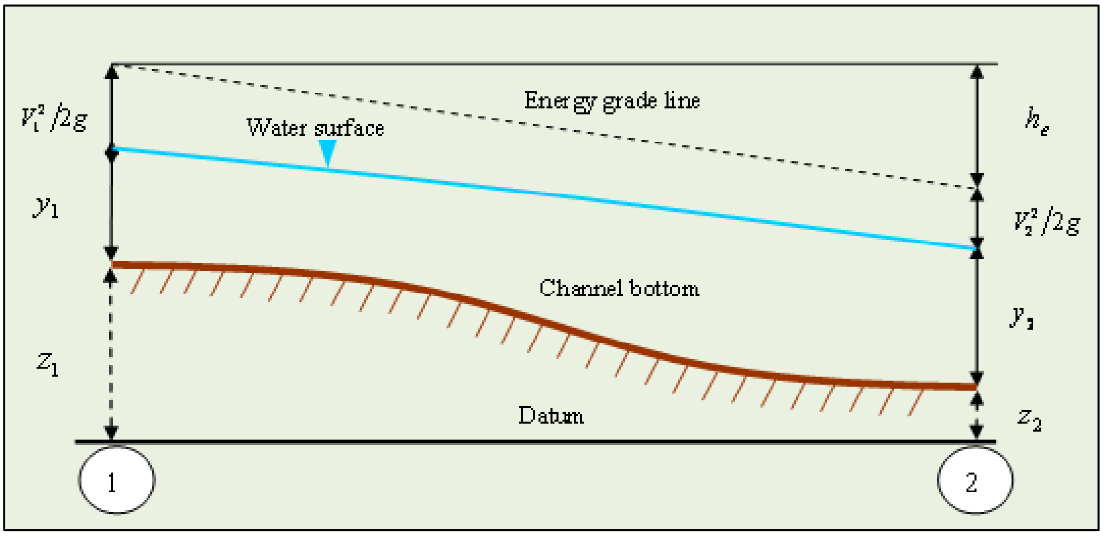


Figure 10 Energy equation (Environment Agency, 2010).

The energy loss h_e can be calculated using the equation $h_e = C\left|\frac{\alpha_1 V_1^2}{2g} - \frac{\alpha_2 V_2^2}{2g}\right|$

(US Army Corps of Engineers, 2010), where α is a factor relating to the complexity of the stream channel (for these channel shapes α =1) and a contraction coefficient of C = 0.1 as both sites were determined to be relatively smooth.

The steps for calculating the discharge at cross section 2 are (Refer Figure 22 and Figure 23 in Appendix 4):

1 Take the measured water level at cross section 1 using debris levels at the site.

2 Enter a trial value for the water level at cross section 2.

3 Calculate a discharge for cross section 2 from which a velocity and total head for cross-section 1 can also be calculated.

4 Iterate the trial water level and energy loss h_e for cross section 2 so that $\left(z_1 + y_1 + \frac{V_1^2}{2g}\right) - \left(z_2 + y_2 + \frac{V_2^2}{2g} + h_e\right) = 0$. Once the difference is zero, the discharge at cross section is calculated from the new value for the cross section 2 water level.

In the situation where a weir is located at cross section 2, a critical flow situation (Froude number =1) can occur at the most constrained section immediately upstream of the weir. With the condition for critical flow, the energy equation can be rearranged to give $Q^2B = gA^3$ where A is the total cross-sectional area of the channel and B is the surface width (Henderson, 1966). The discharge can then be estimated for the most constrained section based on the formula $Q = \sqrt{\frac{gA^3}{B}}$.

Sites 1 and 3 on the Wainui te Whara were chosen for application of this method as they have a weir located just downstream of cross section 2. A spreadsheet has been developed to allow the iteration process outlined in Steps 1 to 4 to be semi-automated using the Excel “Goal Seek” function. The Goal Seek function allows the user to set the result for a formula and adjust an input value to find it.

Appendix 2 – Cross sections and long sections

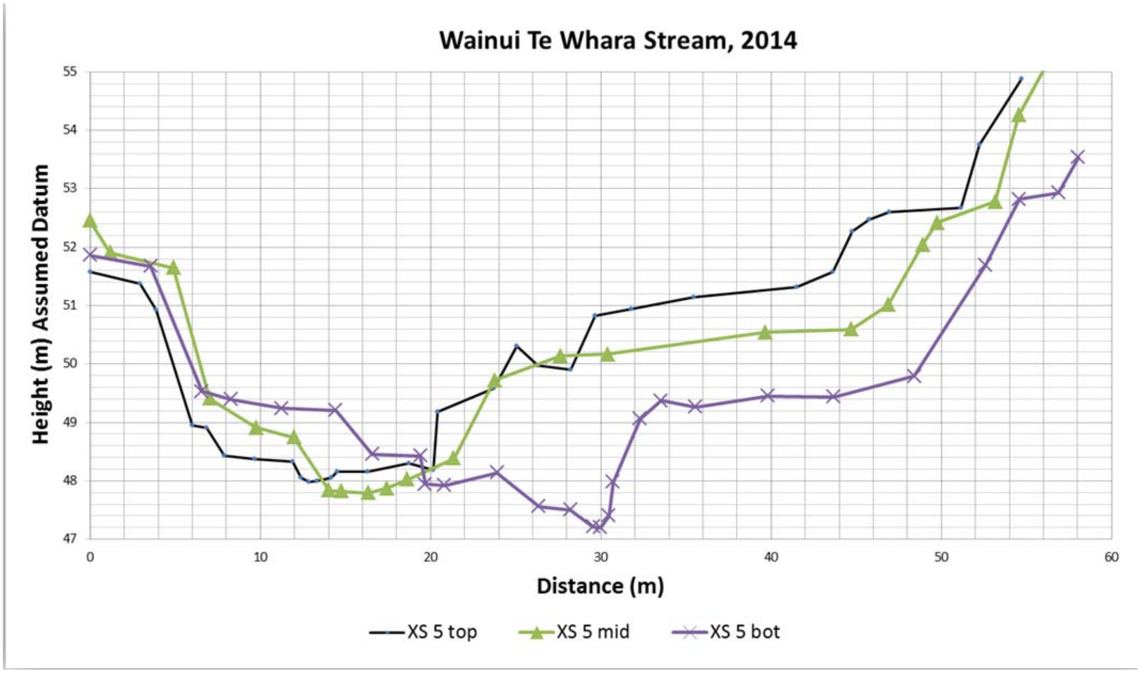


Figure 11 *Site 5 cross sections.*

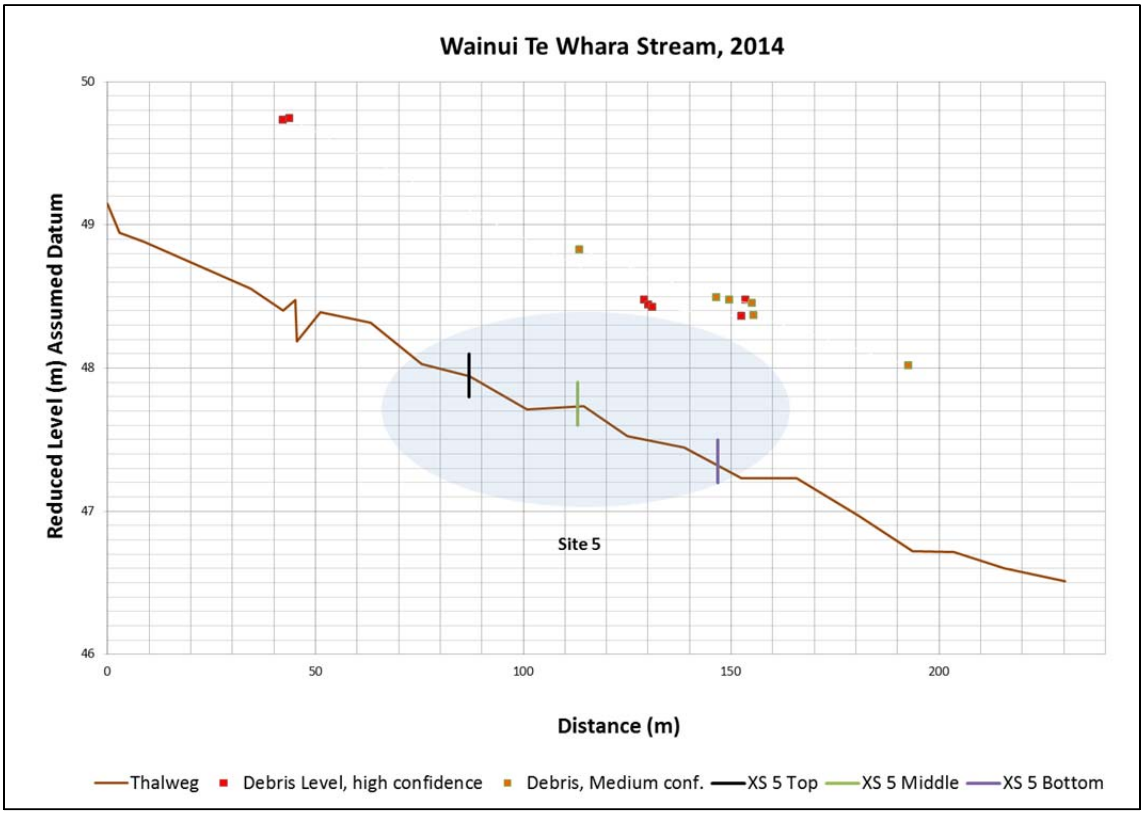


Figure 12 *Site 5 long section.*

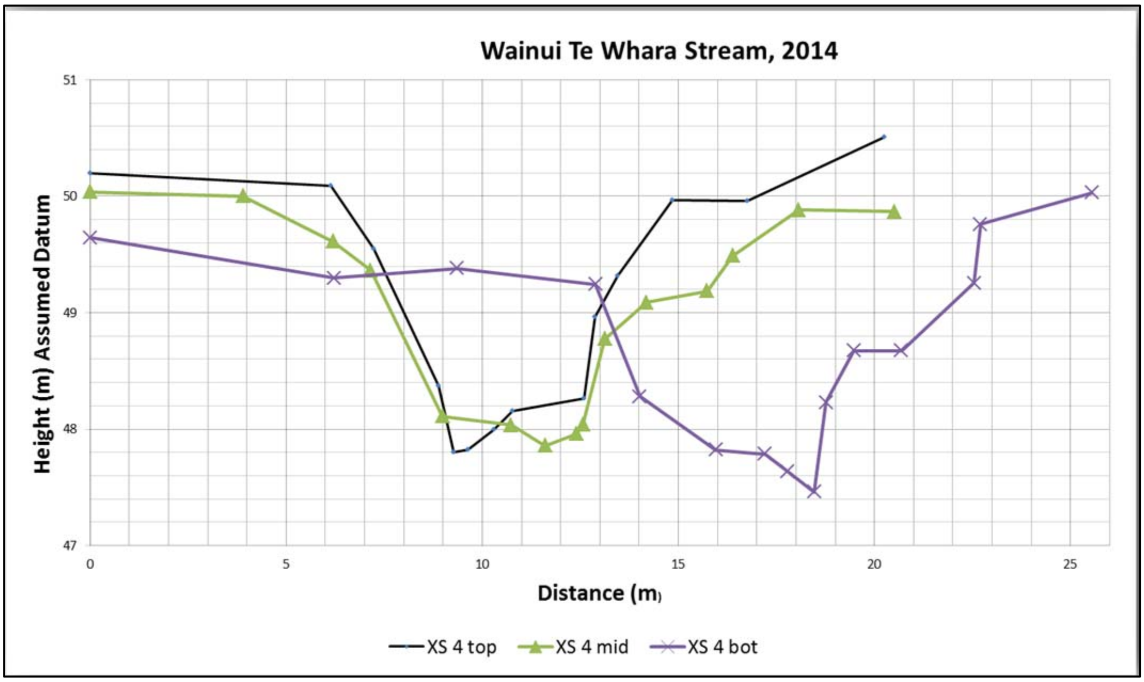


Figure 13 Site 4 cross sections.

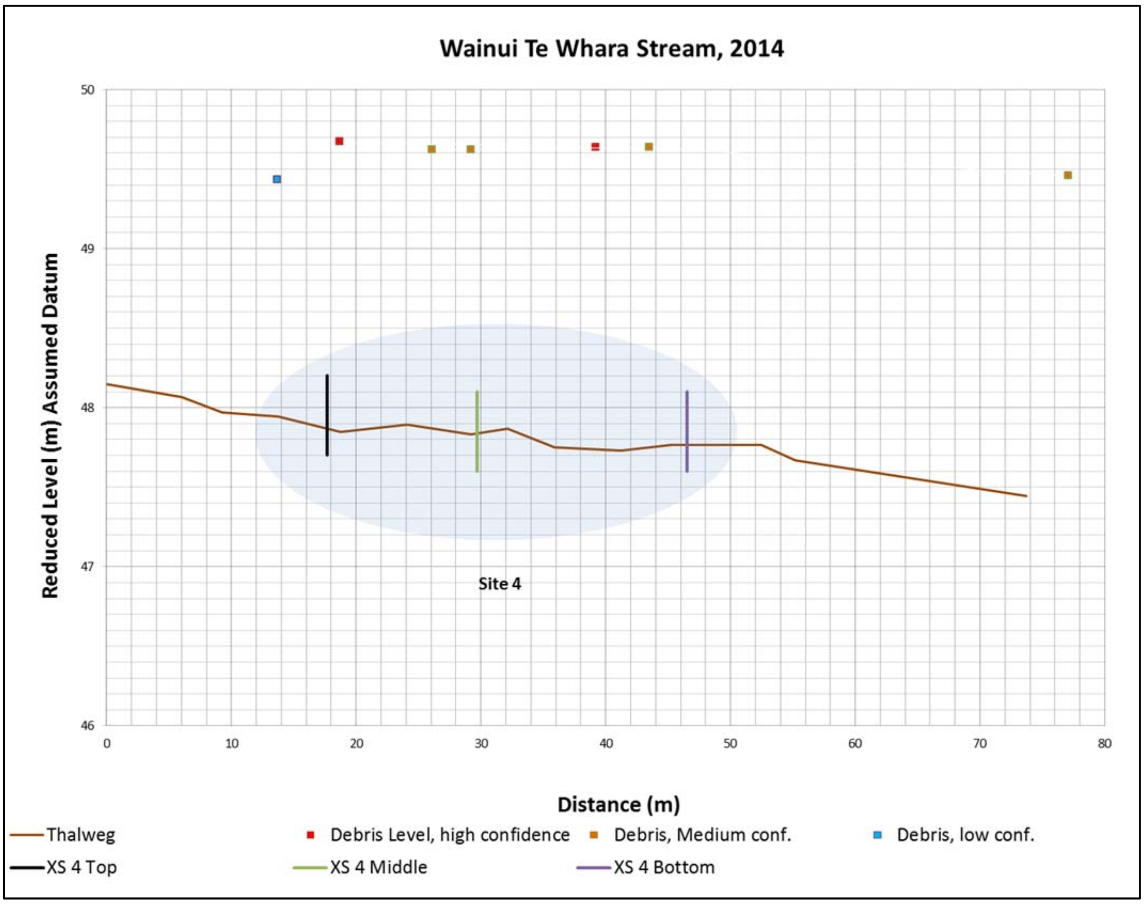


Figure 14 Site 4 long section.

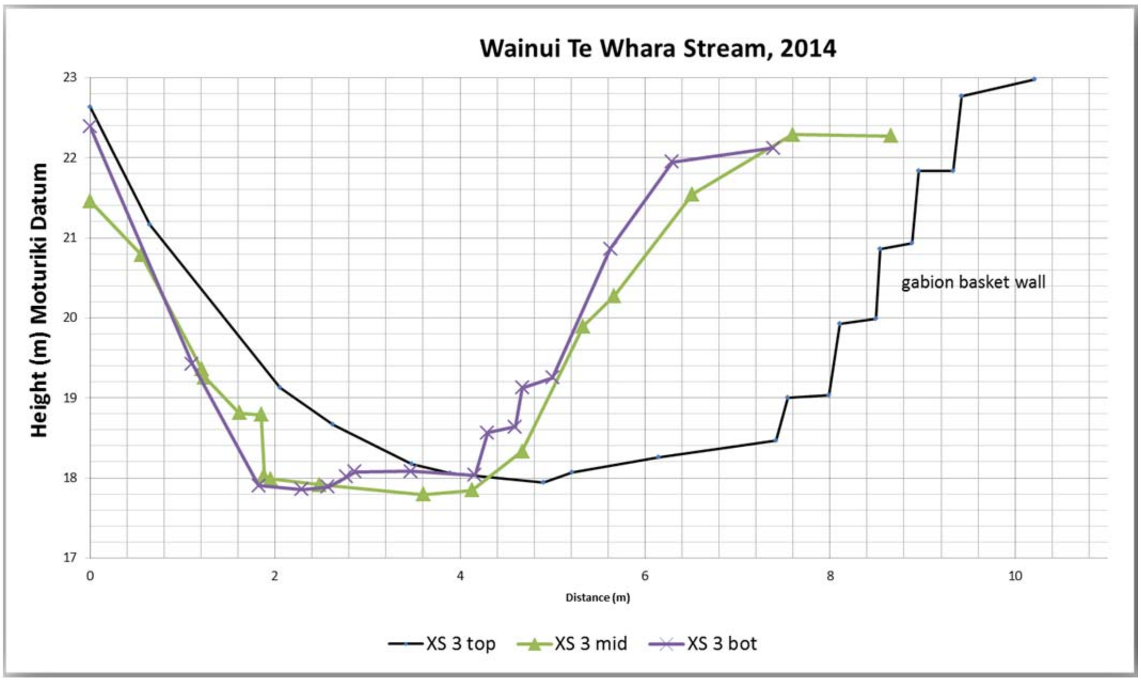


Figure 15 *Site 3 cross sections.*

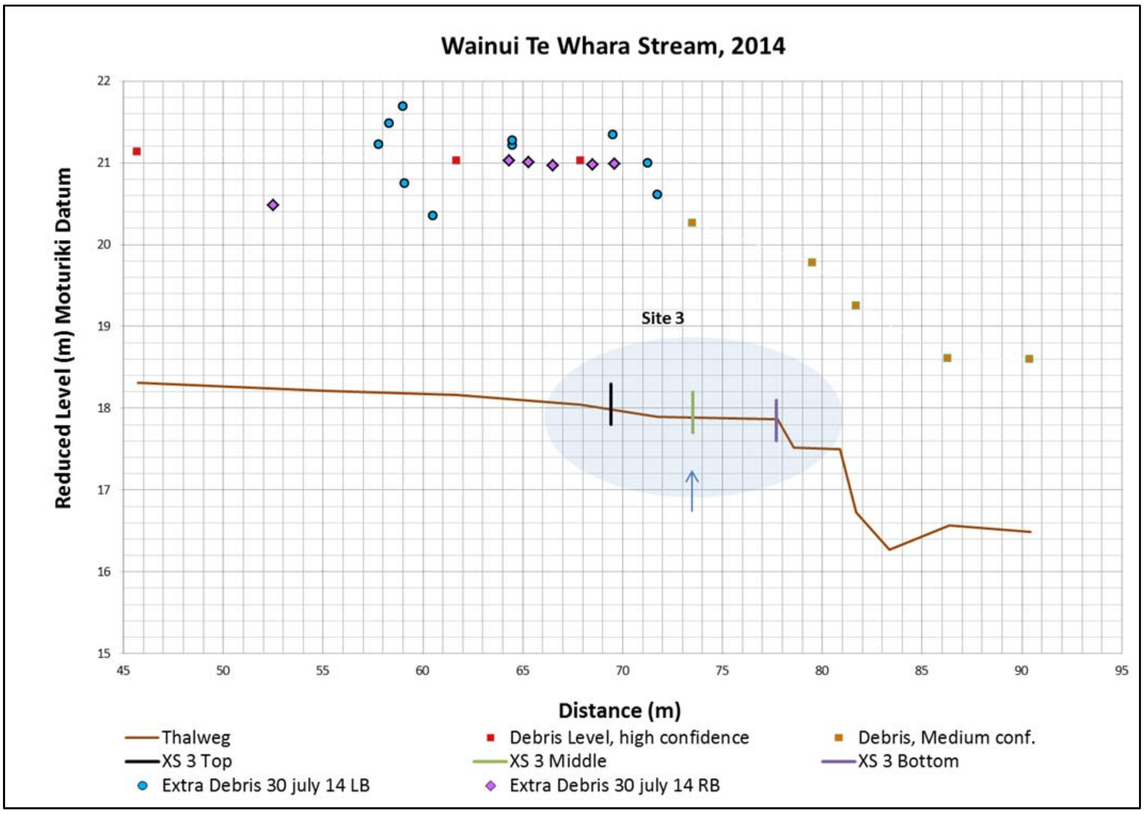


Figure 16 *Site 3 long section.*

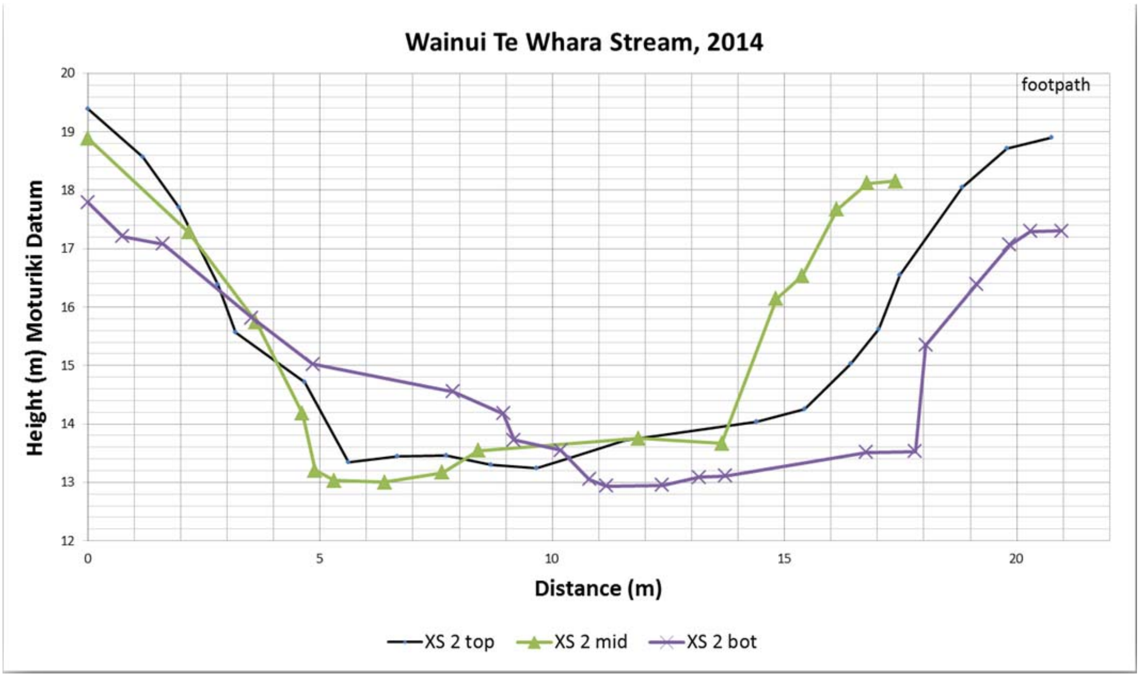


Figure 17 Site 2 cross sections.

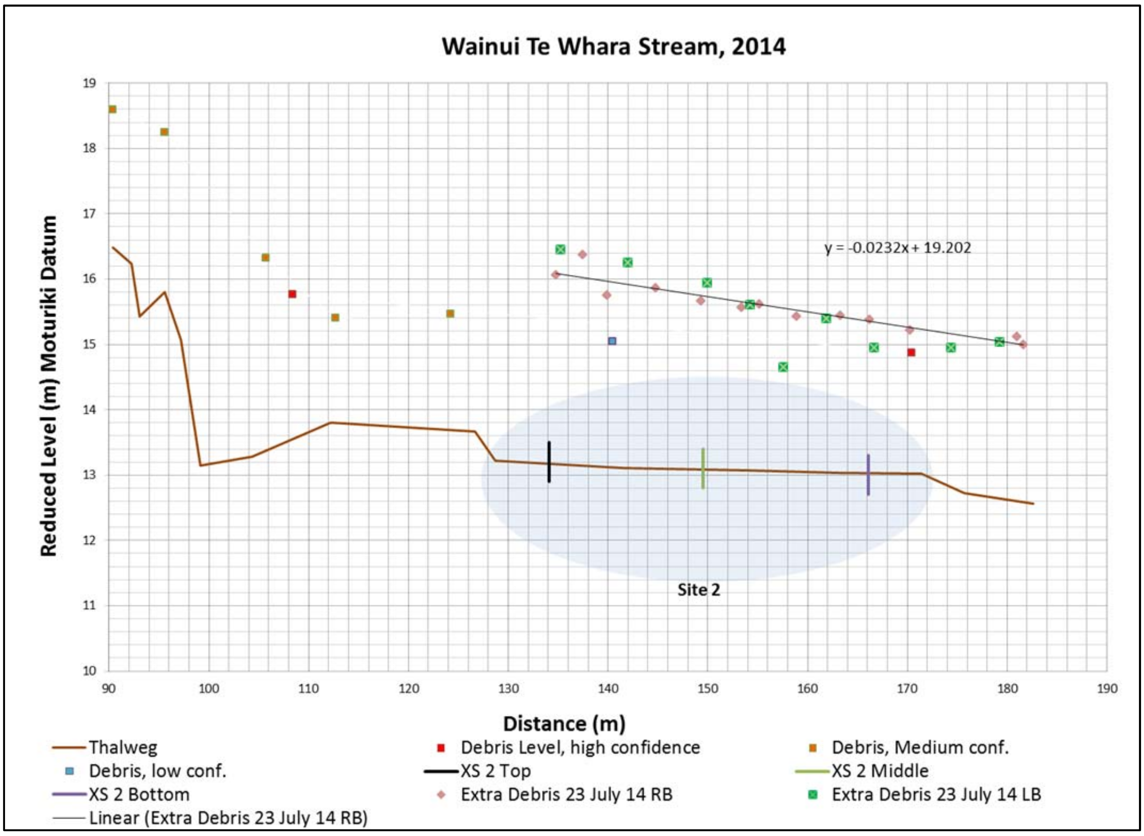


Figure 18 Site 2 long section.

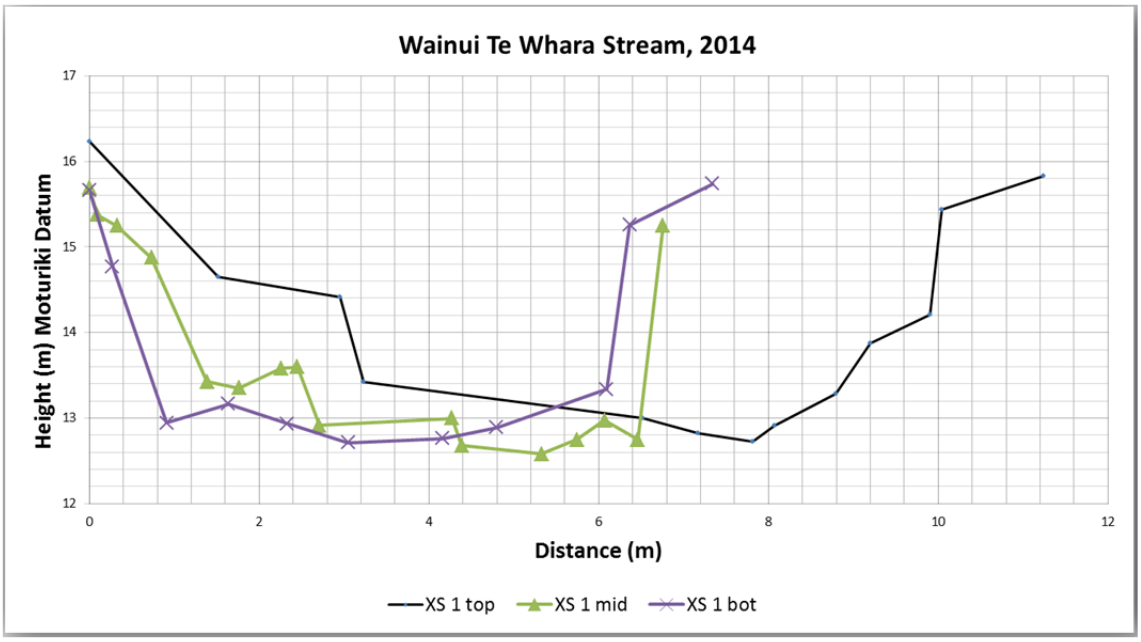


Figure 19 Site 1 cross sections.

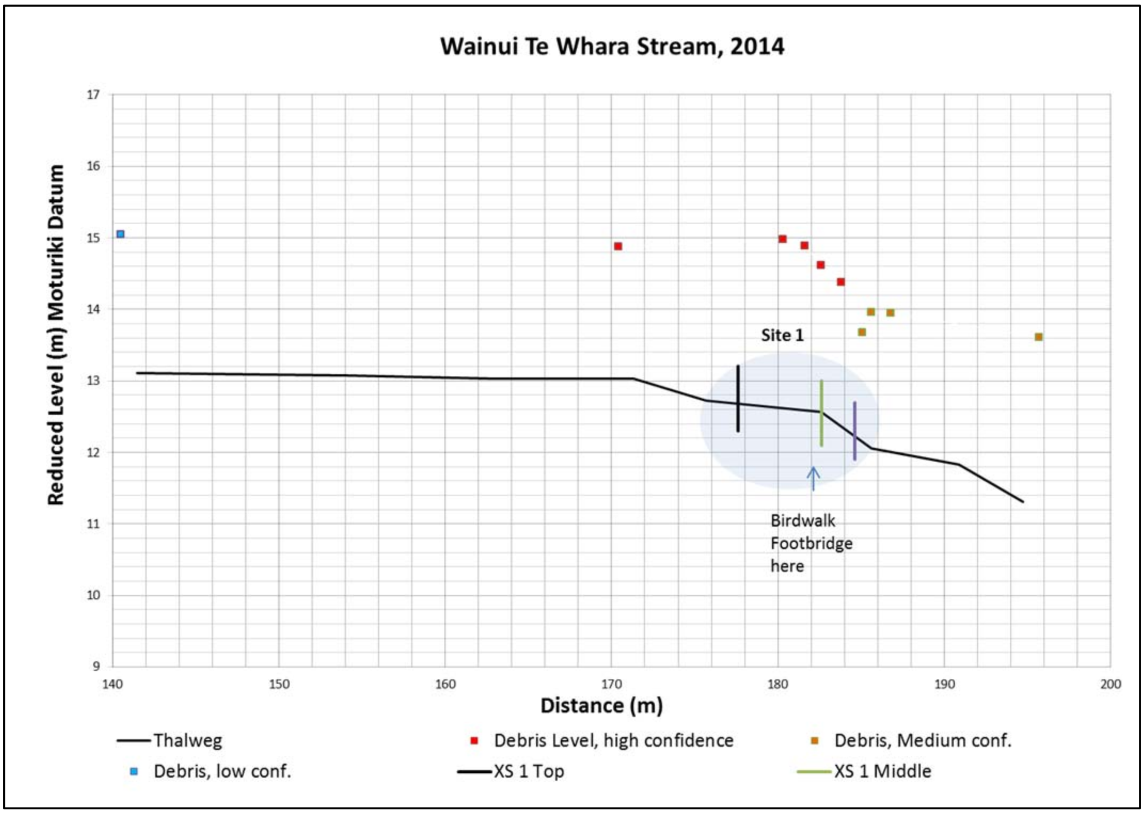


Figure 20 Site 1 long section.

Appendix 3 – Manning's n values

Chapter 3– Basic Data Requirements

Table 3-1 Manning's 'n' Values

Type of Channel and Description	Minimum	Normal	Maximum
A. *Natural Streams*			
1. Main Channels			
a. Clean, straight, full, no rifts or deep pools	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as "d" but more stones	0.045	0.050	0.060
g. Sluggish reaches, weedy. deep pools	0.050	0.070	0.080
h. Very weedy reaches, deep pools, or floodways with heavy stands of timber and brush	0.070	0.100	0.150
2. Flood Plains			
a. Pasture no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
2. Same as above, but heavy sprouts	0.050	0.060	0.080
3. Heavy stand of timber, few down trees, little undergrowth, flow below branches	0.080	0.100	0.120
4. Same as above, but with flow into branches	0.100	0.120	0.160
5. Dense willows, summer, straight	0.110	0.150	0.200
3. Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged			
a. Bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070

Figure 21 Table 3-1 related to natural streams from HEC RAS manual (US Army Corps of Engineers, 2010).

Appendix 4 – Results for critical flow weir analysis

Site 3 bot		
Perturbations		
U/s water level	0	m
Surface Breadth	0	%
For upstream section		
WL u/s	21.03	m RL
WL u/s (perturbed)	21.03	m RL
Area u/s	17.82	m2
Velocity u/s	1.86	m/s
vHead u/s	0.176	m
Total Head u/s	**21.206**	m RL
For critical flow section		
Trial WL	20.266	m RL
Breadth (perturbed)	4.61	m
Discharge	**33.1**	m3/s
Velocity	4.13	m/s
vHead	0.87	m
Total head	21.14	mRL
Losses between		
Contr. loss C	0.10	
Contraction loss	0.069	m
Result		
Total Head u/s	**21.206**	m RL

Figure 22 Site 3 critical flow weir analysis results.

Site 1 mid		
Perturbations		
U/s water level	0	m
Surface Breadth	0	%
For upstream section		
WL u/s	14.98	m RL
WL u/s (perturbed)	14.98	m RL
Area u/s	12.76	m2
Velocity u/s	2.45	m/s
vHead u/s	0.306	m
Total Head u/s	**15.286**	m RL
For critical flow section		
Trial WL	14.525	m RL
Breadth (perturbed)	5.78	m
Discharge	**31.2**	m3/s
Velocity	3.76	m/s
vHead	0.72	m
Total head	15.24	mRL
Losses between		
Contr. loss C	0.10	
Contraction loss	0.041	m
Result		
Total Head u/s	**15.286**	m RL

Figure 23 Site 1 critical flow weir analysis results.

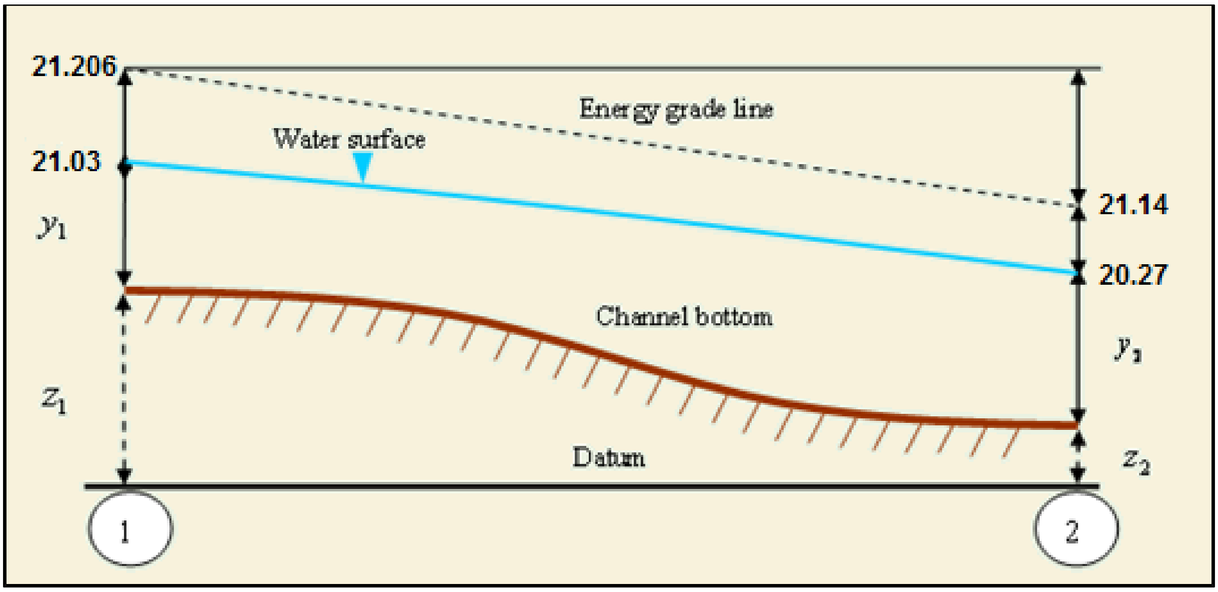
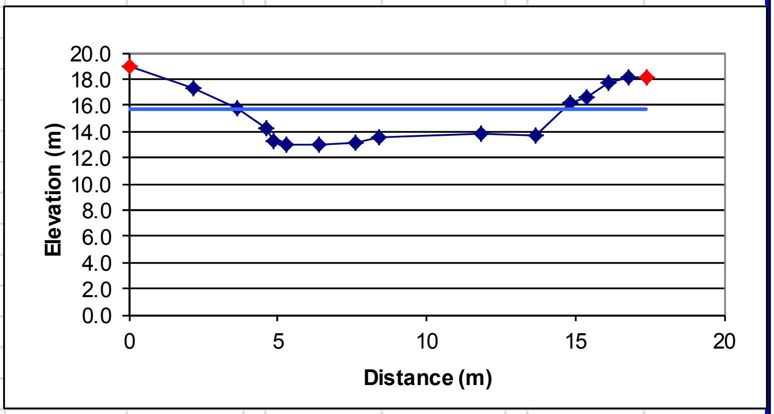


Figure 24 Diagram of Site 3 critical flow weir analysis results (Environment Agency, 2010).

Appendix 5 – Results for slope area method analysis

Site 2 Mid Cross-section

Slope (m/m)	0.0300
Mannings n LB	0.0000
Mannings n MC	0.0450
Mannings n RB	0.0000
Divider LB (m)	0.0000
Divider RB (m)	17.3849
Water Level (m)	15.75



Coordinates		**Left Bank**		**Main Channel**		**Right Bank**	
Distance	Elevation	Area	Perimeter	Area	Perimeter	Area	Perimeter
(m)	(m)	(m^2)	(m)	(m^2)	(m)	(m^2)	(m)
0.000	18.889						
2.178	17.279			Above WL			
3.622	15.741			0.00	0.02		
4.618	14.178			0.79	1.85		
4.889	13.203			0.56	1.01		
5.308	13.031			1.11	0.45		
6.387	13.001			2.95	1.08		
7.633	13.169			3.32	1.26		
8.405	13.539			1.85	0.86		
11.864	13.751			7.29	3.47		
13.648	13.664			3.65	1.79		
14.819	16.14			1.03	2.31		
15.386	16.537			Above WL			
16.129	17.672			Above WL			
16.782	18.116			Above WL			
17.385	18.153			Above WL			
				0.00	0.00		
				0.00	0.00		
				0.00	0.00		
				0.00	0.00		
				0.00	0.00		
				0.00	0.00		
				0.00	0.00		
				0.00	0.00		
	Totals	0.00	0.00	22.55	14.09	0.00	0.00
	Hydraulic Radius (m)			1.60			
	Velocity (m/s)			5.27			
	Flow (m^3/s)	0.00		118.77		0.00	
	Total Flow (m^3/s)	118.77					

Figure 25 Slope area method results.