

Hydraulic Travel Times of Major Waikato Rivers

Prepared by:
Edmund Brown

For:
Environment Waikato
PO Box 4010
HAMILTON EAST

25 January 2005

Document #: 973399

Reviewed by:
Bill Vant

Signature



Date April 2005

Approved for release by:
Viv Smith

Signature



Date April 2005

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1 Introduction

The purpose of this report is to provide quick reference charts of estimated travel times along major Waikato rivers in response to emergency situations such as hazardous spillages.

The term "travel time" is simply the calculated time it takes for a body of water to travel between two points. The rivers and streams analysed are those most at risk of contamination by hazardous substances due to their proximity to major roads and railways.

The travel times are based on measurements of river and stream length, discharge and mean velocity. The travel times for each of the rivers and streams analysed are presented for two reference flows, the 15th and 85th percentile flows. The 15th percentile flow represents high flow conditions which are equalled or exceeded 15 percent of the time and the 85th percentile flow represents low flow conditions which are equalled or exceeded 85 percent of the time.

The flow velocities of the various flow gauging sites in each catchment are referenced to one location, the reference site. This negates the need for the user of the tables to have flow measurements for all the sites.

Note: *The travel times given are only approximate and provide a first approximation for emergency instance planning purposes. However, due to the number of assumptions and limitations used in the calculations there may be considerable variation between what is reported here and what actually occurs for each water body.*

2 How to Use the Travel Time Tables

1. Identify the catchment of interest and then select the correct table of travel times. Maps are provided to aid in selecting the correct table (Figures 3-11). For each river there may be a number of travel-time tables depending on the number of tributaries that cross major transport routes. For example, the Waipa River has five tables.
2. To estimate the travel time using the tables provided, the user needs to know the discharge at the reference site for the river of interest. Where possible the reference sites chosen are telemetered by Environment Waikato. If the discharge is similar to either of the reference flows reported then the travel times can be read directly from the table. If the discharge is less than that given in the table for the 85 percentile flow then the travel time will be greater than those presented. If the flow is greater than the 85 percentile flow, but less than the 15 percentile flow then it is possible to estimate the travel time using a weighed average of the two travel times presented.
3. The matrices are read by reading across the row of the location where the travel time is to be taken from and reading up the column of the downstream location. The point of intersection gives the approximate travel time in hours between the two locations. Three examples are shown in Figure 1 for the low flow of the Waikato River (reference flow of 250 cumecs at Mercer) using data from Table 3:

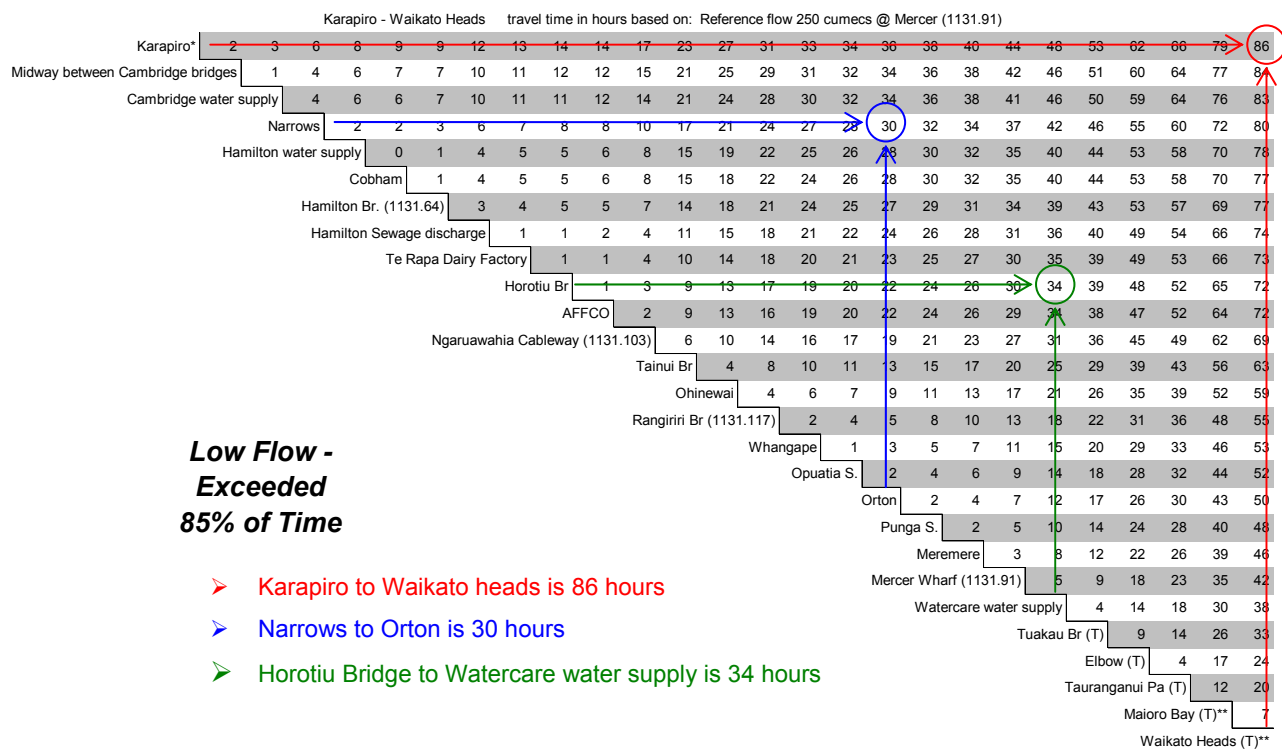


Figure 1: Example of using a travel time matrix.

4. Three examples of weighting the flow are given using data from Table 3 for the travel times between Karapiro and Waikato heads. For the reference flow of 250 cumecs the travel time given is 86 hours and for the reference flow of 535 cumecs the travel time given is 58 hours.
 - If the actual flow at the reference site is 320 cumecs:
 - 1) Calculate the ratio of the actual flow to the reference flow, this is calculated as the difference between the actual flow and the lower reference flow divided by the difference of the two reference flows, $(320 - 250) / (535 - 250) = 0.25$.
 - 2) The weighted travel time is calculated by multiplying the difference in travels times of the two reference flows by the ratio from step 1 which is then taken away from the travel time of the upper reference flow, $86 - (86 - 59) * 0.25 = 79$ hours. The travel time using the mean velocity method is 78 hours.
 - If the actual flow at the reference site is 390 cumecs:
 - 1) Calculate the ratio of the actual flow to the reference flow, this is calculated as the difference between the actual flow and the lower reference flow divided by the difference of the two reference flows, $(390 - 250) / (535 - 250) = 0.5$.
 - 2) The weighted travel time is calculated by multiplying the difference in travels times of the two reference flows by the ratio from step 1 which is then taken away from the travel time of the upper reference flow, $86 - (86 - 58) * 0.5 = 72$ hours. The travel time using the mean velocity method is 73 hours.
 - If the actual flow at the reference site is 465 cumecs:
 - 1) Calculate the ratio of the actual flow to the reference flow, this is calculated as the difference between the actual flow and the lower reference flow divided by the difference of the two reference flows, $(465 - 250) / (535 - 250) = 0.75$.
 - 2) The weighted travel time is calculated by multiplying the difference in travels times of the two reference flows by the ratio from step 1 which is then taken away from the travel time of the upper reference flow, $86 - (86 - 58) * 0.75 = 65$ hours. The travel time using the mean velocity method is 65 hours.

If the discharge is greater than the 15 percentile then the travel time will be less than those presented.

3 Calculation of the Travel Times

The methods outlined below describe how the travel-time tables were calculated.

1. For each river the automated gauging sites were identified. If there were no automated gauging sites, manual flow gaugings were used.
2. One automated or manual gauging site was selected as the reference site for each river. All the gauging sites on a river are referenced to this site. It is best if the reference site is on the Environment Waikato telemetered system so that travel times can be estimated from the office when needed.
3. The travel times have only been calculated for two river discharge rates at the reference site (15th percentile flow and 85th percentile flow). Thus the travel times for the two reference flows cover the upper and lower bounds or 70% of the flow distribution.
4. Once the two discharges for the 15th and 85th percentile have been identified the corresponding discharge for the same percentile flows are found at the other gauging sites on the river.
5. The mean cross sectional velocity for the corresponding discharges identified in step 4 are also calculated, thus giving a velocity profile along the river for the two reference flows. These velocities are listed in the tables next to the appropriate geographic location along the river.
6. The distance between the gauging sites with velocity data and locations where roads and railways traverse were traced from the NZMS 260 series maps. These distances are also listed in the tables. High-use roads have been identified using existing transport route information (Environment Waikato 1997).
7. An estimate of travel time is calculated by dividing the distances along the river by the mean cross sectional velocity.

The method described above was tested using existing data for the Waikato River between Hamilton City and Port Waikato (Waikato Valley Authority 1979). The two reference flows used in this calibration were 350 cumecs and 680 cumecs as measured at Mercer. The Waikato Valley Authority travel times were based on dye tests and transport modelling. Table 1 and Figure 2 show good agreement between the travel times provided by Waikato Valley Authority (1979) and the method described in this report using mean cross sectional velocity.

Table 1: Travel time for the Waikato River from Hamilton Bridge to the River mouth as calculated by the mean velocity method presented in this report and the Waikato Valley Authority (1979).

	Easting	Northing	Distance (m)	Cumulative distance (km)	Reference flow 350 cumecs @ Mercer (1131.91)				Reference flow 680 cumecs @ Mercer (1131.91)			
					Velocity (m/s)	Cumulative hours	Cumulative hours (W.V.A.)	Velocity (m/s)	Cumulative hours	Cumulative hours (W.V.A.)		
Hamilton Br. - Waikato Heads	2711870	6376510	0	0.0	1.08	0	0	0	1.15	0	0	0
Hamilton Br. (1131.64)	2706990	6383590	9408	9.4	2.9	3	3	3	2.5	3	3	2
Hamilton Sewage discharge	2705925	6385190	1956	11.4	0.6	3	3	3	0.5	3	2	2
Te Rapa Dairy Factory	2704820	6387080	2355	13.7	0.7	4	4	4	0.6	4	3	3
Horotiu Br	2703370	6387580	1522	15.2	0.5	5	5	5	0.4	4	4	4
AFFCO	2699830	6391100	5270	20.5	0.75	2.0	7	7	0.92	1.7	6	5
Ngaruawahia Cableway (1131.103)	2700515	6401770	14280	34.8	5.5	12	13	13	4.5	10	10	10
Tainui Br	2700650	6410120	8786	43.6	3.4	16	17	17	2.8	13	12	12
Ohinewai	2698750	6416740	7482	51.1	0.68	3.0	19	21	0.85	2.2	15	16
Rangiriri Br (1131.117)	2694170	6417520	4878	55.9	1.9	21	24	24	1.4	17	18	18
Whangape	2692780	6419430	2541	58.5	1.0	22	25	25	0.8	17	19	19
Opuatia S.	2691790	6423030	3909	62.4	1.6	23	27	27	1.2	19	21	21
Punga S.	2690610	6427110	4463	66.9	1.8	25	29	29	1.3	20	22	22
Meremere	2693300	6429820	3945	70.8	1.6	27	31	31	1.2	21	24	24
Mercer Wharf (1131.91)	2691800	6433685	4286	75.1	0.71	2.8	29	33	1.02	1.9	23	25
Tuakau Br (T)	2682760	6431995	11393	86.5	7.4	37	39	39	5.0	28	30	30
Elbow (T)	2673880	6433845	11613	98.1	7.5	44	45	45	5.1	33	35	35
Tauranganui Pa (T)	2670680	6429660	5585	103.7	3.6	48	49	49	2.4	35	38	38
Maioro Bay (T)**	2665820	6425680	6705	110.4	0.15	12.4	60	57	0.25	7.5	43	43
Waikato Heads (T)**	2663350	6422885	3940	114.3	0.15	7.3	67	70	0.25	4.4	47	50

W.V.A. - Waikato Valley Authority 1979.

** Velocities estimated based on travel times published by Waikato Valley Authority 1979.

(T) denotes tidal influence

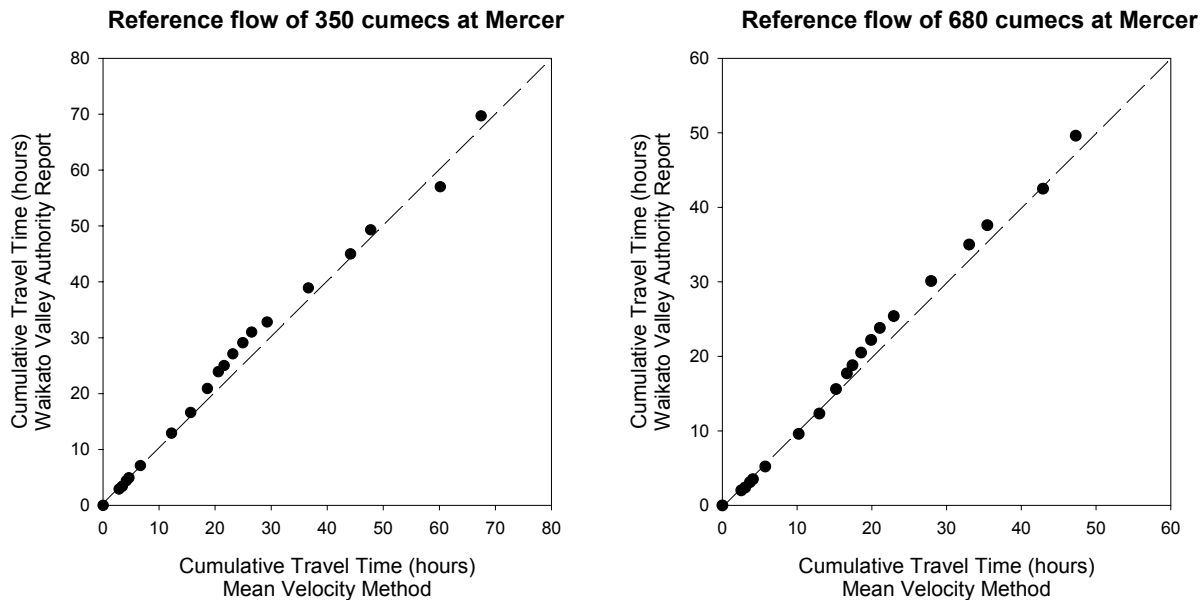


Figure 2: Cumulative travel time for the Waikato River from Hamilton Bridge to the river mouth as calculated by the mean velocity method presented in this report and the Waikato Valley Authority (1979). Dashed line denotes 1:1 line.

3.1 Limitations

3.1.1 Discharge and Velocity Estimates

For each identified discharge for the 15th and 85th percentile flows there is also a range of corresponding velocities, thus a mean velocity has been used. Therefore, it is important to realise that there will be variation in the travel times given.

3.1.2 Tidal Influence

Estimates of travel times in the lower sections of the rivers under tidal influence are to be used with care. In the tables of travel time presented, the locations along the rivers under tidal influence are flagged with the symbol '(T)'. There is little information available for estimating the travel time in the tidal areas where the flood tide can result in a reversal of the river flow direction. Some information is available based on flow modelling of the Waikato River by the Waikato Valley Authority (1979) and Rutherford et al. (1980). This data has been used as a guide for the other tidal influenced rivers in the region. There is also a limited number of flow measurements in the tidal area of the Waihou River. The velocities in the tidal zone of the Waihou River are similar to those for the Waikato River, however, the Waihou data set is small and this similarity may not occur under all flow and tidal conditions.

The travel times for the tidal zones should be taken as the average time for the water body to flow. However, the magnitude and timing of the flood or ebb tide and the corresponding discharge of the river may increase or decrease the travel time considerably.

3.1.3 Transport Mechanisms and Chemistry

Transport mechanisms such as dispersion and dilution, and chemical effects such as attenuation and hydrolysis are not taken into account in the travel times presented.

3.1.4 Storage Lakes

Travel times through storage lakes are difficult to evaluate due to the residence time ranging from days to weeks. In this report the complication of storage lakes only

affects the Waikato River. Thus, travel times for the Waikato River have been divided into two sections: below Karapiro Dam to the Waikato Heads where there are no storage lakes, and from Lake Taupo gates at Taupo township to Karapiro Dam. Estimates of travel time for the Waikato River hydro storage lakes between Lake Taupo and Karapiro Dam are taken from water quality modelling by Rutherford et al. (2001). The dilution ability of the storage lakes may also be useful, so the lake volumes have also been included in Table 4.

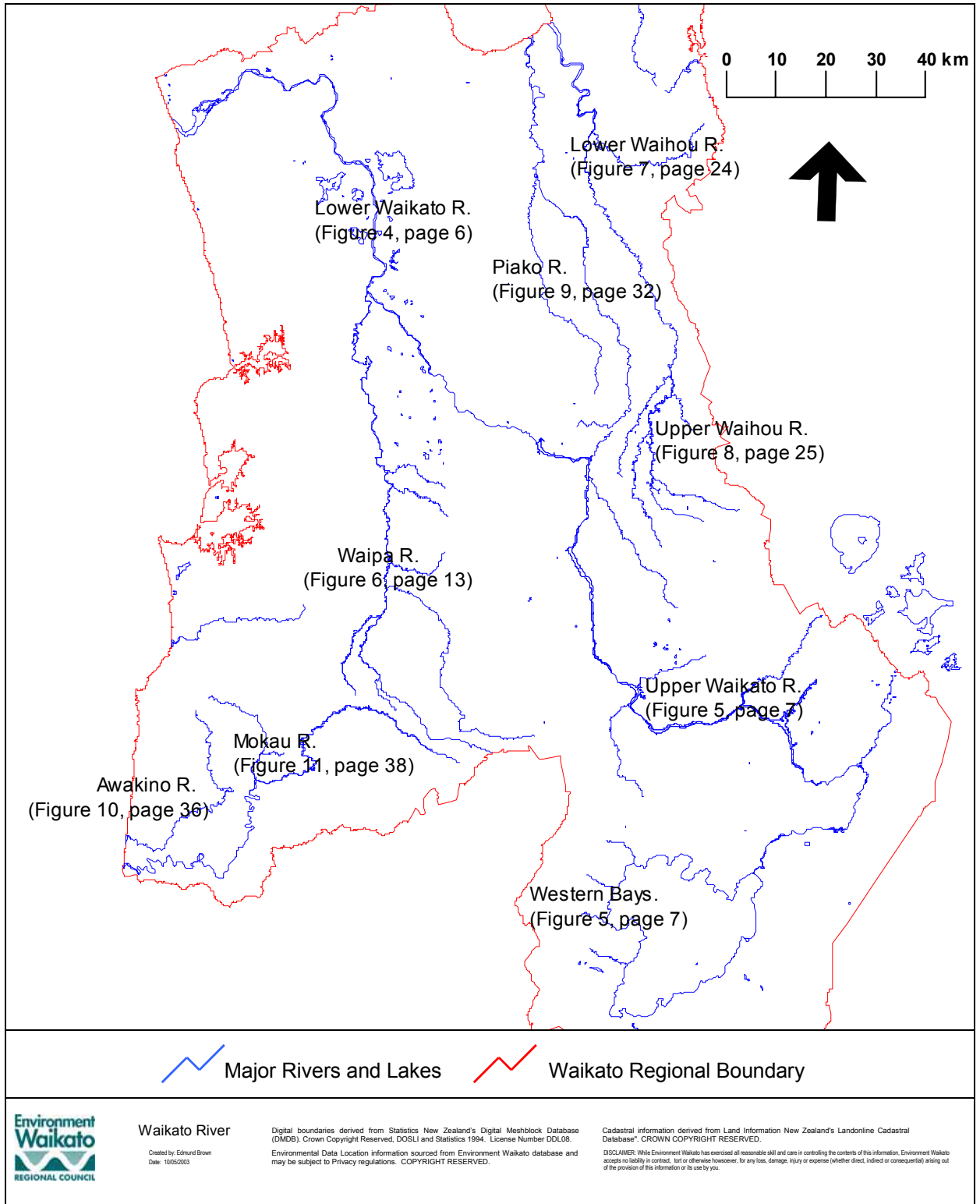


Figure 3: Catchments with calculated hydraulic travel times.

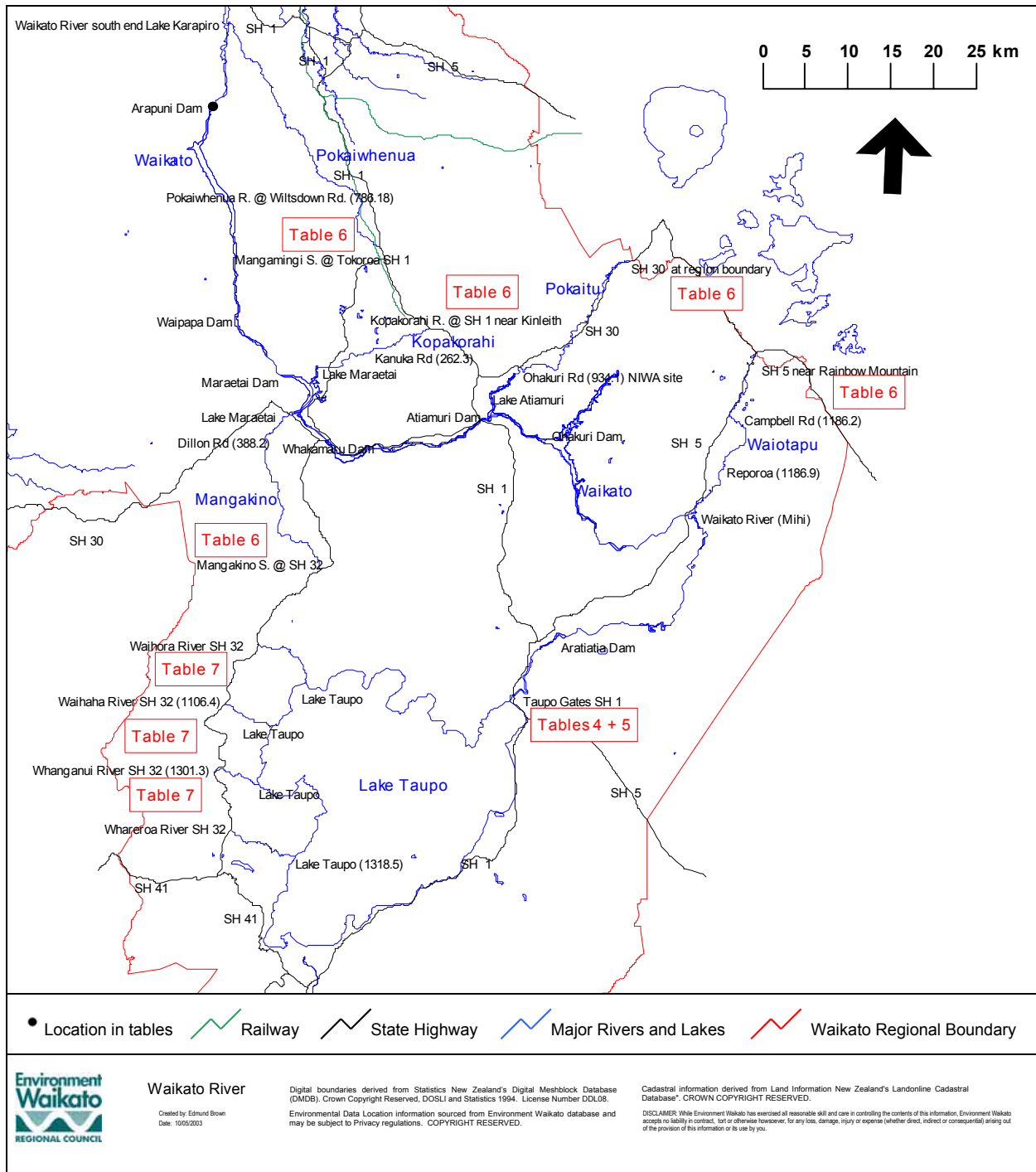


Figure 5: Upper Waikato River and Lake Taupo.

4.1 Karapiro Dam to Waikato Heads

Table 2: Travel time from Karapiro Dam to Waikato Heads.

Karapiro - Waikato Heads	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 250 cumecs @ Mercer (1131.91)			Reference flow 570 cumecs @ Mercer (1131.91)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Karapiro*	2733378	6361060	0	0.0	1	0	0	1.15	0	0
Midway between Cambridge bridges	2728050	6364210	7294	7.3		2.0	2	1.8	2	2
Cambridge water supply	2726300	6364500	1980	9.3		0.6	3	0.5	2	2
Narrows	2716850	6370800	13933	23.2		3.9	6	3.4	6	6
Hamilton water supply	2712700	6374700	7323	30.5		2.0	8	1.8	7	7
Cobham	2712290	6374905	500	31.0		0.1	9	0.1	7	7
Hamilton Br. (1131.64)	2711870	6376510	2112	33.1	1	0.7	9	1.15	0.6	8
Hamilton Sewage discharge	2706990	6383590	9408	42.6		3.2	12	2.6	11	11
Te Rapa Dairy Factory	2705925	6385190	1956	44.5		0.7	13	0.5	11	11
Horotiu Br	2704820	6387080	2355	46.9		0.8	14	0.7	12	12
AFFCO	2703370	6387580	1522	48.4		0.5	14	0.4	12	12
Ngaruawahia Cableway (1131.103)	2699830	6391100	5270	53.7	0.65	2.3	17	0.85	1.8	14
Tainui Br	2700515	6401770	14280	67.9		6.3	23	4.8	19	19
Ohinewai	2700650	6410120	8786	76.7		3.9	27	3.0	22	22
Rangiriri Br (1131.117)	2698750	6416740	7482	84.2	0.6	3.6	31	0.8	2.4	24
Whangape	2694170	6417520	4878	89.1		2.4	33	1.6	26	26
Opuatia S.	2692780	6419430	2541	91.6		1.2	34	0.8	27	27
Orton	2691790	6423030	3909	95.5		1.9	36	1.3	28	28
Punga S.	2690610	6427110	4463	100.0		2.2	38	1.5	29	29
Meremere	2693300	6429820	3945	103.9		1.9	40	1.3	31	31
Mercer Wharf (1131.91)	2691800	6433685	4286	108.2	0.55	3.4	44	0.9	2.1	33
Watercare water supply	2687300	6433690	5850	114.1		4.6	48	2.8	36	36
Tuakau Br (T)	2682760	6431995	5543	119.6		4.4	53	2.7	38	38
Elbow (T)	2673880	6433845	11613	131.2		9.2	62	5.6	44	44
Tauranganui Pa (T)	2670680	6429660	5585	136.8		4	66	3	47	47
Maioro Bay (T)**	2665820	6425680	6705	143.5	0.15	12	79	0.25	7	54
Waikato Heads (T)**	2663350	6422885	3940	147.5	0.15	7	86	0.25	4	58

* No velocity data available - using Hamilton Br data

** Velocities estimated based on travel times published by Waikato Valley Authority 1979.

(T) denotes tidal influence

Table 3: Travel time matrices in hours from Karapiro to Waikato Heads.

Karapiro - Waikato Heads travel time in hours based on: Reference flow 250 cumecs @ Mercer (1131.91)

Karapiro*	2	3	6	8	9	9	12	13	14	14	17	23	27	31	33	34	36	38	40	44	48	53	62	66	79	86
Midway between Cambridge bridges	1	4	6	7	7	10	11	12	12	15	21	25	29	31	32	34	36	38	42	46	51	60	64	77	84	
Cambridge water supply	4	6	6	7	10	11	11	12	14	21	24	28	30	32	34	36	38	41	46	50	59	64	76	83		
Narrows	2	2	3	6	7	8	8	10	17	21	24	27	28	30	32	34	37	42	46	55	60	72	80			
Hamilton water supply	0	1	4	5	5	6	8	15	19	22	25	26	28	30	32	35	40	44	53	58	70	78				
Cobham	1	4	5	5	6	8	15	18	22	24	26	28	30	32	35	40	44	53	58	70	77					
Hamilton Br. (1131.64)	3	4	5	5	7	14	18	21	24	25	27	29	31	34	39	43	53	57	69	77						
Hamilton Sewage discharge	1	1	2	4	11	15	18	21	22	24	26	28	31	36	40	49	54	66	74							
Te Rapa Dairy Factory	1	1	4	10	14	18	20	21	23	25	27	30	35	39	49	53	66	73								
Horotiu Br	1	3	9	13	17	19	20	22	24	26	30	34	39	48	52	65	72									
AFFCO	2	9	13	16	19	20	22	24	26	29	34	38	47	52	64	72										
Ngaruawahia Cableway (1131.103)	6	10	14	16	17	19	21	23	27	31	36	45	49	62	69											
Tainui Br	4	8	10	11	13	15	17	20	25	29	39	43	56	63												
Ohinewai	4	6	7	9	11	13	17	21	26	35	39	52	59													
Rangiriri Br (1131.117)	2	4	5	8	10	13	18	22	31	36	48	55														
Whangape	1	3	5	7	11	15	20	29	33	46	53															
Opuatia S.	2	4	6	9	14	18	28	32	44	52																
Orton	2	4	7	12	17	26	30	43	50																	
Punga S.	2	5	10	14	24	28	40	48																		
Meremere	3	8	12	22	26	39	46																			
Mercer Wharf (1131.91)	5	9	18	23	35	42																				
Watercare water supply	4	14	18	30	38																					
Tuakau Br (T)	9	14	26	33																						
Elbow (T)	4	17	24																							
Tauranganui Pa (T)	12	20																								
Maio Bay (T)**	7																									
Waikato Heads (T)**																										

Low Flow - Exceeded 85% of Time

Karapiro - Waikato Heads travel time in hours based on: Reference flow 570 cumecs @ Mercer (1131.91)

Karapiro*	2	2	6	7	7	8	11	11	12	12	14	19	22	24	26	27	28	29	31	33	36	38	44	47	54	58
Midway between Cambridge bridges	0	4	6	6	6	9	9	10	11	12	17	20	23	24	25	26	28	29	31	34	37	42	45	52	57	
Cambridge water supply	3	5	5	6	8	9	10	10	12	17	20	22	24	24	26	27	29	31	33	36	42	44	52	56		
Narrows	2	2	2	5	6	6	7	8	13	16	19	20	21	22	24	25	27	30	33	38	41	48	53			
Hamilton water supply	0	1	3	4	5	5	7	12	14	17	19	21	22	23	25	28	31	37	39	47	51					
Cobham	1	3	4	4	5	7	11	14	17	18	19	21	22	23	25	28	31	36	39	47	51					
Hamilton Br. (1131.64)	3	3	4	4	6	11	14	16	18	19	20	21	23	25	28	30	36	39	46	50						
Hamilton Sewage discharge	1	1	2	3	8	11	14	15	16	17	19	20	22	25	28	33	36	43	48							
Te Rapa Dairy Factory	1	1	3	8	11	13	15	15	17	18	20	22	24	27	33	35	43	47								
Horotiu Br	0	2	7	10	12	14	15	16	18	19	21	24	26	32	35	42	47									
AFFCO	2	7	10	12	14	14	16	17	18	21	23	26	32	34	42	46										
Ngaruawahia Cableway (1131.103)	5	8	10	12	13	14	15	17	19	22	24	30	33	40	44											
Tainui Br	3	5	7	8	9	11	12	14	17	19	25	28	35	40												
Ohinewai	2	4	5	6	8	9	11	14	16	22	25	32	37													
Rangiriri Br (1131.117)	2	2	4	5	6	9	11	14	20	22	30	34														
Whangape	1	2	4	5	7	10	12	18	21	28	33															
Opuatia S.	1	3	4	6	9	12	17	20	27	32																
Orton	1	3	5	8	10	16	19	26	30																	
Punga S.	1	3	6	9	14	17	25	29																		
Meremere	2	5	8	13	16	23	28																			
Mercer Wharf (1131.91)	3	6	11	14	21	26																				
Watercare water supply	3	8	11	18	23																					
Tuakau Br (T)	6	8	16	20																						
Elbow (T)	3	10	15																							
Tauranganui Pa (T)	7	12																								
Maio Bay (T)**	4																									
Waikato Heads (T)**																										

High Flow - Exceeded 15% of Time

4.2 Lake Taupo to Karapiro Dam

Table 4: Travel time and lake volumes from Lake Taupo to Karapiro Dam.

Karapiro Dam	Lake volume (m ³ x 10 ⁶)***	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 100 cumecs @ Taupo Gates & 250 cumecs @ Mercer (1131.91)*		Reference flow 225 cumecs @ Taupo Gates & 875 cumecs @ Mercer (1131.91)**		
						Velocity m/s	Cumulative hours	Velocity m/s	hours	Cumulative hours
Taupo Gates SH 1	-	2777130	6275740	0	0.0	0	0	0	0	0
Aratiatia Dam	0 (run of river)	2783200	6282600	12100	12.1	25	25	15	15	
Ohakuri Dam	141.5	2779800	6305900	29100	77.2	215	240	75	90	
Atiamuri Dam	19.81	2774070	6307940	750	84.9	30	270	15	105	
Whakamaru Dam	73.58	2755300	6305500	21430	107.2	135	405	50	155	
Maraetai Dam	123.11	2750100	6313200	3470	119.4	125	530	40	195	
Waipapa Dam	16.84	2744750	6320000	9400	128.8	25	555	10	205	
Arapuni Dam	144.33	2741900	6344600	27000	155.8	180	735	60	265	
Karapiro Dam	59.43	2733378	6361060	15760	182.2	140	875	50	315	

* data from Rutherford et al. (2001) p51 for Summer low flow conditions

** data from Rutherford et al. (2001) p80 for Winter high flow conditions

*** The estimates of lake volumes are from Waikato Valley Authority (1979) p26.

There was no travel time data available for the Mercer 15th percentile reference flow of 570 cumecs. The data presented for the Mercer flow of 875 cumecs is for winter high flow conditions which are only exceeded approximately one percent of the time.

Table 5: Travel time matrices in hours from Lake Taupo to Karapiro Dam.

Lake Taupo - Karapiro Dam Reference flow 100 cumecs @ Taupo Gates & 250 cumecs @ Mercer (1131.91)*

Taupo Gates SH 1	25	240	270	405	530	555	735	875
Aratiatia Dam	215	245	380	505	530	710	850	
Ohakuri Dam	30	165	290	315	495	635		
Atiamuri Dam	135	260	285	465	605			
Whakamaru Dam	125	150	330	470				
Maraetai Dam	25	205	345					
Waipapa Dam	180	320						
Arapuni Dam	140							
Karapiro Dam								

**Summer
Low Flow**

Lake Taupo - Karapiro Dam Reference flow 225 cumecs @ Taupo Gates & 875 cumecs @ Mercer (1131.91)**

Taupo Gates SH 1	15	90	105	155	195	205	265	315
Aratiatia Dam	75	90	140	180	190	250	300	
Ohakuri Dam	15	65	105	115	175	225		
Atiamuri Dam	50	90	100	160	210			
Whakamaru Dam	40	50	110	160				
Maraetai Dam	10	70	120					
Waipapa Dam	60	110						
Arapuni Dam	50							
Karapiro Dam								

**Winter
High Flow**

Table 6: Travel time for selected tributaries of the Waikato River between Lake Taupo & Karapiro Dam. None of the reference sites are telemetered.

Waiotapu - Waikato River (Mihi)	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 2.5 cumecs @ Reporoa (1186.9)			Reference flow 4.7 cumecs @ Reporoa (1186.9)		
					Velocity		Cumulative	Velocity		Cumulative
					m/s	hours	hours	m/s	hours	hours
SH 5 near Rainbow Mountain	2804600	6314230	0	0.0		0	0		0	0
Campbell Rd (1186.2)	2802425	6308230	8370	8.4	0.5	5	5	0.7	3	3
Reporoa (1186.9)	2801545	6302200	9800	18.2	0.5	5	10	0.7	4	7
Waikato River (Mihi)	2797360	6296730	10640	28.8		6	16		4	11

Pokaitu - Lake Atiamuri	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 2.8 cumecs @ Ohakuri Rd (934.1)			Reference flow 6.3 cumecs @ Ohakuri Rd (934.1)		
					Velocity		Cumulative	Velocity		Cumulative
					m/s	hours	hours	m/s	hours	hours
SH 30 at region boundary	2790600	6326400	0	0.0		0	0		0	0
Ohakuri Rd (934.1) NIWA site	2778500	6313940	26820	26.8	0.15	50	50	0.45	17	17
Lake Atiamuri	2776200	6311830	5190	32.0		10	60		3	20

Mangakino - Lake Maraetai	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 6.8 cumecs @ Dillon Rd (388.2)			Reference flow 15.8 cumecs @ Dillon Rd (388.2)		
					Velocity		Cumulative	Velocity		Cumulative
					m/s	hours	hours	m/s	hours	hours
Mangakino S. @ SH 32	2754580	6290425	0	0.0		0	0		0	0
Dillon Rd (388.2) NIWA site	2748960	6306570	22700	22.7	0.45	14	14	0.65	10	10
Lake Maraetai	2750180	6308300	2300	25.0		1	15		1	11

Kopakorahi River - Lake Maraetai	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Kopakorahi @ Kanuka Rd. (262.3)			Kopakorahi @ Kanuka Rd. (262.3)		
					Velocity		Cumulative	Velocity		Cumulative
					m/s	hours	hours	m/s	hours	hours
SH 1 near Kinleith	2767250	6318660	0	0.0		0	0		0	0
Kanuka Rd. (262.3)*	2761050	6316230	7845	7.8	0.15	15	15	0.3	7	7
Lake Maraetai	2754140	6314100	9220	17.1		17	32		9	16

* Based on manual flow gaugings, 0.15 m/s and 0.3 m/s are estimated to represent flows that are equalled or exceeded 85% and 15% of the time respectively

Karapiro	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 1.45 cumecs @ Wiltstown Rd (786.18)			Reference flow 2.7 cumecs @ Wiltstown Rd (786.18)*		
					Velocity		Cumulative	Velocity		Cumulative
					m/s	hours	hours	m/s	hours	hours
Mangamingi S. @ Tokoroa SH 1	2761480	6328120	0	0.0		0	0		0	0
Pokaiwhenua R. @ Wiltstown Rd. (786.18)	2757860	6335000	9880	9.9	0.9	3	3	1.2	2	2
Waikato River south end Lake Karapiro	2743900	6354300	29170	39.1		9	12		7	9

4.3 Western Bays of Lake Taupo

Table 7: Travel time for selected tributaries of the Western Bays of Lake Taupo. None of the reference sites are telemetered.

Waihaha River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 2.6 cumecs @ SH 32 (1106.4)			Reference flow 8.6 cumecs @ SH 32 (1106.4)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Waihaha River SH 32 (1106.4)	2743400	6274730	0	0.0	0.15	0	0	0.45	0	0
Lake Taupo	2748990	6272140	7500	7.5		14	14		5	5

Whanganui River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 0.6 cumecs @ SH 32 (1301.3)			Reference flow 2.1 cumecs @ SH 32 (1301.3)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Whanganui River SH 32 (1301.3)	2742100	6266580	0	0.0	0.2	0	0	0.45	0	0
Lake Taupo	2747250	6265370	6650	6.7		9	9		4	4

Waihora River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 2.6 cumecs @ SH 32 (1106.4)			Reference flow 8.6 cumecs @ SH 32 (1106.4)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Waihora River SH 32	2747200	6281570	0	0.0	0.15*	0	0	0.45*	0	0
Lake Taupo	2752740	6277130	9700	9.7		18	18		6	6

* no velocity measurements available, using data from Whanganui & Waihaha Rivers

Whareroa River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 0.6 cumecs @ SH 32 (1318.5)			Reference flow 1.6 cumecs @ SH 32 (1318.5)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Whareroa River SH 32	2744040	6259960	0	0.0		0	0		0	0
Lake Taupo (1318.5)	2751530	6256850	11700	11.7	0.5	7	7	0.55	6	6

5 Waipa Catchment

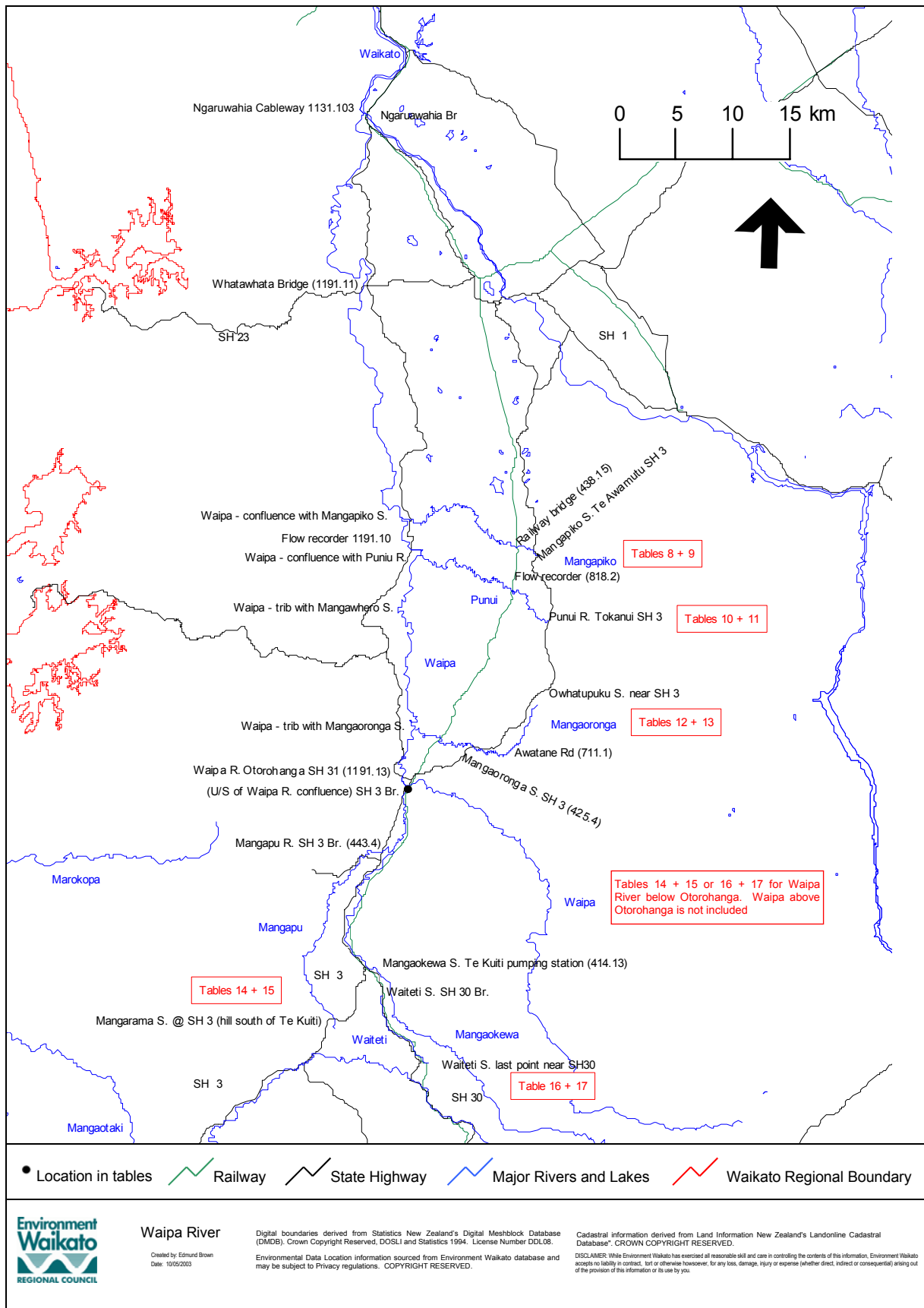


Figure 6: Waipa Catchment. For the Waipa River main stem below Otorohanga use Tables 14 & 15 or 16 & 17. Waipa River above Otorohanga is not included. Refer to Figure 4 for map of the Waikato River below the confluence of the Waipa River.

5.1 Mangapiko River to Waikato Heads

Table 8: Travel time from Mangapiko River to Waikato Heads.

Mangapiko - Waipa - Waikato	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 5 cumecs @ Puniu (818.2)			Reference flow 25 cumecs @ Puniu (818.2)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Mangapiko S. Te Awamutu SH 3	2715027	6352160	0	0.0		0	0		0	0
Railway bridge (438.15)*	2713013	6353046	2836	2.8	0.25	3.5	4	0.5	1.4	1
Waipa - confluence with Mangapiko S.	2702780	6355755	20562	23.4		25.4	29		10.4	12
Whatawhata Bridge (1191.11)	2699631	6376060	27680	51.1	0.2	34.2	63	0.6	12.8	25
Ngaruawahia Cableway (1131.103)	2699412	6391522	28630	79.7	0.65	39.8	103	0.85	13.3	38
Tainui Br.	2700515	6401770	14280	94.0		6.3	109		4.8	43
Ohinewai	2700650	6410120	8786	102.8		3.9	113		3.0	46
Rangiriri Br (1131.117)	2698750	6416740	7482	110.3	0.6	3.6	117	0.8	2.4	48
Whangape	2694170	6417520	4878	115.1		2.4	119		1.6	50
Opuatia S.	2692780	6419430	2541	117.7		1.2	120		0.8	51
Orton	2691790	6423030	3909	121.6		1.9	122		1.3	52
Punga S.	2690610	6427110	4463	126.0		2.2	124		1.5	53
Meremere	2693300	6429820	3945	130.0		1.9	126		1.3	55
Mercer Wharf (1131.91)	2691800	6433685	4286	134.3	0.55	3.4	130	0.9	2.1	57
Tuakau Br (T)	2682760	6431995	11393	145.7		9.0	139		5.5	62
Elbow (T)	2673880	6433845	11613	157.3		9.2	148		5.6	68
Tauranganui Pa (T)	2670680	6429660	5585	162.9		4.4	152		2.7	70
Maio Bay (T)	2665820	6425680	6705	169.6	0.15	12.4	165	0.25	7.5	78
Waikato Heads (T)	2663350	6422885	3940	173.5	0.15	7.3	172	0.25	4.4	82

* velocity estimates based on limited data

(T) denotes tidal influence

Table 9: Travel time matrices in hours from Mangapiko River to Waikato Heads.

Mangapiko - Waipa - Waikato travel time in hours based on: Reference flow 5 cumecs @ Puniu (818.2)

Mangapiko S. Te Awamutu SH 3	4	29	63	103	109	113	117	119	120	122	124	126	130	139	148	152	165	172
Railway bridge (438.15)*	25	60	99	106	110	113	116	117	119	121	123	126	135	144	149	161	169	
Waipa - confluence with Mangapiko S.	34	74	80	84	88	90	91	93	95	97	101	110	119	123	136	143		
Whatawhata Bridge (1191.11)	40	46	50	54	56	57	59	61	63	67	76	85	89	102	109			
Ngaruawahia Cableway (1131.103)	6	10	14	16	17	19	21	23	27	36	45	49	62	69				
Tainui Br.	4	8	10	11	13	15	17	20	29	39	43	56	63					
Ohinewai	4	6	7	9	11	13	17	26	35	39	52	59						
Rangiriri Br (1131.117)	2	4	5	8	10	13	22	31	36	48	55							
Whangape	1	3	5	7	11	20	29	33	46	53								
Opuatia S.	2	4	6	9	18	28	32	44	52									
Orton	2	4	7	17	26	30	43	50										
Punga S.	2	5	14	24	28	40	48											
Meremere	3	12	22	26	39	46												
Mercer Wharf (1131.91)	9	18	23	35	42													
Tuakau Br (T)	9	14	26	33														
Elbow (T)	4	17	24															
Tauranganui Pa (T)	12	20																
Maio Bay (T)	7																	
Waikato Heads (T)																		

**Low Flow -
Exceeded
85% of Time**

Mangapiko - Waipa - Waikato travel time in hours based on: Reference flow 25 cumecs @ Puniu (818.2)

Mangapiko S. Te Awamutu SH 3	1	12	25	38	43	46	48	50	51	52	53	55	57	62	68	70	78	82
Railway bridge (438.15)*	10	23	36	41	44	47	48	49	50	52	53	55	61	66	69	76	81	
Waipa - confluence with Mangapiko S.	13	26	31	34	36	38	39	40	41	43	45	50	56	59	66	70		
Whatawhata Bridge (1191.11)	13	18	21	23	25	26	27	29	30	32	37	43	46	53	58			
Ngaruawahia Cableway (1131.103)	5	8	10	12	13	14	15	17	19	24	30	33	40	44				
Tainui Br.	3	5	7	8	9	11	12	14	19	25	28	35	40					
Ohinewai	2	4	5	6	8	9	11	16	22	25	32	37						
Rangiriri Br (1131.117)	2	2	4	5	6	9	14	20	22	30	34							
Whangape	1	2	4	5	7	12	18	21	28	33								
Opuatia S.	1	3	4	6	12	17	20	27	32									
Orton	1	3	5	10	16	19	26	30										
Punga S.	1	3	9	14	17	25	29											
Meremere	2	8	13	16	23	28												
Mercer Wharf (1131.91)	6	11	14	21	26													
Tuakau Br (T)	6	8	16	20														
Elbow (T)	3	10	15															
Tauranganui Pa (T)	7	12																
Maio Bay (T)	4																	
Waikato Heads (T)																		

**High Flow -
Exceeded
15% of Time**

5.2 Punui River to Waikato Heads

Table 10: Travel time from Punui River to Waikato Heads.

Punui - Waipa - Waikato	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 5 cumecs @ Punui (818.2)			Reference flow 25 cumecs @ Punui (818.2)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Punui R. Tokanui SH 3	2715749	6346550	0	0.0						
Flow recorder (818.2)	2711478	6349978	14248	14.2	0.25	10.6	11	0.5	5.9	6
Waipa - confluence with Punui R.	2704600	6352330	8588	22.8		6.4	17		3.5	9
Flow recorder 1191.10	2703712	6352930	1450	24.3	0.5	1.2	18	0.85	0.6	10
Waipa - trib with Mangapiko S.	2702780	6355755	4383	28.7		3.5	22		1.7	12
Whatawhata Bridge (1191.11)	2699631	6376060	27680	56.3	0.2	18.1	40	0.6	10.6	22
Ngaruawahia Cableway (1131.103)	2699412	6391522	28630	85.0	0.65	39.8	79	0.85	13.3	35
Tainui Br.	2700515	6401770	14280	99.3		6.3	86		4.8	40
Ohinewai	2700650	6410120	8786	108.0		3.9	90		3.0	43
Rangiriri Br (1131.117)	2698750	6416740	7482	115.5	0.6	3.6	93	0.8	2.4	46
Whangape	2694170	6417520	4878	120.4		2.4	96		1.6	47
Opuatia S.	2692780	6419430	2541	122.9		1.2	97		0.8	48
Orton	2691790	6423030	3909	126.9		1.9	99		1.3	49
Punga S.	2690610	6427110	4463	131.3		2.2	101		1.5	51
Meremere	2693300	6429820	3945	135.3		1.9	103		1.3	52
Mercer Wharf (1131.91)	2691800	6433685	4286	139.5	0.55	3.4	106	0.9	2.1	54
Tuakau Br (T)	2682760	6431995	11393	150.9		9.0	115		5.5	60
Elbow (T)	2673880	6433845	11613	162.6		9.2	124		5.6	65
Tauranganui Pa (T)	2670680	6429660	5585	168.1		4.4	129		2.7	68
Maioro Bay (T)	2665820	6425680	6705	174.8	0.15	12.4	141	0.25	7.5	75
Waikato Heads (T)	2663350	6422885	3940	178.8	0.15	7.3	149	0.25	4.4	80

(T) denotes tidal influence

Table 11: Travel time matrices in hours from Punui River to Waikato Heads.

Punui - Waipa - Waikato travel time in hours based on: Reference flow 5 cumecs @ Punui (818.2)

Punui R. Tokanui SH 3	11	17	18	22	40	79	86	90	93	96	97	99	101	103	106	115	124	129	141	149
Flow recorder (818.2)	6	8	11	29	69	75	79	83	85	86	88	90	92	96	105	114	118	131	138	
Waipa - confluence with Punui R.	1	5	23	62	69	73	76	79	80	82	84	86	89	98	108	112	124	132		
Flow recorder 1191.10	3	22	61	68	72	75	78	79	81	83	85	88	97	106	111	123	131			
Waipa - trib with Mangapiko S.	18	58	64	68	72	74	75	77	79	81	85	94	103	107	120	127				
Whatawhata Bridge (1191.11)	40	46	50	54	56	57	59	61	63	67	76	85	89	102	109					
Ngaruawahia Cableway (1131.103)	6	10	14	16	17	19	21	23	27	36	45	49	62	69						
Tainui Br.	4	8	10	11	13	15	17	20	29	39	43	56	63							
Ohinewai	4	6	7	9	11	13	17	26	35	39	52	59								
Rangiriri Br (1131.117)	2	4	5	8	10	13	22	31	36	48	55									
Whangape	1	3	5	7	11	20	29	33	46	53										
Opuatia S.	2	4	6	9	18	28	32	44	52											
Orton	2	4	7	17	26	30	43	50												
Punga S.	2	5	14	24	28	40	48													
Meremere	3	12	22	26	39	46														
Mercer Wharf (1131.91)	9	18	23	35	42															
Tuakau Br (T)	9	14	26	33																
Elbow (T)	4	17	24																	
Tauranganui Pa (T)	12	20																		
Maio Bay (T)	7																			
Waikato Heads (T)																				

**Low Flow -
Exceeded
85% of Time**

Punui - Waipa - Waikato travel time in hours based on: Reference flow 25 cumecs @ Punui (818.2)

Punui R. Tokanui SH 3	6	9	10	12	22	35	40	43	46	47	48	49	51	52	54	60	65	68	75	80
Flow recorder (818.2)	4	4	6	16	30	34	37	40	41	42	44	45	46	48	54	59	62	70	74	
Waipa - confluence with Punui R.	1	2	13	26	31	34	36	38	39	40	41	43	45	50	56	59	66	70		
Flow recorder 1191.10	2	12	26	30	33	36	37	38	39	41	42	44	50	55	58	66	70			
Waipa - trib with Mangapiko S.	11	24	29	32	34	36	36	38	39	41	43	48	54	56	64	68				
Whatawhata Bridge (1191.11)	13	18	21	23	25	26	27	29	30	32	37	43	46	53	58					
Ngaruawahia Cableway (1131.103)	5	8	10	12	13	14	15	17	19	24	30	33	40	44						
Tainui Br.	3	5	7	8	9	11	12	14	19	25	28	35	40							
Ohinewai	2	4	5	6	8	9	11	16	22	25	32	37								
Rangiriri Br (1131.117)	2	2	4	5	6	9	14	20	22	30	34									
Whangape	1	2	4	5	7	12	18	21	28	33										
Opuatia S.	1	3	4	6	12	17	20	27	32											
Orton	1	3	5	10	16	19	26	30												
Punga S.	1	3	9	14	17	25	29													
Meremere	2	8	13	16	23	28														
Mercer Wharf (1131.91)	6	11	14	21	26															
Tuakau Br (T)	6	8	16	20																
Elbow (T)	3	10	15																	
Tauranganui Pa (T)	7	12																		
Maio Bay (T)	4																			
Waikato Heads (T)																				

**High Flow -
Exceeded
15% of Time**

5.3 Mangaoronga Stream to Waikato Heads

Table 12: Travel time from Mangaoronga Stream to Waikato Heads.

Waikato	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 5 cumecs @ Puniu (818.2)			Reference flow 25 cumecs @ Puniu (818.2)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Owhatupuku S. near SH 3	2714823	6339185	0	0.0		0	0	0	0	0
Awatane Rd (711.1)*	2712127	6334940	5733	5.7	0.05	15.9	16	0.2	6.4	6
Mangaoronga S. SH 3 (425.4)*	2709134	6335628	6224	12.0	0.15	5.3	21	0.3	3.0	9
Waipa - trib with Mangaoronga S.	2704094	6337040	10207	22.2		8.7	30		4.9	14
Waipa - trib with Mangawhero S.	2702720	6347812	17050	39.2		14.6	45		8.2	23
Waipa - trib with Puniu S.	2704600	6352330	6489	45.7		5.5	50		3.1	26
Flow recorder 1191.10	2703712	6352930	1450	47.2	0.5	1.2	51	0.85	0.6	26
Waipa - trib with Mangapiko S.	2702780	6355755	4383	51.5		3.5	55		1.7	28
Whatawhata Bridge (1191.11)	2699631	6376060	27680	79.2	0.2	18.1	73	0.6	10.6	39
Ngaruawahia Cableway (1131.103)	2699412	6391522	28630	107.8	0.65	39.8	113	0.85	13.3	52
Tainui Br.	2700515	6401770	14280	122.1		6.3	119		4.8	57
Ohinewai	2700650	6410120	8786	130.9		3.9	123		3.0	60
Rangiriri Br (1131.117)	2698750	6416740	7482	138.4	0.6	3.6	126	0.8	2.4	62
Whangape	2694170	6417520	4878	143.3		2.4	129		1.6	64
Opuatia S.	2692780	6419430	2541	145.8		1.2	130		0.8	64
Orton	2691790	6423030	3909	149.7		1.9	132		1.3	66
Punga S.	2690610	6427110	4463	154.2		2.2	134		1.5	67
Meremere	2693300	6429820	3945	158.1		1.9	136		1.3	68
Mercer Wharf (1131.91)	2691800	6433685	4286	162.4	0.55	3.4	139	0.9	2.1	71
Tuakau Br (T)	2682760	6431995	11393	173.8		9.0	148		5.5	76
Elbow (T)	2673880	6433845	11613	185.4		9.2	158		5.6	82
Tauranganui Pa (T)	2670680	6429660	5585	191.0		4.4	162		2.7	84
Maioro Bay (T)	2665820	6425680	6705	197.7	0.15	12.4	174	0.25	7.5	92
Waikato Heads (T)	2663350	6422885	3940	201.7	0.15	7.3	182	0.25	4.4	96

* velocity estimates based on limited data

(T) denotes tidal influence

Table 13: Travel time matrices in hours from Mangaoronga Stream to Waikato Heads.

Owhatupuku - Mangaoronga - Waipa - Waikato travel time in hours based on: Reference flow 5 cumecs @ Puniu (818.2)

Owhatupuku S. near SH 3	16	21	30	45	50	51	55	73	113	119	123	126	129	130	132	134	136	139	148	158	162	174	182
Awatane Rd (711.1)*	5	14	29	34	35	39	57	97	103	107	111	113	114	116	118	120	123	132	142	146	159	166	
Mangaoronga S. SH 3 (425.4)*	9	23	29	30	33	52	91	98	102	105	108	109	111	113	115	118	127	136	141	153	161		
Waipa - trib with Mangaoronga S.	15	20	21	25	43	83	89	93	96	99	100	102	104	106	109	118	128	132	145	152			
Waipa - trib with Mangawhero S.	6	7	10	28	68	74	78	82	84	85	87	90	91	95	104	113	118	130	137				
Waipa - trib with Puniu S.	1	5	23	62	69	73	76	79	80	82	84	86	89	98	108	112	124	132					
Flow recorder 1191.10	3	22	61	68	72	75	78	79	81	83	85	88	97	106	111	123	131						
Waipa - trib with Mangapiko S.	18	58	64	68	72	74	75	77	79	81	85	94	103	107	120	127							
Whatawhata Bridge (1191.11)	40	46	50	54	56	57	59	61	63	67	76	85	89	102	109								
Ngaruawahia Cableway (1131.103)	6	10	14	16	17	19	21	23	27	36	45	49	62	69									
Tainui Br.	4	8	10	11	13	15	17	20	29	39	43	56	63										
Ohinewai	4	6	7	9	11	13	17	26	35	39	52	59											
Rangiriri Br (1131.117)	2	4	5	8	10	13	22	31	36	48	55												
Whangape	1	3	5	7	11	20	29	33	46	53													
Opuatia S.	2	4	6	9	18	28	32	44	52														
Orton	2	4	7	17	26	30	43	50															
Punga S.	2	5	14	24	28	40	48																
Meremere	3	12	22	26	39	46																	
Mercer Wharf (1131.91)	9	18	23	35	42																		
Tuakau Br (T)	9	14	26	33																			
Elbow (T)	4	17	24																				
Tauranganui Pa (T)	12	20																					
Maio Bay (T)	7																						
Waikato Heads (T)																							

**Low Flow -
Exceeded
85% of Time**

Owhatupuku - Mangaoronga - Waipa - Waikato travel time in hours based on: Reference flow 25 cumecs @ Puniu (818.2)

Owhatupuku S. near SH 3	6	9	14	23	26	28	39	52	57	60	62	64	64	66	67	68	71	76	82	84	92	96
Awatane Rd (711.1)*	3	8	16	19	20	22	32	45	50	53	56	57	58	59	61	62	64	70	75	78	85	90
Mangaoronga S. SH 3 (425.4)*	5	13	16	17	19	29	42	47	50	53	54	55	56	58	59	61	67	72	75	82	87	
Waipa - trib with Mangaoronga S.	8	11	12	14	24	37	42	45	48	49	50	51	53	54	56	62	67	70	77	82		
Waipa - trib with Mangawhero S.	3	4	5	16	29	34	37	39	41	42	43	45	46	48	53	59	62	69	74			
Waipa - trib with Puniu S.	1	2	13	26	31	34	36	38	39	40	41	43	45	50	56	59	66	70				
Flow recorder 1191.10	2	12	26	30	33	36	37	38	39	41	42	44	50	55	58	66	70					
Waipa - trib with Mangapiko S.	11	24	29	32	34	36	36	38	39	41	43	48	54	56	64	68						
Whatawhata Bridge (1191.11)	13	18	21	23	25	26	27	29	30	32	37	43	46	53	58							
Ngaruawahia Cableway (1131.103)	5	8	10	12	13	14	15	17	19	24	30	33	40	44								
Tainui Br.	3	5	7	8	9	11	12	14	19	25	28	35	40									
Ohinewai	2	4	5	6	8	9	11	16	22	25	32	37										
Rangiriri Br (1131.117)	2	2	4	5	6	9	14	20	22	30	34											
Whangape	1	2	4	5	7	12	18	21	28	33												
Opuatia S.	1	3	4	6	12	17	20	27	32													
Orton	1	3	5	10	16	19	26	30														
Punga S.	1	3	9	14	17	25	29															
Meremere	2	8	13	16	23	28																
Mercer Wharf (1131.91)	6	11	14	21	26																	
Tuakau Br (T)	6	8	16	20																		
Elbow (T)	3	10	15																			
Tauranganui Pa (T)	7	12																				
Maio Bay (T)	4																					
Waikato Heads (T)																						

**High Flow -
Exceeded
15% of Time**

5.4 Mangapu Stream to Waikato Heads (includes Waipa River downstream of Otorohanga)

Table 14: Travel time from Mangapu Stream to Waikato Heads.

	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 5 cumecs @ Puniu (818.2)			Reference flow 25 cumecs @ Puniu (818.2)			
					Velocity m/s	Cumulative hours	hours	Velocity m/s	Cumulative hours	hours	
Mangarama - Mangapu - Waipa - Waikato											
Mangarama S. @ SH 3 (hill south of Te Kuiti)	2696874	6311670	0	0.0		0	0	0	0	0	0
Mangapu R. SH 3 Br. (443.4)	2701091	6326235	25707	25.7	0.5	13.6	14	0.65	9.2	9	
Mangapu R. - trib with Mangaokewa R.	2702000	6326400	1908	27.6		1.0	15		0.7	10	
(U/S of Waipa R. confluence) SH 3 Br.	2703297	6331860	8566	36.2		4.5	19		3.1	13	
Waipa R. Otorohanga SH 31 (1191.13)	2702981	6332860	1180	37.4	0.55	0.6	20	0.9	0.4	13	
Waipa - trib with Mangaoronga S.	2704094	6337040	6866	44.2		3.6	23		2.2	16	
Waipa - trib with Mangawhero S.	2702720	6347812	17050	61.3		9.0	32		5.4	21	
Waipa - trib with Puniu S.	2704600	6352330	6489	67.8		3.4	36		2.1	23	
Flow recorder 1191.10	2703712	6352930	1450	69.2	0.5	1.2	37	0.85	0.6	24	
Waipa - trib with Mangapiko S.	2702780	6355755	4383	73.6		3.5	40		1.7	25	
Whatawhata Bridge (1191.11)	2699631	6376060	27680	101.3	0.2	18.1	59	0.6	10.6	36	
Ngaruawahia Cableway (1131.103)	2699412	6391522	28630	129.9	0.65	39.8	98	0.85	13.3	49	
Tainui Br.	2700515	6401770	14280	144.2		6.3	105		4.8	54	
Ohinewai	2700650	6410120	8786	153.0		3.9	109		3.0	57	
Rangiriri Br (1131.117)	2698750	6416740	7482	160.5	0.6	3.6	112	0.8	2.4	59	
Whangape	2694170	6417520	4878	165.3		2.4	115		1.6	61	
Opuatia S.	2692780	6419430	2541	167.9		1.2	116		0.8	62	
Orton	2691790	6423030	3909	171.8		1.9	118		1.3	63	
Punga S.	2690610	6427110	4463	176.2		2.2	120		1.5	64	
Meremere	2693300	6429820	3945	180.2		1.9	122		1.3	66	
Mercer Wharf (1131.91)	2691800	6433685	4286	184.5	0.55	3.4	125	0.9	2.1	68	
Tuakau Br (T)	2682760	6431995	11393	195.9		9.0	134		5.5	73	
Elbow (T)	2673880	6433845	11613	207.5		9.2	143		5.6	79	
Tauranganui Pa (T)	2670680	6429660	5585	213.1		4.4	148		2.7	82	
Maio Bay (T)	2665820	6425680	6705	219.8	0.15	12.4	160	0.25	7.5	89	
Waikato Heads (T)	2663350	6422885	3940	223.7	0.15	7.3	168	0.25	4.4	93	

(T) denotes tidal influence

Table 15: Travel time matrices in hours from Mangapu Stream to Waikato Heads.

Mangarama - Mangapu - Waipa - Waikato		travel time in hours based on: Reference flow 5 cumecs @ Puniu (818.2)																							
Mangarama S. @ SH 3 (hill south of Te Kuiti)	14	15	19	20	23	32	36	37	40	59	98	105	109	112	115	116	118	120	122	125	134	143	148	160	168
Mangapu R. SH 3 Br. (443.4)	1	6	6	10	19	22	23	27	45	85	91	95	99	101	102	104	106	108	112	121	130	134	147	154	
Mangapu R. - trib with Mangaokewa R.	5	5	9	18	21	22	26	44	84	90	94	98	100	101	103	105	107	111	120	129	133	146	153		
(U/S of Waipa R. confluence) SH 3 Br.	1	4	4	13	17	18	21	39	79	86	89	93	95	97	99	101	103	106	115	124	129	141	148		
Waipa R. Otorohanga SH 31 (1191.13)	4	13	16	17	21	39	79	85	89	92	95	96	98	100	102	105	114	124	128	140	148				
Waipa - trib with Mangaoronga S.	9	12	14	17	35	75	81	85	89	91	92	94	96	98	102	111	120	124	137	144					
Waipa - trib with Mangawhero S.	3	5	8	26	66	72	76	80	82	83	85	87	89	93	102	111	115	128	135						
Waipa - trib with Puniu S.	1	5	23	62	69	73	76	79	80	82	84	86	89	98	108	112	124	132							
Flow recorder 1191.10	3	22	61	68	72	75	78	79	81	83	85	88	97	106	111	123	131								
Waipa - trib with Mangapiko S.	18	58	64	68	72	74	75	77	79	81	85	94	103	107	120	127									
Whatawhata Bridge (1191.11)	40	46	50	54	56	57	59	61	63	67	76	85	89	102	109										
Ngaruawahia Cableway (1131.103)	6	10	14	16	17	19	21	23	27	36	45	49	62	69											
Tainui Br.	4	8	10	11	13	15	17	20	29	39	43	56	63												
Ohinewai	4	6	7	9	11	13	17	26	35	39	52	59													
Rangiriri Br (1131.117)	2	4	5	8	10	13	22	31	36	48	55														
Whangape	1	3	5	7	11	20	29	33	46	53															
Opuatia S.	2	4	6	9	18	28	32	44	52																
Orton	2	4	7	17	26	30	43	50																	
Punga S.	2	5	14	24	28	40	48																		
Meremere	3	12	22	26	39	46																			
Mercer Wharf (1131.91)	9	18	23	35	42																				
Tuakau Br (T)	9	14	26	33																					
Elbow (T)	4	17	24																						
Tauranganui Pa (T)	12	20																							
Maio Bay (T)	7																								
Waikato Heads (T)																									

Low Flow - Exceeded 85% of Time

Mangarama - Mangapu - Waipa - Waikato		travel time in hours based on: Reference flow 25 cumecs @ Puniu (818.2)																							
Mangarama S. @ SH 3 (hill south of Te Kuiti)	9	10	13	13	16	21	23	24	25	36	49	54	57	59	61	62	63	64	66	68	73	79	82	89	93
Mangapu R. SH 3 Br. (443.4)	1	4	4	6	12	14	14	16	27	40	45	48	50	52	53	54	55	57	59	64	70	72	80	84	
Mangapu R. - trib with Mangaokewa R.	3	3	6	11	13	14	15	26	39	44	47	49	51	52	53	55	56	58	63	69	72	79	84		
(U/S of Waipa R. confluence) SH 3 Br.	0	3	8	10	11	12	23	36	41	44	46	48	49	50	51	53	55	60	66	69	76	80			
Waipa R. Otorohanga SH 31 (1191.13)	2	8	10	10	12	22	36	41	44	46	48	48	50	51	52	54	60	66	68	76	80				
Waipa - trib with Mangaoronga S.	5	7	8	10	20	34	38	41	44	45	46	47	49	50	52	58	63	66	74	78					
Waipa - trib with Mangawhero S.	2	3	4	15	28	33	36	38	40	41	42	44	45	47	52	58	61	68	73						
Waipa - trib with Puniu S.	1	2	13	26	31	34	36	38	39	40	41	43	45	50	56	59	66	70							
Flow recorder 1191.10	2	12	26	30	33	36	37	38	39	41	42	44	50	55	58	66	70								
Waipa - trib with Mangapiko S.	11	24	29	32	34	36	36	38	39	41	43	48	54	56	64	68									
Whatawhata Bridge (1191.11)	13	18	21	23	25	26	27	29	30	32	37	43	46	53	58										
Ngaruawahia Cableway (1131.103)	5	8	10	12	13	14	15	17	19	24	30	33	40	44											
Tainui Br.	3	5	7	8	9	11	12	14	19	25	28	35	40												
Ohinewai	2	4	5	6	8	9	11	16	22	25	32	37													
Rangiriri Br (1131.117)	2	2	4	5	6	9	14	20	22	30	34														
Whangape	1	2	4	5	7	12	18	21	28	33															
Opuatia S.	1	3	4	6	12	17	20	27	32																
Orton	1	3	5	10	16	19	26	30																	
Punga S.	1	3	9	14	17	25	29																		
Meremere	2	8	13	16	23	28																			
Mercer Wharf (1131.91)	6	11	14	21	26																				
Tuakau Br (T)	6	8	16	20																					
Elbow (T)	3	10	15																						
Tauranganui Pa (T)	7	12																							
Maio Bay (T)	4																								
Waikato Heads (T)																									

High Flow - Exceeded 15% of Time

5.5 Mangaokewa Stream to Waikato Heads (includes Waipa River downstream of Otorohanga)

Table 16: Travel time from Mangaokewa Stream to Waikato Heads.

Waiteti - Mangaokewa - Waipa - Waikato	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 5 cumecs @ Puniu (818.2)			Reference flow 25 cumecs @ Puniu (818.2)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Waiteti S. last point near SH30	2705270	6307825	0	0.0		0	0		0	0
Waiteti S. SH 30 Br.	2701162	6313716	8520	8.5		5.3	5		3.0	3
Mangaokewa S. Te Kuiti pumping station (414.13)	2699770	6316230	4641	13.2	0.45	2.6	8	0.8	1.6	5
Mangapu R.	2702000	6326400	17772	30.9		9.9	18		6.0	11
(U/S of Waipa R. confluence) SH 3 Br.	2703297	6331860	8566	39.5		4.8	22		2.9	13
Waipa R. Otorohanga SH 31 (1191.13)	2702981	6332860	1180	40.7	0.55	0.6	23	0.85	0.4	14
Waipa - trib with Mangaoronga S.	2704094	6337040	6866	47.5		3.6	27		2.2	16
Waipa - trib with Mangawhero S.	2702720	6347812	17050	64.6		9.0	36		5.6	22
Waipa - trib with Puniu S.	2704600	6352330	6489	71.1		3.4	39		2.1	24
Flow recorder 1191.10	2703712	6352930	1450	72.5	0.5	1.2	40	0.85	0.6	24
Waipa - trib with Mangapiko S.	2702780	6355755	4383	76.9		3.5	44		1.7	26
Whatawhata Bridge (1191.11)	2699631	6376060	27680	104.6	0.2	18.1	62	0.6	10.6	37
Ngaruawahia Cableway (1131.103)	2699412	6391522	28630	133.2	0.65	39.8	102	0.85	13.3	50
Tainui Br.	2700515	6401770	14280	147.5		6.3	108		4.8	55
Ohinewai	2700650	6410120	8786	156.3		3.9	112		3.0	58
Rangiriri Br (1131.117)	2698750	6416740	7482	163.8	0.6	3.6	116	0.8	2.4	60
Whangape	2694170	6417520	4878	168.7		2.4	118		1.6	62
Opuatia S.	2692780	6419430	2541	171.2		1.2	119		0.8	62
Orton	2691790	6423030	3909	175.1		1.9	121		1.3	64
Punga S.	2690610	6427110	4463	179.6		2.2	123		1.5	65
Meremere	2693300	6429820	3945	183.5		1.9	125		1.3	66
Mercer Wharf (1131.91)	2691800	6433685	4286	187.8	0.55	3.4	128	0.9	2.1	69
Tuakau Br (T)	2682760	6431995	11393	199.2		9.0	138		5.5	74
Elbow (T)	2673880	6433845	11613	210.8		9.2	147		5.6	80
Tauranganui Pa (T)	2670680	6429660	5585	216.4		4.4	151		2.7	82
Maioro Bay (T)	2665820	6425680	6705	223.1	0.15	12.4	164	0.25	7.5	90
Waikato Heads (T)	2663350	6422885	3940	227.0	0.15	7.3	171	0.25	4.4	94

(T) denotes tidal influence

Table 17: Travel time matrices in hours from Mangaokewa Stream to Waikato Heads.

Waiteti - Mangaokewa - Waipa - Waikato		travel time in hours based on: Reference flow 5 cumecs @ Puniu (818.2)																								
Waiteti S. last point near SH30	5	8	18	22	23	27	36	39	40	44	62	102	108	112	116	118	119	121	123	125	128	138	147	151	164	171
Waiteti S. SH 30 Br.	3	12	17	18	21	30	34	35	39	57	96	103	107	110	113	114	116	118	120	123	132	141	146	158	166	
Mangaokewa S. Te Kuiti pumping station (414.13)	10	15	15	19	28	31	32	36	54	94	100	104	108	110	111	113	115	117	121	130	139	143	156	163		
Mangapu R.	5	5	9	18	21	23	26	44	84	90	94	98	100	101	103	105	107	111	120	129	133	146	153			
(U/S of Waipa R. confluence) SH 3 Br.	1	4	13	17	18	21	39	79	86	89	93	95	97	99	101	103	106	115	124	129	141	148				
Waipa R. Otorohanga SH 31 (1191.13)	4	13	16	17	21	39	79	85	89	92	95	96	98	100	102	105	114	124	128	140	148					
Waipa - trib with Mangaoronga S.	9	12	14	17	35	75	81	85	89	91	92	94	96	98	102	111	120	124	137	144						
Waipa - trib with Mangawhero S.	3	5	8	26	66	72	76	80	82	83	85	87	89	93	102	111	115	128	135							
Waipa - trib with Puniu S.	1	5	23	62	69	73	76	79	80	82	84	86	89	98	108	112	124	132								
Flow recorder 1191.10	3	22	61	68	72	75	78	79	81	83	85	88	97	106	111	123	131									
Waipa - trib with Mangapiko S.	18	58	64	68	72	74	75	77	79	81	85	94	103	107	120	127										
Whatawhata Bridge (1191.11)	40	46	50	54	56	57	59	61	63	67	76	85	89	102	109											
Ngaruahia Cableway (1131.103)	6	10	14	16	17	19	21	23	27	36	45	49	62	69												
Tainui Br.	4	8	10	11	13	15	17	20	29	39	43	56	63													
Ohinewai	4	6	7	9	11	13	17	26	35	39	52	59														
Rangiriri Br (1131.117)	2	4	5	8	10	13	22	31	36	48	55															
Whangape	1	3	5	7	11	20	29	33	46	53																
Opuatia S.	2	4	6	9	18	28	32	44	52																	
Orton	2	4	7	17	26	30	43	50																		
Punga S.	2	5	14	24	28	40	48																			
Meremere	3	12	22	26	39	46																				
Mercer Wharf (1131.91)	9	18	23	35	42																					
Tuakau Br (T)	9	14	26	33																						
Elbow (T)	4	17	24																							
Tauranganui Pa (T)	12	20																								
Maio Bay (T)	7																									
Waikato Heads (T)																										

Low Flow - Exceeded 85% of Time

Waiteti - Mangaokewa - Waipa - Waikato		travel time in hours based on: Reference flow 25 cumecs @ Puniu (818.2)																							
Waiteti S. last point near SH30	3	5	11	13	14	16	22	24	26	37	50	55	58	60	62	64	65	66	69	74	80	82	90	94	
Waiteti S. SH 30 Br.	2	8	10	11	13	19	21	21	23	34	47	52	55	57	59	59	61	62	64	66	71	77	79	87	91
Mangaokewa S. Te Kuiti pumping station (414.13)	6	9	9	11	17	19	20	21	32	45	50	53	55	57	58	59	61	62	64	70	75	78	85	90	
Mangapu R.	3	3	6	11	13	14	15	26	39	44	47	50	51	52	53	55	56	58	64	69	72	79	84		
(U/S of Waipa R. confluence) SH 3 Br.	0	3	8	10	11	13	23	36	41	44	47	48	49	50	52	53	55	61	66	69	76	81			
Waipa R. Otorohanga SH 31 (1191.13)	2	8	10	10	12	23	36	41	44	46	48	49	50	51	53	55	60	66	69	76	80				
Waipa - trib with Mangaoronga S.	6	8	8	10	21	34	39	42	44	46	46	48	49	50	53	58	64	66	74	78					
Waipa - trib with Mangawhero S.	2	3	4	15	28	33	36	38	40	41	42	44	45	47	52	58	61	68	73						
Waipa - trib with Puniu S.	1	2	13	26	31	34	36	38	39	40	41	43	45	50	56	59	66	70							
Flow recorder 1191.10	2	12	26	30	33	36	37	38	39	41	42	44	50	55	58	66	70								
Waipa - trib with Mangapiko S.	11	24	29	32	34	36	36	38	39	41	43	48	54	56	64	68									
Whatawhata Bridge (1191.11)	13	18	21	23	25	26	27	29	30	32	37	43	46	53	58										
Ngaruahia Cableway (1131.103)	5	8	10	12	13	14	15	17	19	24	30	33	40	44											
Tainui Br.	3	5	7	8	9	11	12	14	19	25	28	35	40												
Ohinewai	2	4	5	6	8	9	11	16	22	25	32	37													
Rangiriri Br (1131.117)	2	2	4	5	6	9	14	20	22	30	34														
Whangape	1	2	4	5	7	12	18	21	28	33															
Opuatia S.	1	3	4	6	12	17	20	27	32																
Orton	1	3	5	10	16	19	26	30																	
Punga S.	1	3	9	14	17	25	29																		
Meremere	2	8	13	16	23	28																			
Mercer Wharf (1131.91)	6	11	14	21	26																				
Tuakau Br (T)	6	8	16	20																					
Elbow (T)	3	10	15																						
Tauranganui Pa (T)	7	12																							
Maio Bay (T)	4																								
Waikato Heads (T)																									

High Flow - Exceeded 15% of Time

6 Waihou River

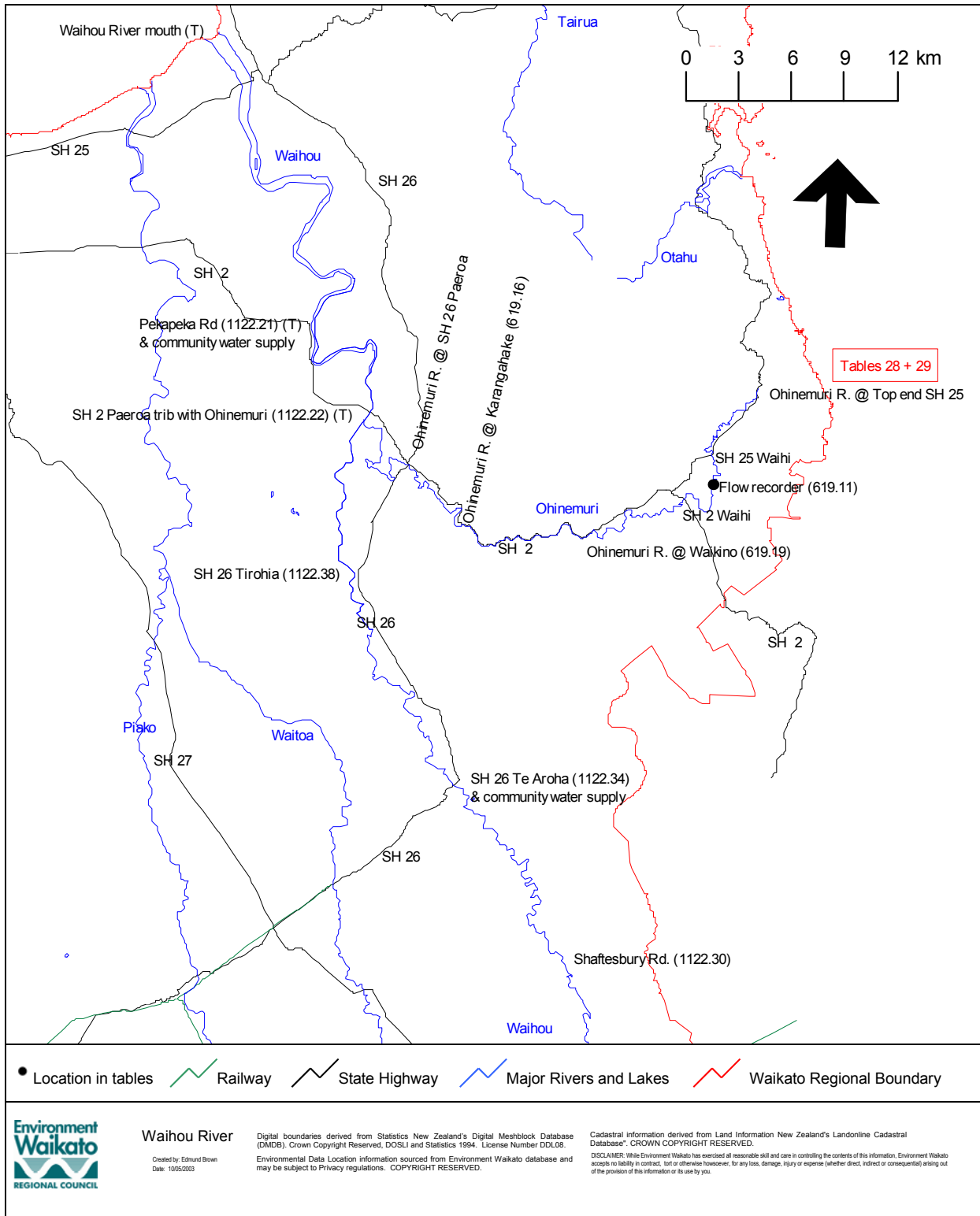


Figure 7: Lower Waihou River.

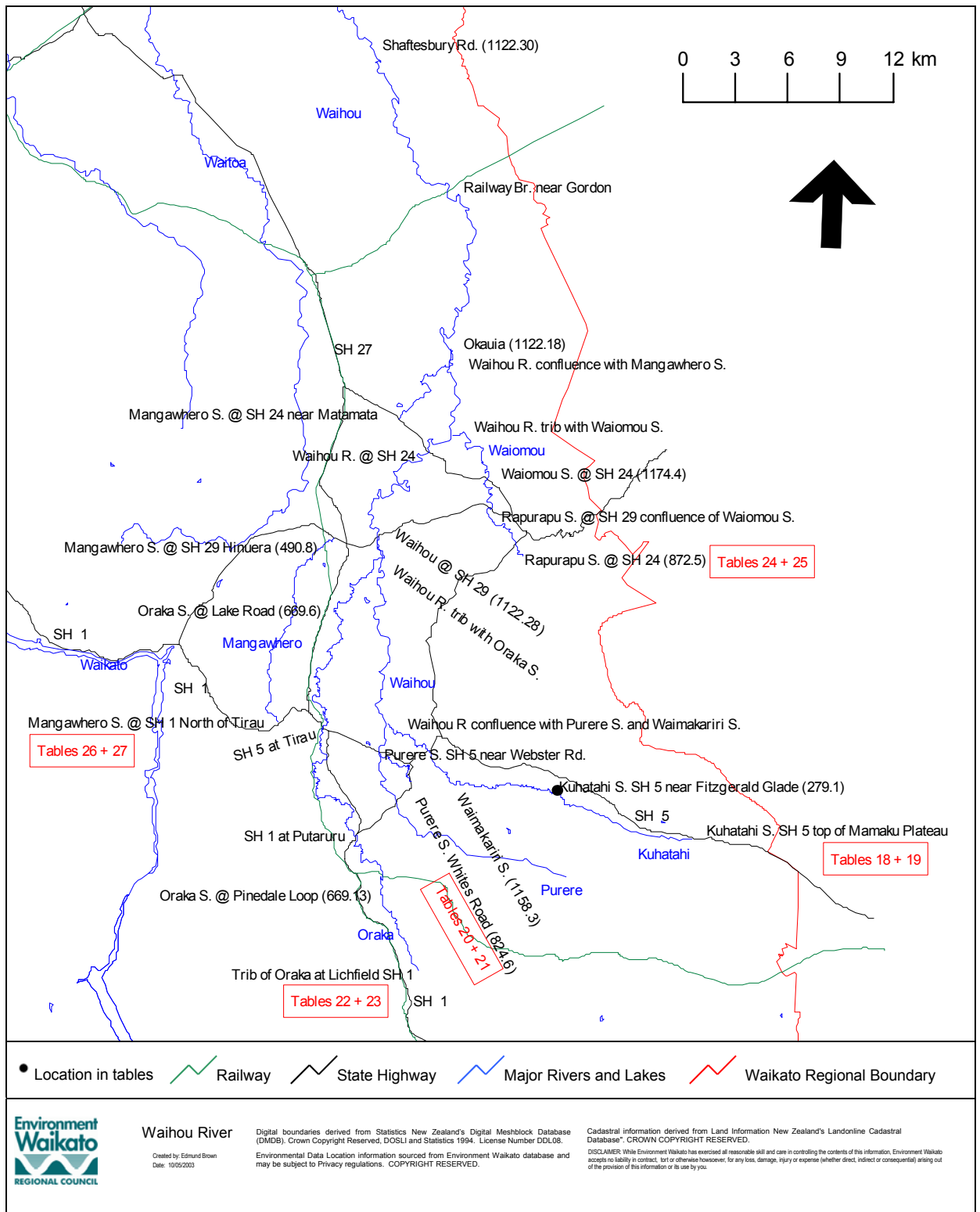


Figure 8: Upper Waihou River.

6.1 Kuhatahi Stream to Waihou River Mouth

Table 18: Travel time Kuhatahi & Waimakariri Streams to Waihou River Mouth.

Kuhatahi - Waimakariri - Waihou River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)			Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Kuhatahi S. SH 5 top of Mamaku Plateau	2774000	6347600	0	0.0		0	0		0	0
Kuhatahi S. SH 5 near Fitzgerald Glade (279.1)	2766253	6350380	9115	9.1	0.2	5.1	5	0.25	4.8	5
Waimakariri S. (1158.3)	2760566	6350760	7340	16.5	0.8	2.7	8	0.8	2.6	7
Waihou R. confluence with Purere S. and Waimakariri S.	2756640	6354220	7120	23.6			2.6			10
Waihou R. trib with Oraka S.	2756400	6363600	14865	38.4			5.5			15
Waihou @ SH 29 (1122.28)	2756100	6364900	1600	40.0	0.7	0.7	17	0.75	0.6	16
Waihou R. @ SH 24	2759060	6369640	14115	54.2			6.0			22
Waihou R. trib with Waiomou S.	2760325	6370600	2935	57.1			1.3			23
Waihou R. trib with Mangawhero S.	2760200	6374500	5800	62.9			2.5			25
Okauia (1122.18)	2760240	6375525	1300	64.2	0.6	0.7	27	0.65	0.6	26
Railway Br. near Gordon	2760050	6384475	16145	80.3			8.2			33
Shaftesbury Rd. (1122.30)	2755020	6393300	16366	96.7			8.3			41
SH 26 Te Aroha (1122.34) (community water supply)	2749500	6402600	20420	117.1	0.5	11.3	55	0.55	9.5	50
SH 26 Tirohia (1122.38)	2743860	6414655	21045	138.2	0.5	18.0	73	0.65	13.0	63
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	2744808	6423810	11565	149.7			9.9			70
Pekapeka Rd (1122.21) (T) (community water supply)	2741500	6428900	10495	160.2			9.0			77
Waihou River mouth (T)	2736200	6444800	24860	185.1	0.15	21.2	113	0.25	15.3	92

(T) denotes tidal influence

* velocity estimated for tidal zone

Table 19: Travel time matrices in hours Kuhatahi & Waimakariri Streams to Waihou River Mouth.

Kuhatahi - Waimakariri - Waihou River travel time in hours based on: Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)

Kuhatahi S. SH 5 top of Mamaku Plateau	5	8	10	16	17	23	24	26	27	35	43	55	73	83	92	113
Kuhatahi S. SH 5 near Fitzgerald Glade (279.1)	3	5	11	12	18	19	21	22	30	38	50	68	78	87	108	
Waimakariri S. (1158.3)	3	8	9	15	16	19	19	27	36	47	65	75	84	105		
Waihou R. confluence with Purere S. and Waimakariri S.	6	6	12	13	16	17	25	33	44	62	72	81	102			
Waihou R. trib with Oraka S.	1	7	8	10	11	19	28	39	57	67	76	97				
Waihou @ SH 29 (1122.28)	6	7	10	10	19	27	38	56	66	75	96					
Waihou R. @ SH 24	1	4	4	13	21	32	50	60	69	90						
Waihou R. trib with Waiomou S.	2	3	11	20	31	49	59	68	89							
Waihou R. trib with Mangawhero S.	1	9	17	28	46	56	65	87								
Okauia (1122.18)	8	16	28	46	56	65	86									
Railway Br. near Gordon	8	20	38	47	56	78										
Shaftesbury Rd. (1122.30)	11	29	39	48	69											
SH 26 Te Aroha (1122.34) (community water supply)	18	28	37	58												
SH 26 Tirohia (1122.38)	10	19	40													
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	9	30														
Pekapeka Rd (1122.21) (T) (community water supply)	21															
Waihou River mouth (T)																

Low Flow - Exceeded 85% of Time

Kuhatahi - Waimakariri - Waihou River travel time in hours based on: Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)

Kuhatahi S. SH 5 top of Mamaku Plateau	5	7	10	15	16	22	23	25	26	33	41	50	63	70	77	92
Kuhatahi S. SH 5 near Fitzgerald Glade (279.1)	3	5	11	11	17	18	20	21	28	36	45	58	65	72	87	
Waimakariri S. (1158.3)	3	8	9	14	15	18	18	26	33	43	56	63	69	85		
Waihou R. confluence with Purere S. and Waimakariri S.	5	6	12	13	15	16	23	31	40	53	60	67	82			
Waihou R. trib with Oraka S.	1	6	7	10	10	18	25	35	48	55	61	77				
Waihou @ SH 29 (1122.28)	6	7	9	10	17	25	34	47	54	61	76					
Waihou R. @ SH 24	1	3	4	12	19	29	42	49	55	71						
Waihou R. trib with Waiomou S.	2	3	10	18	27	40	48	54	69							
Waihou R. trib with Mangawhero S.	1	8	16	25	38	45	52	67								
Okauia (1122.18)	7	15	25	37	45	51	66									
Railway Br. near Gordon	8	17	30	37	44	59										
Shaftesbury Rd. (1122.30)	9	22	30	36	51											
SH 26 Te Aroha (1122.34) (community water supply)	13	20	27	42												
SH 26 Tirohia (1122.38)	7	14	29													
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	6	22														
Pekapeka Rd (1122.21) (T) (community water supply)	15															
Waihou River mouth (T)																

High Flow - Exceeded 15% of Time

6.2 Purere Stream to Waihou River Mouth

Table 20: Travel time Purere Stream to Waihou River Mouth.

Purere - Waihou River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)			Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Purere S. Whites Road (824.6)	2757924	6350920	0	0.0	0.3	0	0	0.3	0	0
Purere S. SH 5 near Webster Rd.	2756131	6352590	3972	4.0		2.2	2		2.1	2
Waihou R confluence with Purere S. and Waimakariri S.	2756640	6354220	2729	6.7		1.5	4		1.4	4
Waihou R. trib with Oraka S.	2756400	6363600	14865	21.6		8.3	12		7.9	11
Waihou @ SH 29 (1122.28)	2756100	6364900	1600	23.2	0.7	0.7	13	0.75	0.6	12
Waihou R. @ SH 24	2759060	6369640	14115	37.3		6.0	19		5.6	18
Waihou R. trib with Waiomou S.	2760325	6370600	2935	40.2		1.3	20		1.2	19
Waihou R. trib with Mangawhero S.	2760200	6374500	5800	46.0		2.5	22		2.3	21
Okauia (1122.18)	2760240	6375525	1300	47.3	0.6	0.7	23	0.65	0.6	22
Railway Br. near Gordon	2760050	6384475	16145	63.5		8.2	31		7.5	29
Shaftesbury Rd. (1122.30)	2755020	6393300	16366	79.8		8.3	40		7.6	37
SH 26 Te Aroha (1122.34) (community water supply)	2749500	6402600	20420	100.2	0.5	11.3	51	0.55	10.3	47
SH 26 Tirohia (1122.38)	2743860	6414655	21045	121.3	0.5	18.0	69	0.65	13.0	60
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	2744808	6423810	11565	132.9		9.9	79		7.1	67
Pekapeka Rd (1122.21) (T) (community water supply)	2741500	6428900	10495	143.4		9.0	88		6.5	74
Waihou River mouth (T)	2736200	6444800	24860	168.2	0.15	21.2	109	0.25	15.3	89

(T) denotes tidal influence

* velocity estimated for tidal zone

Table 21: Travel time matrices in hours Purere Stream to Waihou River Mouth.

Purere - Waihou River travel time in hours based on: Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)

Purere S. Whites Road (824.6)	2	4	12	13	19	20	22	23	31	40	51	69	79	88	109
Purere S. SH 5 near Webster Rd.		2	10	10	16	18	20	21	29	37	49	67	77	85	107
Waihou R confluence with Purere S. and Waimakariri S.			8	9	15	16	19	19	28	36	47	65	75	84	105
Waihou R. trib with Oraka S.				1	7	8	10	11	19	28	39	57	67	76	97
Waihou @ SH 29 (1122.28)					6	7	10	10	19	27	38	56	66	75	96
Waihou R. @ SH 24						1	4	4	13	21	32	50	60	69	90
Waihou R. trib with Waiomou S.							2	3	11	20	31	49	59	68	89
Waihou R. trib with Mangawhero S.								1	9	17	28	46	56	65	87
Okauia (1122.18)									8	16	28	46	56	65	86
Railway Br. near Gordon										8	20	38	47	56	78
Shaftesbury Rd. (1122.30)											11	29	39	48	69
SH 26 Te Aroha (1122.34) (community water supply)												18	28	37	58
SH 26 Tirohia (1122.38)													10	19	40
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)														9	30
Pekapeka Rd (1122.21) (T) (community water supply)															21
Waihou River mouth (T)															

**Low Flow - Exceeded
85% of Time**

Purere - Waihou River travel time in hours based on: Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)

Purere S. Whites Road (824.6)	2	4	11	12	18	19	21	22	29	37	47	60	67	74	89
Purere S. SH 5 near Webster Rd.		1	9	10	16	17	19	20	27	35	45	58	65	72	87
Waihou R confluence with Purere S. and Waimakariri S.			8	9	14	15	18	18	26	33	44	57	64	70	85
Waihou R. trib with Oraka S.				1	6	7	10	10	18	25	36	49	56	62	78
Waihou @ SH 29 (1122.28)					6	7	9	10	17	25	35	48	55	62	77
Waihou R. @ SH 24						1	3	4	12	19	29	42	50	56	71
Waihou R. trib with Waiomou S.							2	3	10	18	28	41	48	55	70
Waihou R. trib with Mangawhero S.								1	8	16	26	39	46	53	68
Okauia (1122.18)									7	15	25	38	45	52	67
Railway Br. near Gordon										8	18	31	38	44	60
Shaftesbury Rd. (1122.30)											10	23	30	37	52
SH 26 Te Aroha (1122.34) (community water supply)												13	20	27	42
SH 26 Tirohia (1122.38)													7	14	29
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)														6	22
Pekapeka Rd (1122.21) (T) (community water supply)															15
Waihou River mouth (T)															

**High Flow - Exceeded
15% of Time**

6.3 Oraka Stream to Waihou River Mouth

Table 22: Travel time Oraka Stream to Waihou River Mouth.

Oraka - Waihou River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)			Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)		
					Velocity m/s	Cumulative hours	hours	Velocity m/s	Cumulative hours	hours
Trib of Oraka at Lichfield SH 1	2758420	6340140	0	0.0		0	0		0	0
Oraka S. @ Pinedale Loop (669.13)	2756200	6344550	5580	5.6	0.5	3.4	3	0.55	3.1	3
SH 1 at Putaruru	2754800	6347800	5844	11.4		3.6	7		3.2	6
SH 5 at Tirau	2752980	6354030	11585	23.0		7.2	14		6.4	13
Oraka S. @ Lake Road (669.6)	2753700	6360780	11790	34.8	0.4	6.0	20	0.45	5.5	18
Waihou R. trib with Oraka S.	2756400	6363600	5385	40.2		2.7	23		2.5	21
Waihou @ SH 29 (1122.28)	2756100	6364900	1600	41.8	0.7	0.7	24	0.75	0.6	21
Waihou R. @ SH 24	2759060	6369640	14115	55.9		6.0	30		5.6	27
Waihou R. trib with Waiomou S.	2760325	6370600	2935	58.8		1.3	31		1.2	28
Waihou R. trib with Mangawhero S.	2760200	6374500	5800	64.6		2.5	33		2.3	30
Okauia (1122.18)	2760240	6375525	1300	65.9	0.6	0.7	34	0.65	0.6	31
Railway Br. near Gordon	2760050	6384475	16145	82.1		8.2	42		7.5	39
Shaftesbury Rd. (1122.30)	2755020	6393300	16366	98.4		8.3	50		7.6	46
SH 26 Te Aroha (1122.34) (community water supply)	2749500	6402600	20420	118.9	0.5	11.3	62	0.55	10.3	56
SH 26 Tirohia (1122.38)	2743860	6414655	21045	139.9	0.5	18.0	80	0.65	13.0	69
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	2744808	6423810	11565	151.5		9.9	90		7.1	77
Pekapeka Rd (1122.21) (T) (community water supply)	2741500	6428900	10495	162.0		9.0	99		6.5	83
Waihou River mouth (T)	2736200	6444800	24860	186.8	0.15	21.2	120	0.25	15.3	98

(T) denotes tidal influence
 * velocity estimated for tidal zone

Table 23: Travel time matrices in hours Oraka Stream to Waihou River Mouth.

Oraka - Waihou River travel time in hours based on: Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)

Trib of Oraka at Lichfield SH 1	3	7	14	20	23	24	30	31	33	34	42	50	62	80	90	99	120
Oraka S. @ Pinedale Loop (669.13)	4	11	17	19	20	26	27	30	31	39	47	58	76	86	95	116	
SH 1 at Putaruru	7	13	16	17	23	24	26	27	35	43	55	73	83	92	113		
SH 5 at Tirau	6	9	9	15	17	19	20	28	36	48	66	75	84	106			
Oraka S. @ Lake Road (669.6)	3	3	9	11	13	14	22	30	42	60	69	78	100				
Waihou R. trib with Oraka S.	1	7	8	10	11	19	28	39	57	67	76	97					
Waihou @ SH 29 (1122.28)	6	7	10	10	19	27	38	56	66	75	96						
Waihou R. @ SH 24	1	4	4	13	21	32	50	60	69	90							
Waihou R. trib with Waiomou S.	2	3	11	20	31	49	59	68	89								
Waihou R. trib with Mangawhero S.	1	9	17	28	46	56	65	87									
Okauia (1122.18)	8	16	28	46	56	65	86										
Railway Br. near Gordon	8	20	38	47	56	78											
Shaftesbury Rd. (1122.30)	11	29	39	48	69												
SH 26 Te Aroha (1122.34) (community water supply)	18	28	37	58													
SH 26 Tirohia (1122.38)	10	19	40														
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	9	30															
Pekapeka Rd (1122.21) (T) (community water supply)	21																
Waihou River mouth (T)																	

Low Flow - Exceeded 85% of Time

Oraka - Waihou River travel time in hours based on: Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)

Trib of Oraka at Lichfield SH 1	3	6	13	18	21	21	27	28	30	31	39	46	56	69	77	83	98
Oraka S. @ Pinedale Loop (669.13)	3	10	15	18	18	24	25	27	28	35	43	53	66	73	80	95	
SH 1 at Putaruru	6	12	14	15	21	22	24	25	32	40	50	63	70	77	92		
SH 5 at Tirau	5	8	9	14	15	18	18	26	33	44	57	64	70	86			
Oraka S. @ Lake Road (669.6)	2	3	9	10	12	13	20	28	38	51	58	65	80				
Waihou R. trib with Oraka S.	1	6	7	10	10	18	25	36	49	56	62	78					
Waihou @ SH 29 (1122.28)	6	7	9	10	17	25	35	48	55	62	77						
Waihou R. @ SH 24	1	3	4	12	19	29	42	50	56	71							
Waihou R. trib with Waiomou S.	2	3	10	18	28	41	48	55	70								
Waihou R. trib with Mangawhero S.	1	8	16	26	39	46	53	68									
Okauia (1122.18)	7	15	25	38	45	52	67										
Railway Br. near Gordon	8	18	31	38	44	60											
Shaftesbury Rd. (1122.30)	10	23	30	37	52												
SH 26 Te Aroha (1122.34) (community water supply)	13	20	27	42													
SH 26 Tirohia (1122.38)	7	14	29														
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	6	22															
Pekapeka Rd (1122.21) (T) (community water supply)	15																
Waihou River mouth (T)																	

High Flow - Exceeded 15% of Time

6.4 Rapurapa and Waiomou Streams to Waihou River Mouth

Table 24: Travel time Rapurapa & Waiomou Streams to Waihou River Mouth.

Rapurapa - Waiomou - Waihou River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)			Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)		
					Velocity m/s	Cumulative hours	hours	Velocity m/s	Cumulative hours	hours
Rapurapa S. @ SH 24 (872.5)	2764320	6363740	0	0.0	0.25	0	0	0.4	0	0
Rapurapa S. @ SH 29 confluence of Waiomou S.	2762530	6366400	4925	4.9		4.6	5		2.9	3
Waiomou S. @ SH 24 (1174.4)	2762280	6368150	2920	7.8	0.35	1.7	6	0.55	1.4	4
Waihou R. trib with Waiomou S.	2760325	6370600	5374	13.2		3.1	9		2.5	7
Waihou R. trib with Mangawhero S.	2760200	6374500	5800	19.0		3.4	13		2.7	9
Okauia (1122.18)	2760240	6375525	1300	20.3	0.6	0.7	13	0.65	0.6	10
Railway Br. near Gordon	2760050	6384475	16145	36.5		8.2	22		7.5	17
Shaftesbury Rd. (1122.30)	2755020	6393300	16366	52.8		8.3	30		7.6	25
SH 26 Te Aroha (1122.34) (community water supply)	2749500	6402600	20420	73.3	0.5	11.3	41	0.55	10.3	35
SH 26 Tirohia (1122.38)	2743860	6414655	21045	94.3	0.5	18.0	59	0.65	13.0	48
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	2744808	6423810	11565	105.9		9.9	69		7.1	56
Pekapeka Rd (1122.21) (T) (community water supply)	2741500	6428900	10495	116.4		9.0	78		6.5	62
Waihou River mouth (T)	2736200	6444800	24860	141.2	0.15	21.2	99	0.25	15.3	77

(T) denotes tidal influence

* velocity estimated for tidal zone

Table 25: Travel time matrices in hours Rapurapa & Waiomou Streams to Waihou River Mouth.

Rapurapa - Waiomou - Waihou River travel time in hours based on: Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)

Rapurapa S. @ SH 24 (872.5)	5	6	9	13	13	22	30	41	59	69	78	99
Rapurapa S. @ SH 29 confluence of Waiomou S.		2	5	8	9	17	25	37	55	65	74	95
Waiomou S. @ SH 24 (1174.4)			3	7	7	15	24	35	53	63	72	93
Waihou R. trib with Waiomou S.				3	4	12	20	32	50	60	69	90
Waihou R. trib with Mangawhero S.					1	9	17	28	46	56	65	87
Okauia (1122.18)						8	16	28	46	56	65	86
Railway Br. near Gordon							8	20	38	47	56	78
Shaftesbury Rd. (1122.30)								11	29	39	48	69
SH 26 Te Aroha (1122.34) (community water supply)									18	28	37	58
SH 26 Tirohia (1122.38)										10	19	40
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)											9	30
Pekapeka Rd (1122.21) (T) (community water supply)												21
Waihou River mouth (T)												

**Low Flow -
Exceeded 85% of
Time**

Rapurapa - Waiomou - Waihou River travel time in hours based on: Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)

Rapurapa S. @ SH 24 (872.5)	3	4	7	9	10	17	25	35	48	56	62	77
Rapurapa S. @ SH 29 confluence of Waiomou S.		1	4	7	7	15	22	32	45	53	59	74
Waiomou S. @ SH 24 (1174.4)			2	5	6	13	21	31	44	51	58	73
Waihou R. trib with Waiomou S.				3	3	11	18	29	42	49	55	71
Waihou R. trib with Mangawhero S.					1	8	16	26	39	46	53	68
Okauia (1122.18)						7	15	25	38	45	52	67
Railway Br. near Gordon							8	18	31	38	44	60
Shaftesbury Rd. (1122.30)								10	23	30	37	52
SH 26 Te Aroha (1122.34) (community water supply)									13	20	27	42
SH 26 Tirohia (1122.38)										7	14	29
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)											6	22
Pekapeka Rd (1122.21) (T) (community water supply)												15
Waihou River mouth (T)												

**High Flow -
Exceeded 15% of
Time**

6.5 Mangawhero Stream to Waihou River Mouth

Table 26: Travel time Mangawhero Stream to Waihou River Mouth.

Mangawhero - Waihou River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)			Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)		
					Velocity m/s	Cumulative hours	hours	Velocity m/s	Cumulative hours	hours
Mangawhero S. @ SH 1 North of Tirau	2750420	6354280	0	0.0		0	0		0	0
Mangawhero S. @ SH 29 Hinuera (490.8)	2753615	6364807	13780	13.8	0.3	8.5	9	0.45	7.0	7
Mangawhero S. @ SH 24 near Matamata	2757270	6371540	13070	26.9		8.1	17		6.6	14
Waihou R. confluence with Mangawhero S.	2760200	6374500	6183	33.0		3.8	20		3.1	17
Waihou R @ Okauia (1122.18)	2760240	6375525	1300	34.3	0.6	0.7	21	0.65	0.6	17
Railway Br. near Gordon	2760050	6384475	16145	50.5		8.2	29		7.5	25
Shaftesbury Rd. (1122.30)	2755020	6393300	16366	66.8		8.3	37		7.6	32
SH 26 Te Aroha (1122.34) (community water supply)	2749500	6402600	20420	87.3	0.5	11.3	49	0.55	10.3	43
SH 26 Tirohia (1122.38)	2743860	6414655	21045	108.3	0.5	18.0	67	0.65	13.0	56
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	2744808	6423810	11565	119.9		9.9	77		7.1	63
Pekapeka Rd (1122.21) (T) (community water supply)	2741500	6428900	10495	130.4		9.0	86		6.5	69
Waihou River mouth (T)	2736200	6444800	24860	155.2	0.15	21.2	107	0.25	15.3	85

(T) denotes tidal influence
 * velocity estimated for tidal zone

Table 27: Travel time matrices in hours Mangawhero Stream to Waihou River Mouth.

Mangawhero - Waihou River travel time in hours based on: Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)

Mangawhero S. @ SH 1 North of Tirau	9	17	20	21	29	37	49	67	77	86	107
Mangawhero S. @ SH 29 Hinuera (490.8)	8	12	13	21	29	40	58	68	77	98	
Mangawhero S. @ SH 24 near Matamata	4	4	13	21	32	50	60	69	90		
Waihou R. confluence with Mangawhero S.		1	9	17	28	46	56	65	87		
Waihou R @ Okauia (1122.18)		8	16	28	46	56	65	86			
Railway Br. near Gordon		8	20	38	47	56	78				
Shaftesbury Rd. (1122.30)		11	29	39	48	69					
SH 26 Te Aroha (1122.34) (community water supply)		18	28	37	58						
SH 26 Tirohia (1122.38)		10	19	40							
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)		9	30								
Pekapeka Rd (1122.21) (T) (community water supply)		21									
Waihou River mouth (T)											

Low Flow - Exceeded 85% of Time

Mangawhero - Waihou River travel time in hours based on: Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)

Mangawhero S. @ SH 1 North of Tirau	7	14	17	17	25	32	43	56	63	69	85
Mangawhero S. @ SH 29 Hinuera (490.8)	7	10	10	18	25	36	49	56	62	78	
Mangawhero S. @ SH 24 near Matamata	3	4	11	19	29	42	49	56	71		
Waihou R. confluence with Mangawhero S.		1	8	16	26	39	46	53	68		
Waihou R @ Okauia (1122.18)		7	15	25	38	45	52	67			
Railway Br. near Gordon		8	18	31	38	44	60				
Shaftesbury Rd. (1122.30)		10	23	30	37	52					
SH 26 Te Aroha (1122.34) (community water supply)		13	20	27	42						
SH 26 Tirohia (1122.38)		7	14	29							
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)		6	22								
Pekapeka Rd (1122.21) (T) (community water supply)		15									
Waihou River mouth (T)											

High Flow - Exceeded 15% of Time

6.6 Ohinemuri River to Waihou River Mouth

Table 28: Travel time Ohinemuri River to Waihou River Mouth.

Ohinemuri - Waihou River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)			Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)		
					Velocity m/s	Cumulative hours	hours	Velocity m/s	Cumulative hours	hours
Ohinemuri R. @ Top end SH 25	2766770	6425200	0	0.0		0	0		0	0
SH 25 Waihi	2764160	6421360	6975	7.0		7.8	8		3.2	3
Flow recorder (619.11)	2764222	6419685	3080	10.1	0.25	2.9	11	0.6	1.1	4
SH 2 Waihi	2762610	6418870	4110	14.2		3.8	14		1.5	6
Ohinemuri R. @ Waikino (619.19)	2757520	6417100	8855	23.0	0.35	8.2	23	0.9	3.3	9
Ohinemuri R. @ Karangahake (619.16)	2750665	6417000	8925	31.9	0.25	12.4	35	0.6	5.8	15
Ohinemuri R. @ SH 26 Paeroa	2747000	6420800	8200	40.1		11.4	46		5.4	20
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)	2744808	6423810	9475	49.6		13.2	60		6.2	27
Pekapeka Rd (1122.21) (T) (community water supply)	2741500	6428900	10495	60.1		14.6	74		6.9	33
Waihou River mouth (T)	2736200	6444800	24860	85.0	0.15	34.5	109	0.25	16.2	50

(T) denotes tidal influence

* velocity estimated for tidal zone

Table 29: Travel time matrices in hours Ohinemuri River to Waihou River Mouth.

Ohinemuri - Waihou River travel time in hours based on: Reference flow 27 cumecs @ SH 26 Te Aroha (1122.34)

Ohinemuri R. @ Top end SH 25	8	11	14	23	35	46	60	74	109
SH 25 Waihi		3	7	15	27	39	52	66	101
Flow recorder (619.11)			4	12	24	36	49	64	98
SH 2 Waihi				8	21	32	45	60	94
Ohinemuri R. @ Waikino (619.19)					12	24	37	52	86
Ohinemuri R. @ Karangahake (619.16)						11	25	39	74
Ohinemuri R. @ SH 26 Paeroa							13	28	62
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)								15	49
Pekapeka Rd (1122.21) (T) (community water supply)									35
Waihou River mouth (T)									

**Low Flow -
Exceeded 85% of
Time**

Ohinemuri - Waihou River travel time in hours based on: Reference flow 55 cumecs @ SH 26 Te Aroha (1122.34)

Ohinemuri R. @ Top end SH 25	3	4	6	9	15	20	27	33	50
SH 25 Waihi		1	3	6	12	17	23	30	46
Flow recorder (619.11)			2	5	11	16	22	29	45
SH 2 Waihi				3	9	14	21	28	44
Ohinemuri R. @ Waikino (619.19)					6	11	17	24	40
Ohinemuri R. @ Karangahake (619.16)						5	12	18	35
Ohinemuri R. @ SH 26 Paeroa							6	13	29
SH 2 Paeroa trib with Ohinemuri (1122.22) (T)								7	23
Pekapeka Rd (1122.21) (T) (community water supply)									16
Waihou River mouth (T)									

**High Flow -
Exceeded 15% of
Time**

7 Piako River

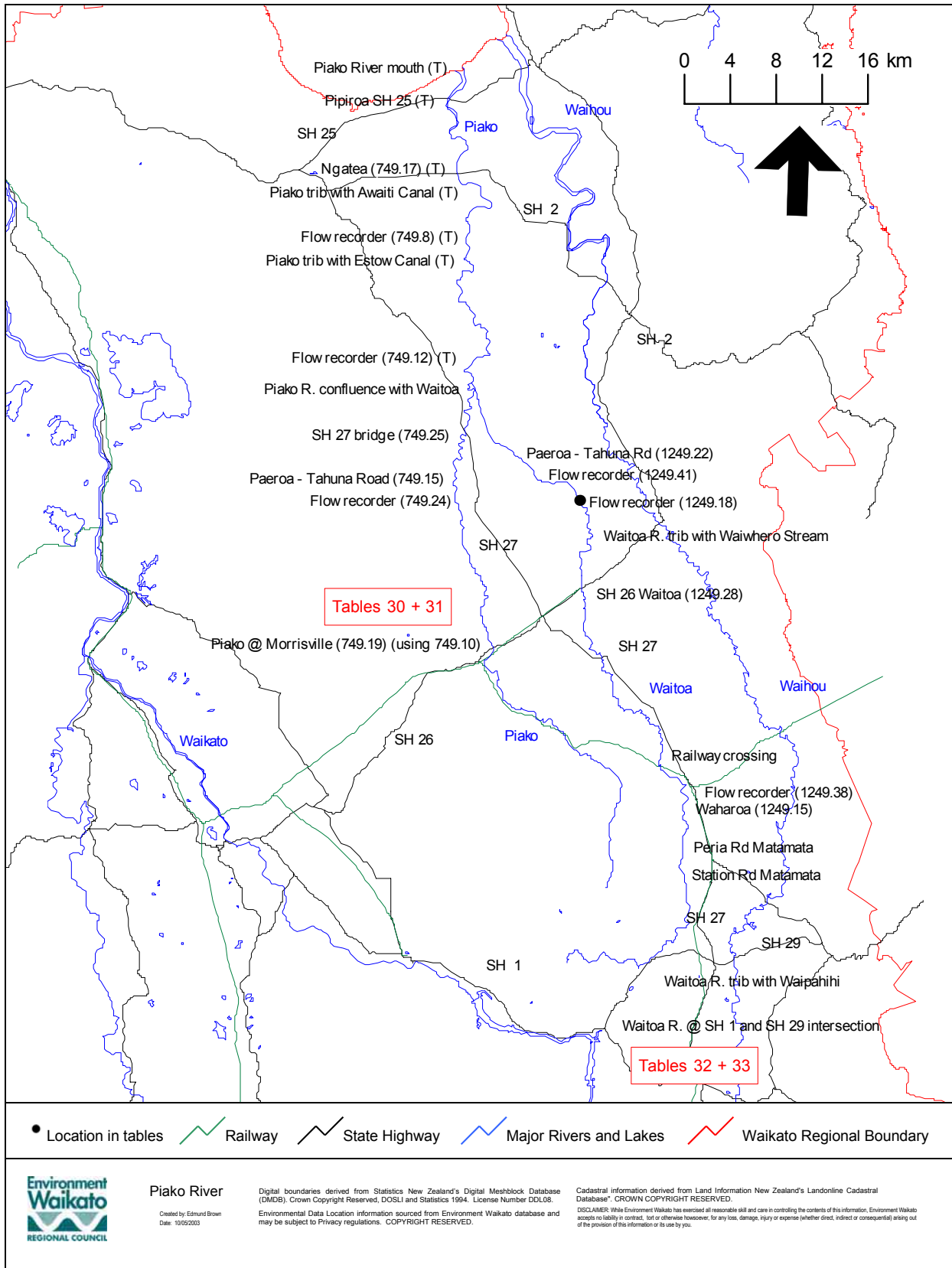


Figure 9: Piako River.

7.1 Morrinsville to Piako River Mouth

Table 30: Travel time Piako River from Morrinsville to river mouth.

Piako	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 0.9 cumecs @ Paeroa-Tahuna Rd. (749.15)			Reference flow 13 cumecs @ Paeroa-Tahuna Rd. (749.15)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Piako @ Morrinsville (749.19) (using 749.10)	2735170	6392050	0	0.0	0.3	0	0	0.6	0	0
Flow recorder (749.24)	2731660	6404845	15759	15.8		19.5	19		8.8	9
Paeroa - Tahuna Road (749.15)	2731760	6406730	2470	18.2	0.15	4.6	24	0.4	2.1	11
SH 27 bridge (749.25)	2732200	6410100	5085	23.3		9.4	33		4.3	15
Piako R. trib with Waitoa	2733338	6414493	6420	29.7		11.9	45		5.5	21
Flow recorder (749.12) (T)	2732460	6416110	1995	31.7	0.15*	3.7	49	0.25*	2.2	23
Piako trib with Estow Canal (T)	2732510	6425920	14456	46.2		26.8	76		16.1	39
Flow recorder (749.8) (T)	2732655	6427190	1515	47.7		2.8	79		1.7	41
Piako trib with Awaiti Canal (T)	2732280	6432180	5370	53.1		9.9	89		6.0	47
Ngatea (749.17) (T)	2731950	6433140	1030	54.1		1.9	90		1.1	48
Pipiroa SH 25 (T)	2731120	6439730	8955	63.1		16.6	107		10.0	58
Piako River mouth (T)	2732430	6441800	2725	65.8	0.15*	5.0	112	0.25*	3.0	61

(T) denotes tidal influence

* velocity estimated for tidal zone

Table 31: Travel time matrices in hours Piako River from Morrinsville to river mouth.

Piako travel time in hours based on: Reference flow 0.9 cumecs @ Paeroa-Tahuna Rd. (749.15)

Piako @ Morrinsville (749.19) (using 749.10)	19	24	33	45	49	76	79	89	90	107	112
Flow recorder (749.24)		5	14	26	30	56	59	69	71	88	93
Paeroa - Tahuna Road (749.15)			9	21	25	52	55	65	66	83	88
SH 27 bridge (749.25)				12	16	42	45	55	57	74	79
Piako R. trib with Waitoa					4	30	33	43	45	62	67
Flow recorder (749.12) (T)						27	30	40	41	58	63
Piako trib with Estow Canal (T)							3	13	15	31	36
Flow recorder (749.8) (T)								10	12	28	33
Piako trib with Awaiti Canal (T)									2	18	24
Ngatea (749.17) (T)										17	22
Pipiroa SH 25 (T)											5
Piako River mouth (T)											

Low Flow - Exceeded 85% of Time

Piako travel time in hours based on: Reference flow 13 cumecs @ Paeroa-Tahuna Rd. (749.15)

Piako @ Morrinsville (749.19) (using 749.10)	9	11	15	21	23	39	41	47	48	58	61
Flow recorder (749.24)		2	6	12	14	30	32	38	39	49	52
Paeroa - Tahuna Road (749.15)			4	10	12	28	30	36	37	47	50
SH 27 bridge (749.25)				5	8	24	25	31	33	43	46
Piako R. trib with Waitoa					2	18	20	26	27	37	40
Flow recorder (749.12) (T)						16	18	24	25	35	38
Piako trib with Estow Canal (T)							2	8	9	19	22
Flow recorder (749.8) (T)								6	7	17	20
Piako trib with Awaiti Canal (T)									1	11	14
Ngatea (749.17) (T)										10	13
Pipiroa SH 25 (T)											3
Piako River mouth (T)											

High Flow - Exceeded 15% of Time

7.2 Waitoa River to Piako River Mouth

Table 32: Travel time Waitoa River to Piako River Mouth.

Waitoa -Piako	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 0.9 cumecs @ Paeroa-Tahuna Rd. (749.15)			Reference flow 13 cumecs @ Paeroa-Tahuna Rd. (749.15)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Waitoa R. @ SH 1 and SH 29 intersection	2744860	6358675	0	0.0	0.15	0	0	0.5	0	0
Waitoa R. trib with Waipahihi	2748620	6363325	8065	8.1		14.9	15	4.5	4	
Station Rd Matamata	2751700	6372060	14595	22.7		27.0	42	8.1	13	
Peria Rd Matamata	2751580	6374655	3193	25.9		5.9	48	1.8	14	
Waharoa (1249.15)	2751700	6378235	4317	30.2		8.0	56	2.4	17	
Flow recorder (1249.38)	2752098	6378620	543	30.7	0.15	0.7	57	0.5	0.3	17
Railway crossing	2749656	6381582	5256	36.0		6.5	63	2.9	20	
SH 27	2744503	6391064	13570	49.5		16.8	80	7.5	28	
SH 26 Waitoa (1249.28)	2742747	6397134	11833	61.4	0.3	10.1	90	0.5	6.6	34
Waitoa R. trib with Waiwhero Stream	2743620	6401745	6752	68.1		5.8	96	3.8	38	
Flow recorder (1249.18)	2742645	6404800	3863	72.0	0.35	3.9	100	0.5	2.1	40
Flow recorder (1249.41)	2738715	6406700	4998	77.0		5.0	105	2.8	43	
Paeroa - Tahuna Rd (1249.22)	2737240	6408406	2410	79.4	0.2	3.8	108	0.5	1.8	45
Piako R. confluence with Waitoa	2733338	6414493	7830	87.2		12.4	121	5.8	50	
Flow recorder (749.12) (T)	2732460	6416110	1995	89.2	0.15	3.7	125	0.25	2.2	53
Piako trib with Estow Canal (T)	2732510	6425920	14456	103.7		26.8	151	16.1	69	
Flow recorder (749.8) (T)	2732655	6427190	1515	105.2		2.8	154	1.7	70	
Piako trib with Awaiti Canal (T)	2732280	6432180	5370	110.6		9.9	164	6.0	76	
Ngatea (749.17) (T)	2731950	6433140	1030	111.6		1.9	166	1.1	77	
Piapiroa SH 25 (T)	2731120	6439730	8955	120.5		16.6	183	10.0	87	
Piako River mouth (T)	2732430	6441800	2725	123.3	0.15	5.0	188	0.25	3.0	90

(T) denotes tidal influence

* velocity estimated for tidal zone

Table 33: Travel time matrices in hours Waitoa River to Piako River Mouth.

Waitoa -Piako travel time in hours based on: Reference flow 0.9 cumecs @ Paeroa-Tahuna Rd. (749.15)

Waitoa R. @ SH 1 and SH 29 intersection	15	42	48	56	57	63	80	90	96	100	105	108	121	125	151	154	164	166	183	188
Waitoa R. trib with Waipahihi	27	33	41	42	48	65	75	81	85	90	94	106	110	136	139	149	151	168	173	
Station Rd Matamata	6	14	15	21	38	48	54	58	63	66	79	83	109	112	122	124	141	146		
Peria Rd Matamata	8	9	15	32	42	48	52	57	61	73	77	103	106	116	118	135	140			
Waharoa (1249.15)	1	7	24	34	40	44	49	53	65	69	95	98	108	110	127	132				
Flow recorder (1249.38)	6	23	33	39	43	48	52	64	68	95	98	108	109	126	131					
Railway crossing	17	27	33	37	42	45	58	62	88	91	101	103	120	125						
SH 27	10	16	20	25	29	41	45	72	74	84	86	103	108							
SH 26 Waitoa (1249.28)	6	10	15	19	31	35	61	64	74	76	93	98								
Waitoa R. trib with Waiwhero Stream	4	9	13	25	29	56	58	68	70	87	92									
Flow recorder (1249.18)	5	9	21	25	52	55	65	66	83	88										
Flow recorder (1249.41)	4	16	20	47	50	59	61	78	83											
Paeroa - Tahuna Rd (1249.22)	12	16	43	46	56	58	74	79												
Piako R. confluence with Waitoa	4	30	33	43	45	62	67													
Flow recorder (749.12) (T)	27	30	40	41	58	63														
Piako trib with Estow Canal (T)	3	13	15	31	36															
Flow recorder (749.8) (T)	10	12	28	33																
Piako trib with Awaiti Canal (T)	2	18	24																	
Ngatea (749.17) (T)	17	22																		
Pipiroa SH 25 (T)	5																			
Piako River mouth (T)																				

**Low Flow -
Exceeded 85%
of Time**

Waitoa -Piako travel time in hours based on: Reference flow 13 cumecs @ Paeroa-Tahuna Rd. (749.15)

Waitoa R. @ SH 1 and SH 29 intersection	4	13	14	17	17	20	28	34	38	40	43	45	50	53	69	70	76	77	87	90
Waitoa R. trib with Waipahihi	8	10	12	13	16	23	30	33	36	38	40	46	48	64	66	72	73	83	86	
Station Rd Matamata	2	4	4	7	15	22	25	27	30	32	38	40	56	58	64	65	75	78		
Peria Rd Matamata	2	3	6	13	20	23	26	28	30	36	38	54	56	62	63	73	76			
Waharoa (1249.15)	0	3	11	17	21	23	26	28	34	36	52	54	60	61	71	74				
Flow recorder (1249.38)	3	10	17	21	23	26	27	33	36	52	53	59	60	70	73					
Railway crossing	8	14	18	20	23	25	30	33	49	50	56	57	67	70						
SH 27	7	10	12	15	17	23	25	41	43	49	50	60	63							
SH 26 Waitoa (1249.28)	4	6	9	10	16	18	35	36	42	43	53	56								
Waitoa R. trib with Waiwhero Stream	2	5	7	13	15	31	32	38	40	50	53									
Flow recorder (1249.18)	3	5	10	13	29	30	36	37	47	50										
Flow recorder (1249.41)	2	8	10	26	28	34	35	45	48											
Paeroa - Tahuna Rd (1249.22)	6	8	24	26	32	33	43	46												
Piako R. confluence with Waitoa	2	18	20	26	27	37	40													
Flow recorder (749.12) (T)	16	18	24	25	35	38														
Piako trib with Estow Canal (T)	2	8	9	19	22															
Flow recorder (749.8) (T)	6	7	17	20																
Piako trib with Awaiti Canal (T)	1	11	14																	
Ngatea (749.17) (T)	10	13																		
Pipiroa SH 25 (T)	3																			
Piako River mouth (T)																				

**High Flow -
Exceeded 15%
of Time**

8 Awakino River

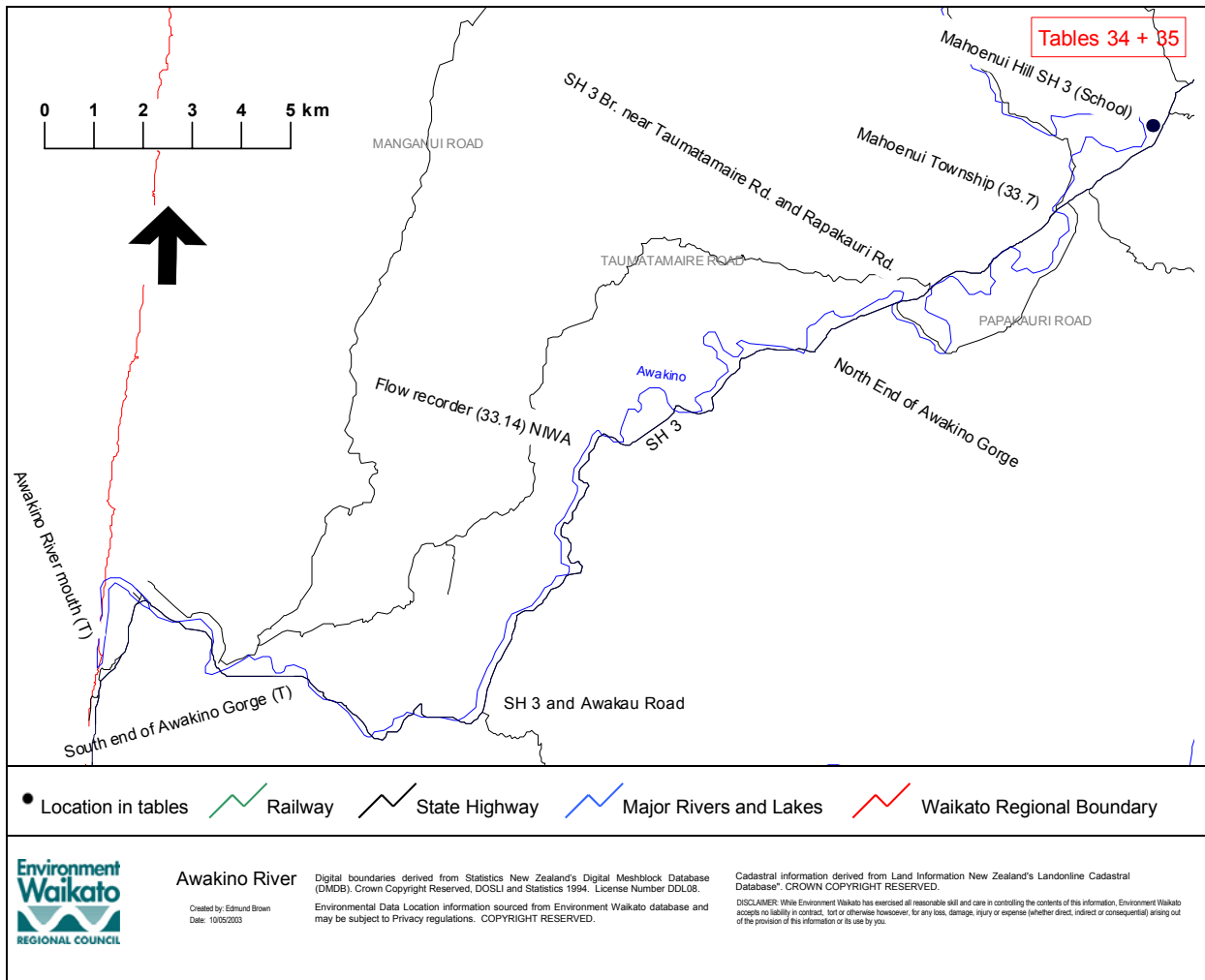


Figure 10: Awakino River.

8.1 Awakino River

Table 34: Travel time Awakino River. Reference site is not telemetered.

Awakino River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 3 cumecs @ Awakino Gorge (33.14)			Reference flow 25 cumecs @ Awakino Gorge (33.14)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Mahoenui Hill SH 3 (School)	2672460	6291830	0	0.0		0	0		0	0
Mahoenui Township (33.7)	2670546	6290140	3711	3.7	0.35**	3.4	3	1**	1.2	1
SH 3 Br. near Taumatamaire Rd. and Rapakauri Rd.	2667498	6288291	9574	13.3		8.9	12		3.0	4
North End of Awakino Gorge	2665597	6287372	3030	16.3		2.8	15		1.0	5
Flow recorder (33.14) NIWA	2661040	6285242	9580	25.9	0.25	13.3	28	0.75	5.3	11
SH3 and Awakau Road	2658831	6279950	6983	32.9		9.7	38		3.9	14
South end of Awakino Gorge (T)	2655420	6280555	4813	37.7	0.15*	8.9	47	0.25*	5.3	20
Awakino River mouth (T)	2651122	6280868	8020	45.7	0.15*	14.9	62	0.25*	8.9	29

(T) denotes tidal influence

* velocity estimated for tidal zone

** based on limited data set

Table 35: Travel time matrices in hours Awakino River.

Awakino River travel time in hours based on: Reference flow 3 cumecs @ Awakino Gorge (33.14)

Mahoenui Hill SH 3 (School)	3	12	15	28	38	47	62
Mahoenui Township (33.7)		9	12	25	35	44	58
SH 3 Br. near Taumatamaire Rd. and Rapakauri Rd.			3	16	26	35	50
North End of Awakino Gorge				13	23	32	47
Flow recorder (33.14) NIWA					10	19	33
SH3 and Awakau Road						9	24
South end of Awakino Gorge (T)							15
Awakino River mouth (T)							

Low Flow - Exceeded 85% of Time

Awakino River travel time in hours based on: Reference flow 25 cumecs @ Awakino Gorge (33.14)

Mahoenui Hill SH 3 (School)	1	4	5	11	14	20	29
Mahoenui Township (33.7)		3	4	9	13	19	27
SH 3 Br. near Taumatamaire Rd. and Rapakauri Rd.			1	6	10	16	24
North End of Awakino Gorge				5	9	15	23
Flow recorder (33.14) NIWA					4	9	18
SH3 and Awakau Road						5	14
South end of Awakino Gorge (T)							9
Awakino River mouth (T)							

High Flow - Exceeded 15% of Time

9 Mokau River

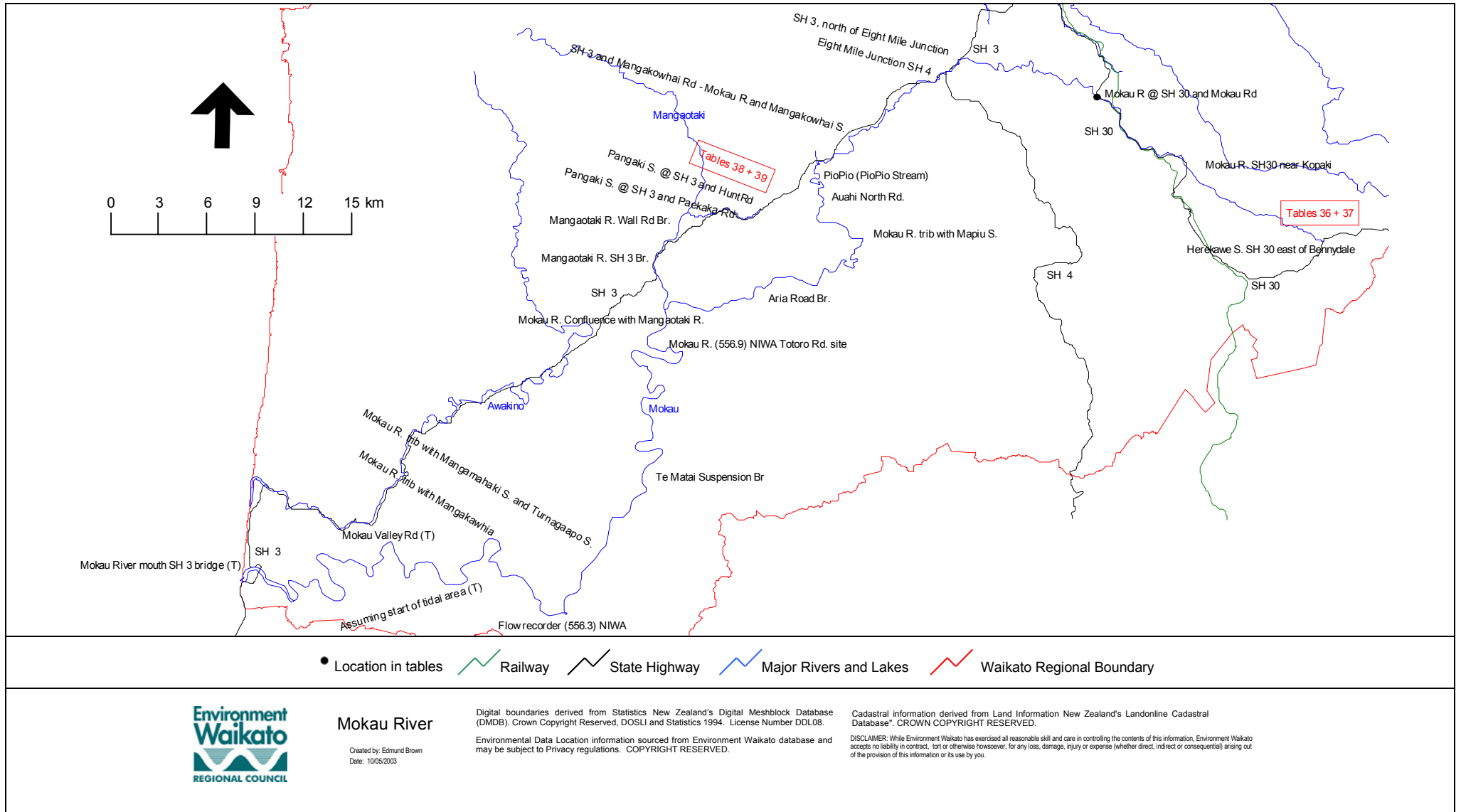


Figure 11: Mokau River.

9.1 Herekawe Stream to Mokau River Mouth

Table 36: Travel time Herekawe Stream to Mokau River Mouth. Reference site is not telemetered.

Herekawe - Mokau River Mouth	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 9 cumecs @ NIWA site (556.9)			Reference flow 65 cumecs @ NIWA site (556.9)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Herekawe S. SH 30 east of Bennydale	2717762	6297317	0	0.0	0.5	0	0	1.35	0	0
Mokau R. SH30 near Kopaki	2709563	6301672	10300	10.3		6.0	6		2.1	2
Mokau R. @ SH 30 and Mokau Rd	2703664	6306273	9814	20.1		5.7	12		2.0	4
SH 3, north of Eight Mile Junction	2695230	6308720	14760	34.9		8.6	20		3.0	7
Eight Mile Junction SH 4	2694300	6307660	2222	37.1		1.3	22		0.5	8
SH3 and Mangakowhai Rd - Mokau R.and Mangakowhai S.	2688535	6303846	11894	49.0		7.0	29		2.4	10
PioPio (PioPio Stream)	2686160	6301683	5167	54.2		3.0	32		1.1	11
Auahi North Rd.	2686502	6300553	3980	58.1		2.3	34		0.8	12
Mokau R. trib with Mapiu S.	2689020	6297510	6511	64.6		3.8	38		1.3	13
Aria Road Br.	2685501	6294873	8280	72.9		4.8	43		1.7	15
Mokau R. trib with Mangaotaki R.	2676900	6293020	10703	83.6		6.3	49		2.2	17
Mokau R. (556.9) NIWA Totoro Rd. site	2675922	6290805	3000	86.6	0.45	2.8	52	1.35	0.8	18
Te Matai Suspension Br	2675502	6282630	21030	107.7		19.5	71		5.7	24
Mokau R. trib with Mangamahaki S. and Turnagaapo S.	2672931	6278124	6165	113.8		5.7	77		1.7	25
Flow recorder (556.3) NIWA	2670280	6274200	5283	119.1	0.15	9.8	87	0.7	3.1	28
Mokau R. trib with Mangakawhia	2666683	6278613	8217	127.3		15.2	102		4.8	33
Assuming start of tidal area (T)	2664615	6276250	4400	131.7	0.15	8.1	110	0.25	4.9	38
Mokau Valley Rd (T)	2660087	6278500	7585	139.3		14.0	124		8.4	47
Mokau River mouth SH 3 bridge (T)	2651633	6277000	20340	159.7	0.15	37.7	162	0.25	22.6	69

(T) denotes tidal influence

* velocity estimated for tidal zone

Table 37: Travel time matrices in hours Herekawe Stream to Mokau River Mouth.

Herekawe - Mokau River Mouth travel time in hours based on: Reference flow 9 cumecs @ NIWA site (556.9)

Herekawe S. SH 30 east of Bennydale	6	12	20	22	29	32	34	38	43	49	52	71	77	87	102	110	124	162
Mokau R. SH30 near Kopaki	6	14	16	23	26	28	32	37	43	46	65	71	81	96	104	118	156	
Mokau R. @ SH 30 and Mokau Rd	9	10	17	20	22	26	31	37	40	59	65	75	90	98	112	150		
SH 3, north of Eight Mile Junction	1	8	11	14	17	22	29	31	51	56	66	81	90	104	141			
Eight Mile Junction SH 4	7	10	12	16	21	27	30	49	55	65	80	88	102	140				
SH3 and Mangakowhai Rd - Mokau R.and Mangakowhai S.	3	5	9	14	20	23	43	48	58	73	81	95	133					
PioPio (PioPio Stream)	2	6	11	17	20	39	45	55	70	78	92	130						
Auahi North Rd.	4	9	15	18	37	43	53	68	76	90	128							
Mokau R. trib with Mapiu S.	5	11	14	33	39	49	64	72	86	124								
Aria Road Br.	6	9	29	34	44	59	67	81	119									
Mokau R. trib with Mangaotaki R.	3	22	28	38	53	61	75	113										
Mokau R. (556.9) NIWA Totoro Rd. site	19	25	35	50	58	72	110											
Te Matai Suspension Br	6	15	31	39	53	91												
Mokau R. trib with Mangamahaki S. and Turnagaapo S.	10	25	33	47	85													
Flow recorder (556.3) NIWA	15	23	37	75														
Mokau R. trib with Mangakawhia	8	22	60															
Assuming start of tidal area (T)	14	52																
Mokau Valley Rd (T)	38																	
Mokau River mouth SH 3 bridge (T)																		

Low Flow - Exceeded 85% of Time

Herekawe - Mokau River Mouth travel time in hours based on: Reference flow 65 cumecs @ NIWA site (556.9)

Herekawe S. SH 30 east of Bennydale	2	4	7	8	10	11	12	13	15	17	18	24	25	28	33	38	47	69
Mokau R. SH30 near Kopaki	2	5	6	8	9	10	11	13	15	16	22	23	26	31	36	44	67	
Mokau R. @ SH 30 and Mokau Rd	3	3	6	7	8	9	11	13	14	20	21	24	29	34	42	65		
SH 3, north of Eight Mile Junction	0	3	4	5	6	8	10	11	17	18	21	26	31	39	62			
Eight Mile Junction SH 4	2	4	4	6	7	10	10	16	18	21	26	31	39	62				
SH3 and Mangakowhai Rd - Mokau R.and Mangakowhai S.	1	2	3	5	7	8	14	15	18	23	28	37	59					
PioPio (PioPio Stream)	1	2	4	6	7	13	14	17	22	27	35	58						
Auahi North Rd.	1	3	5	6	12	13	17	21	26	35	57							
Mokau R. trib with Mapiu S.	2	4	5	10	12	15	20	25	33	56								
Aria Road Br.	2	3	9	10	13	18	23	32	54									
Mokau R. trib with Mangaotaki R.	1	7	8	11	16	21	29	52										
Mokau R. (556.9) NIWA Totoro Rd. site	6	7	10	15	20	29	51											
Te Matai Suspension Br	2	5	10	14	23	45												
Mokau R. trib with Mangamahaki S. and Turnagaapo S.	3	8	13	21	44													
Flow recorder (556.3) NIWA	5	10	18	41														
Mokau R. trib with Mangakawhia	5	13	36															
Assuming start of tidal area (T)	8	31																
Mokau Valley Rd (T)	23																	
Mokau River mouth SH 3 bridge (T)																		

High Flow - Exceeded 15% of Time

9.2 Pangaki and Mangaotaki Streams to Mokau River Mouth

Table 38: Travel time Pangaki and Mangaotaki Streams to Mokau River Mouth. Reference site is not telemetered.

Pangaki - Mangaotaki - Mokau River	Easting	Northing	Intermediate distance (m)	Cumulative distance (km)	Reference flow 9 cumecs @ NIWA site (556.9)			Reference flow 65 cumecs @ NIWA site (556.9)		
					Velocity m/s	hours	Cumulative hours	Velocity m/s	hours	Cumulative hours
Pangaki S. @ SH 3 and HuntRd	2682726	6299290	0	0.0	0.5	0	0	1.35	0	0
Pangaki S. @ SH 3 and Paekaka Rd	2681735	6298644	1350	1.4		0.8	1		0.3	0
Mangaotaki R. Wall Rd Br.	2677929	6298850	4956	6.3		2.9	4		1.0	1
Mangaotaki R. SH 3 Br.	2676323	6296307	3508	9.8		2.1	6		0.7	2
Mokau R. Confluence with Mangaotaki R.	2676900	6293020	3810	13.6		2.2	8		0.8	3
Mokau R. (556.9) NIWA Totoro Rd. site	2675922	6290805	3000	16.6	0.45	2.8	11	1.35	0.8	4
Te Matai Suspension Br	2675502	6282630	21030	37.7		19.5	30		5.7	9
Mokau R. trib with Mangamahaki S. and Turnagaapo S.	2672931	6278124	6165	43.8		5.7	36		1.7	11
Flow recorder (556.3) NIWA	2670280	6274200	5283	49.1	0.15	9.8	46	0.7	3.1	14
Mokau R. trib with Mangakawhia	2666683	6278613	8217	57.3		15.2	61		4.8	19
Assuming start of tidal area (T)	2664615	6276250	4400	61.7	0.15	8.1	69	0.25	4.9	24
Mokau Valley Rd (T)	2660087	6278500	7585	69.3		14.0	83		8.4	32
Mokau River mouth SH 3 bridge (T)	2651633	6277000	20340	89.6	0.15	37.7	121	0.25	22.6	55

(T) denotes tidal influence

* velocity estimated for tidal zone

Table 39: Travel time matrices in hours Pangaki and Mangaotaki Streams to Mokau River Mouth.

Pangaki - Mangaotaki - Mokau River travel time in hours based on: Reference flow 9 cumecs @ NIWA site (556.9)

Pangaki S. @ SH 3 and HuntRd	1	4	6	8	11	30	36	46	61	69	83	121
Pangaki S. @ SH 3 and Paekaka Rd		3	5	7	10	29	35	45	60	68	82	120
Mangaotaki R. Wall Rd Br.			2	4	7	27	32	42	57	65	79	117
Mangaotaki R. SH 3 Br.				2	5	24	30	40	55	63	77	115
Mokau R. Confluence with Mangaotaki R.					3	22	28	38	53	61	75	113
Mokau R. (556.9) NIWA Totoro Rd. site						19	25	35	50	58	72	110
Te Matai Suspension Br							6	15	31	39	53	91
Mokau R. trib with Mangamahaki S. and Turnagaapo S.								10	25	33	47	85
Flow recorder (556.3) NIWA									15	23	37	75
Mokau R. trib with Mangakawhia										8	22	60
Assuming start of tidal area (T)											14	52
Mokau Valley Rd (T)												38
Mokau River mouth SH 3 bridge (T)												

**Low Flow -
Exceeded
85% of Time**

Pangaki - Mangaotaki - Mokau River travel time in hours based on: Reference flow 65 cumecs @ NIWA site (556.9)

Pangaki S. @ SH 3 and HuntRd	0	1	2	3	4	9	11	14	19	24	32	55
Pangaki S. @ SH 3 and Paekaka Rd		1	2	3	3	9	11	14	19	23	32	55
Mangaotaki R. Wall Rd Br.			1	2	2	8	10	13	18	22	31	54
Mangaotaki R. SH 3 Br.				1	2	7	9	12	17	22	30	53
Mokau R. Confluence with Mangaotaki R.					1	7	8	11	16	21	29	52
Mokau R. (556.9) NIWA Totoro Rd. site						6	7	10	15	20	29	51
Te Matai Suspension Br							2	5	10	14	23	45
Mokau R. trib with Mangamahaki S. and Turnagaapo S.								3	8	13	21	44
Flow recorder (556.3) NIWA									5	10	18	41
Mokau R. trib with Mangakawhia										5	13	36
Assuming start of tidal area (T)											8	31
Mokau Valley Rd (T)												23
Mokau River mouth SH 3 bridge (T)												

**High Flow -
Exceeded
15% of Time**

10 References

- Environment Waikato 1997: Regional Hazardous Substances Transport Study. Environment Waikato, Hamilton. Technical Report, 1997/09. 35 p.
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