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Relative Effects of River Flow, Water Temperature and Abstraction on Trout in the Torepatutahi Stream

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EXECUTIVE SUMMARY

Increasing demand for water for out of stream uses such as irrigation and community supply have the potential to adversely effect the value of the Torepatutahi stream as a significant habitat for resident trout populations and as cold water refuge for trout from the Waikato River. Changes in water level resulting from increased out of stream water use also has the potential to reduce the area and quality of marginal wetlands in the mid reaches of the stream.

In order to investigate these potential effects Environment Waikato conducted detailed investigations on the fishery, flow regimes and temperature of the Torepatutahi Stream over a four month period.

Drift dives were carried out in February, March, April and May 2000 to record the abundance and distribution of trout in the lower reaches of the stream and in the area of its confluence with the Waikato River. Temperature data loggers were deployed in the stream and river to record water temperatures at 30 minute intervals over the 4 month period and a series of stream gaugings were conducted under various flow and water abstraction conditions to determine the relative effects on the stream of hydro manipulation of the river, seasonality, and water abstraction.

Numbers of trout per km in the lower Torepatutahi stream were substantially higher than in other similar streams surveyed by the Eastern Fish and Game Council. Rainbow trout were numerically dominant, however there were also large numbers of large brown trout present in the stream throughout the study period. Trout numbers were lower than expected in the confluence area with the Waikato River.

Flow gauging confirmed that the one in five year low flow of the Torepatutahi stream at the Broadlands Road bridge was 3.95 cubic metres per second and that the current level of water abstraction was having a small but measurable effect on stream flows. Water abstraction was not, however, consistently correlated with a drop in stream levels.

Fluctuations in Waikato River levels as a result of hydro generation were sufficiently large to cause a fluctuation of +/- 7 cm in Torepatutahi stream levels at Broadlands Road bridge (5km upstream of the confluence), and this effect was larger than that caused by water abstraction. Low river levels acted to reduce the size and persistence of the cold water plume at the confluence of the Torepatutahi stream and the Waikato River.

It was concluded that the upper Torepatutahi stream provides significant spawning and juvenile trout habitat and further abstraction of water from this reach would be deleterious to these values. Trout in the middle and lower reaches of the stream rely on marginal macrophyte beds for invertebrate food and consequently, the continued productivity of the stream as a trout fishery is subject to the maintenance of these beds.

Further abstraction of water from the middle and lower reaches of the stream up to 15% of the Q_5 is unlikely to result in any adverse effects on the values of the stream. Abstraction of a greater percentage of the flow may threaten the wetland habitat along the margins of the middle reaches of the stream.

1 INTRODUCTION

1.1 Background

Water abstraction for pasture irrigation occurs from a large number of streams and rivers in the Waikato Region and in many cases this abstraction is considered to have little or no adverse effect on these water bodies. However, in some areas such as the Reporoa basin, demand for water is high and is increasing. Consequently, large volumes of water are already being taken while more is sought from many of the local streams.

There are currently 13 resource consents to abstract water from the Torepatutahi Catchment, including both the Torepatutahi Stream, and the Rautawiri Stream and their tributaries. Combined, these resource consents authorise a total abstraction rate from the Torepatutahi Catchment of 577 litres per second.

The one in five year (Q_5) low flow has been calculated as 3950 litres per second at the Broadlands Road bridge and 5030 litres per second at the Vaile Road bridge. On this basis the catchment is presently allocated to 11.6% of the Q_5 flow at Vaile Road bridge.

The Waikato Regional Council has received a further 5 applications to abstract water from the catchment, four for irrigation purposes, totalling 232 litres per second, and one for community supply totalling 141.3 litres per second. These applications are currently on hold pending a reassessment of the water availability in the catchment. If granted, these applications would take the total maximum abstraction rate from the catchment to 950 litres per second, or 18.9% of the Q_5 flow at Vaile Road.

Of particular concern in these large spring fed streams is the impact of summer water abstraction for irrigation on local trout populations which rely heavily on the streams for cool water refuge during the peak summer months when larger water bodies such as the Waikato River become too warm to sustain them.

Also of concern are the potential effects of reduced water levels on the complex of shallow wetlands along the margins of the stream in its middle reaches. These wetlands extend over a length of approximately 4km. It has been suggested that these wetlands are the result of large springs which erupt adjacent to the stream however, the relationship between the wetlands and stream levels is not clear.

Waikato Regional Council staff have monitored flow rates and rainfall in a number of the eastern Reporoa Streams over recent years and have hypothesised that there is a time lag between low rainfall seasons and low spring flow into the streams (and consequent low stream flow) of approximately 34 months. As a result of this time lag, low flow events do not always coincide with high summer demand for irrigation water. However, in the summer of 2000-01 these two events are predicted to coincide and as a consequence any effects on summer stream temperatures and trout habitat resulting form water abstraction are likely to be most pronounced in this period.

This study seeks to monitor changes in the flow, temperature, and trout habitat characteristics of the lower reaches of the Torepatutahi Stream and at its confluence with the Waikato River over the peak summer season and into early autumn 2001.

2 OBJECTIVES

The objectives of this study were to:

(i) *Estimate and monitor the abundance, size-structure and species composition of trout in the lower Torepatutahi Stream and in the cold water plume at its' confluence with the Waikato River in the upper half of Lake Ohakuri.*

(ii) *Monitor stream temperature and flow patterns throughout the study period during periods of full and no water abstraction.*

(iii) *Assess the effects of water abstraction during summer low flow conditions on the trout habitat characteristics of the Torepatutahi Stream.*

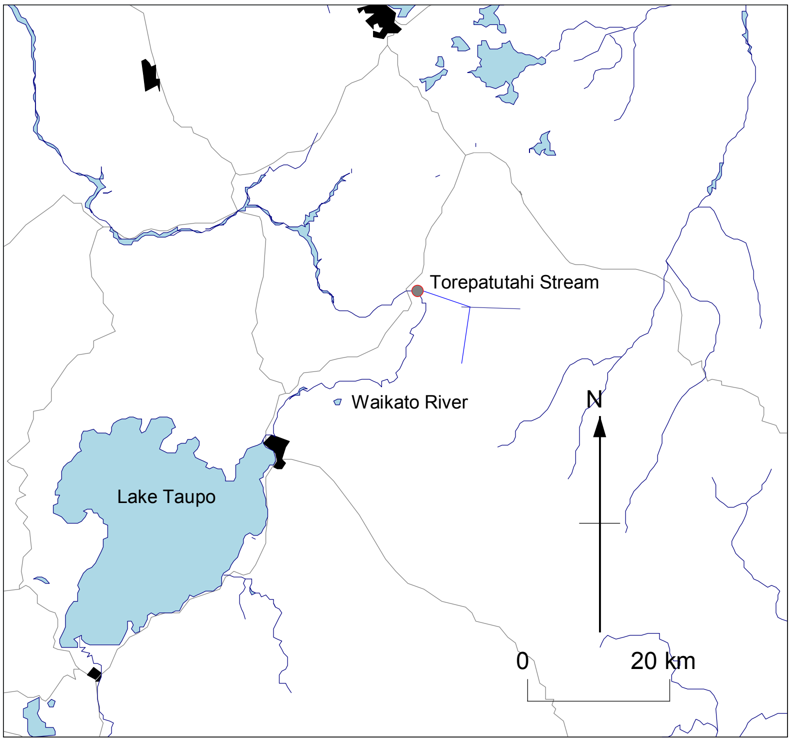

Figure 1. Schematic map of the Waikato River and it's point of confluence with the Torepatutahi Stream (NZMS 260 U17: 985-965).

3 METHODS

3.1 Drift diving

Drift diving was used to determine the abundance of trout in the Torepatutahi Stream. Drift diving has been used to estimate salmonid populations in New Zealand rivers for the past 20 years (Hicks & Watson, 1985) and has also been used to assess the effect of natural disturbances on trout stocks and to provide a means of evaluating the impacts of habitat manipulations on riverine trout populations (Teirney & Jowett, 1990).

The standardised technique developed for use in New Zealand conditions (Hicks & Watson 1985) was used in the Torepatutahi Stream. A team of two divers, outfitted with snorkel gear, drifted downstream, side by side, counting fish. Trout were separated into species and classified into four size categories (Table 1). Divers' tallies were recorded at the end of each pool or run sequence.

Table 1: The four size categories used to classify trout in New Zealand.

Size category	Length (cm)
Fingerlings	<10
Small	>10 & <20
Medium	>20 & <40
Large	>20 & <40

Observations were made of other stream characteristics, such as algae growth, aquatic macrophytes, and riparian vegetation. Underwater visibility was measured using a black and white secchi disc.

Boat observations
It was not possible to obtain accurate drift dive counts at the confluence site as trout moved out into the Waikato River and out of the view of the divers. Therefore, observations were made from a small inflatable boat, which was drifted down the Waikato River over the confluence site. Three drifts over a 100m section of the Waikato River were carried out on each sampling occasion with the highest count obtained used as the final estimate.

3.1.1 Site selection

The drift dives were conducted over a 1 km length of the Torepatutahi Stream down to it's confluence with the Waikato River at approximately NZMS 260 U17 985 965 (Figure 1). The 1 km length of stream was divided into three sections, the upper and lower sections were located above and below the Vaile Road Bridge, respectively and the confluence section was situated at the mouth of the stream and the mainstem of the Waikato River.

3.2 Water Temperature Monitoring

Stream water temperatures were recorded at 30 minute intervals from 3 February to 30 April 2001 by 10 Tidbit™ data-loggers which were deployed at the following locations:

- In the Waikato River: 2 loggers 50m upstream, 1 logger 5m downstream, 2 loggers 50m downstream and 2 loggers 100m downstream of the confluence with the Torepatutahi Stream. The configuration of loggers in the Waikato River is shown in Figure 2.
- In the Torepatutahi Stream, one logger each at the Vaile Road, Broadlands Road and Plateau Road bridges.

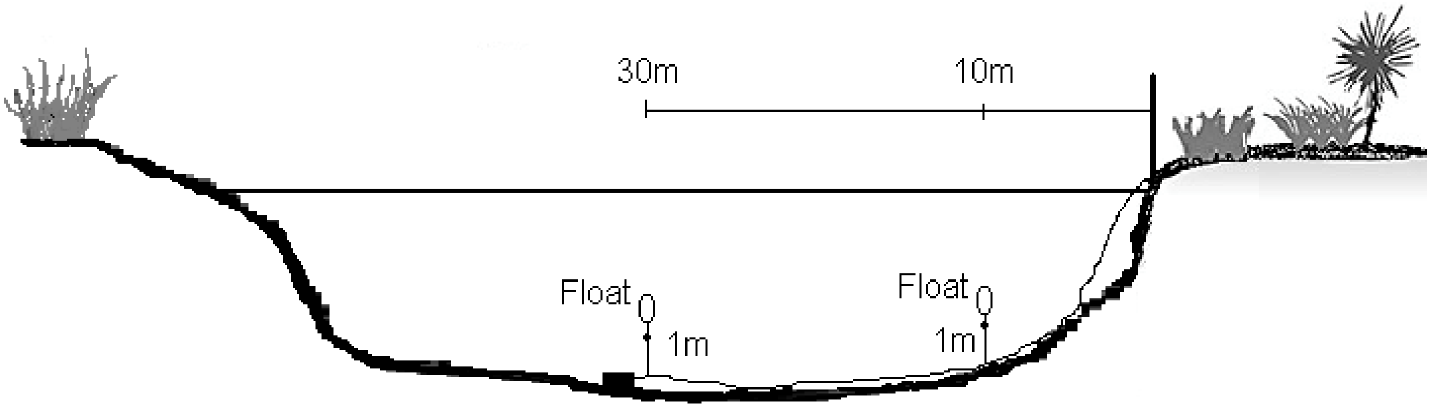

Figure 2. Schematic of data logger deployment in the Waikato River.

Unfortunately the confluence of the Waikato River and Torepatutahi Stream is located adjacent to a public reserve and the data loggers deployed on the mainstem of the Waikato River were tampered with during the course of the study. The data loggers upstream of the confluence were lifted from the water within the first week of the trial and were not returned to Environment Waikato until after the trial had been completed, while the loggers deployed 50 metres downstream of the confluence were not recovered at all. Fortunately, sufficient data loggers remained in the river to provide an accurate, if slightly less detailed than planned, assessment of in river temperature changes.

3.3 Waikato River Level Fluctuation

The Torepatutahi Stream enters the Waikato River approximately half way between the Aratiatia and Ohakuri dams, consequently, water levels in the confluence area are affected by the operation of both of these dams and can fluctuate considerably on any given day. In order to account for any influence these fluctuations may be having on stream temperatures and trout refugia, river level and flow data was obtained from Contact Energy from their recorder at Ohaaki approximately 5km upstream of the study location. Because of the separation between the two sites this data does not exactly reflect river levels at the Torepatutahi stream, however it gives an reasonably accurate reflection of the daily fluctuation and range of levels likely to occur there.

3.4 Water Abstraction and Stream Flow Monitoring

In order to assess the relative effect of water abstraction for pasture irrigation on Torepatutahi Stream flows, temperatures, physical habitat assessment and flow gaugings were conducted by Waikato Regional Council staff at five locations on the Torepatutahi Stream and on each of the major tributary streams.

Gaugings were conducted on 14, 15 and 20 December 2000 while irrigation abstraction was occurring and on 21 February and 11 April 2001 without irrigation abstraction occurring. On both occasions local irrigators were very co-operative and all irrigation abstraction had ceased for a period of 8 hours prior to any gaugings being undertaken. This was considered to be sufficient time for stream levels to have recovered from the effects of irrigation abstraction.

In June 2000, Agricultural Business Associates also conducted a study (Phillips, 2000) on the likely effect of water abstraction on flows in the Torepatutahi Stream as part of an assessment of environmental effects (AEE) for a resource consent application to take water from the system. The data presented in the AEE has also been considered in the context of this larger study and, where appropriate, has been used to supplement the results and conclusions made.

4 Habitat descriptions

The Torepatutahi Stream is a spring-fed tributary of the Waikato River. It rises at the edge of the Kaingaroa Plateau and flows through Reporoa to the Waikato River. The Torepatutahi is primarily spring fed and consequently, has a relatively stable flow of cool, clean water. Water quality in the Torepatutahi Stream is very high. Springs deliver water at ground temperature and so the Torepatutahi is cool and well oxygenated all year round.

The upper reaches of the Torepatutahi Stream (upstream of the Otonga Stream) are typically small and shallow with very stable flows and water temperatures, the stream bed is comprised of mixed sand and gravel and provides excellent habitat for trout spawning and invertebrates.

Downstream of the Otonga Stream confluence large springs erupt in the bed of the stream and the nature of the stream changes dramatically. The middle and lower reaches of the Torepatutahi Stream are incised with a "u" shaped channel. The streambed substrate is comprised mainly of unstable pumice sands. There are no riffles or rapids, but pools and runs. Aquatic weed growth is the basis for aquatic invertebrate and fish production and extensive margins of aquatic macrophytes are present in the lower reaches of the stream (Mitchell, 1995). When diving, it became apparent that these thick macrophyte beds isolate the inner stream channel from the riverbanks and so provide excellent in-stream cover for trout.

All drift dives were carried out in the lower 1 km of the stream but the 1 km reach was divided into 3 sections.

4.1.1 Upper Dive Section

The upper dive section was situated immediately above the Vaile Road Bridge. This site (Figure 3) was characterised by a deep, incised channel with extensive macrophyte beds comprised mainly of Canadian pond-weed (*Elodea canadensis*) and “oxygen weed” (*Lagarosiphon major*) along the margins. The riverbed substrate was composed mainly of highly mobile pumice sand.

Riparian vegetation was comprised mainly of pasture grasses with occasional cabbage trees (*Cordyline australis*), manuka (*Leptospermum scoparuium*) and willow (*Salix sp.*) (Table 2).

Figure 3: Upper dive section - upstream view

4.1.2 Lower Dive Section

The Torepatutahi Stream below the Vaile Road Bridge was wider than the upper section with no definite pools or riffles (Figure 4). However, stream depth and width were heavily influenced by water level fluctuations in the Waikato River. As in the upper site, extensive macrophyte beds were present which were comprised mainly of Egeria (*Egeria densa*) and hornwort (*Ceratophyllum demersum*) with a streambed substrate composed mainly of mobile pumice sand. Riparian vegetation was comprised of willow trees (*Salix sp.*) and carex grasses (*Carex sp.*).

Figure 4: Lower dive section at high river level - downstream view

4.1.3 Confluence Dive Section

This site was located at the confluence of the Torepatutahi Stream and Waikato River (Figure 5). Hence, this site was most heavily influenced by water level fluctuations in the Waikato River. When diving, it was apparent that Torepatutahi Stream water mixed rapidly into the Waikato River. There was a marked diffraction effect due to the difference between the cool Torepatutahi water and the warmer Waikato River water. There was often no defined cool water plume, particularly during low river levels, but rather pockets and eddies of cold water and a small flow along the true right-bank.

The stream-bed was comprised almost entirely of coarse pumice sand and small ignimbrite pebbles. Hornwort and Egeria were the dominant aquatic macrophytes at this site. The dominant riparian plants were willow trees, pasture and carex grasses.

Figure 5: Confluence dive section - downstream view

Table 2: Stream substrate, river morphology, fish cover and riparian vegetation present in the upper and lower drift dive sites on the Torepatutahi Stream.

Habitat feature	Upper site	Lower site	Confluence site
Stream substrate	Sand, pebbles	Sand, pebbles	Sand
River morphology	Runs, pools	Runs, pools	Pools, runs
Fish cover	Water depth, aquatic plants	Water depth, aquatic plants	Water depth, aquatic plants
Aquatic vegetation	Lagarosiphon, Elodea	Egeria, hornwort, Elodea	Hornwort, Egeria
Riparian vegetation	Pasture grasses, carex grass, cabbage trees, willow trees	Carex grass, pasture grasses, willow trees	Carex grass, pasture grasses, willow trees

5 RESULTS

5.1 Dive conditions

Six dives were carried out on a two-weekly basis from 12 February 2001 to 22 April 2001. Drift dives were carried out in sunny weather conditions, except on 12 February when heavy rain caused discolouration of the Torepatutahi Stream with fine suspended pumice.

The dives commenced at about 09:00 hours and were completed by 13:00 hours. Water temperature was recorded every 30 minutes by data loggers.

Table 3: Survey date and secchi disc reading, Lower Torepatutahi Stream, February to April 2001.

Sampling date/ 2001	Secchi Disc (m)
12 February	2.5
25 February	3.0
11 March	3.5
25 March	3.5
9 April	5.5
22 April	4.0

5.2 Species composition and abundance

5.2.1 Species composition

Rainbow trout were the dominant salmonid species in the lower Torepatutahi Stream comprising between 84 and 98% of the trout population (Table 4). Brown trout were most numerous in the upper site on 25 February and the lower site on 9 April. Brown trout were generally larger in size than rainbow trout.

Table 4. The number of trout per km and proportion of brown and rainbow trout in the Torepatutahi Stream, 25 February to 22 April 2001. Note: it was not possible to identify trout to species at the confluence site.

Sampling date	Upper				Lower			
2001	*Brown*		*Rainbow*		*Brown*		*Rainbow*	
	n/km	%	n/km	%	n/km	%	n/km	%
25 February	29	12.7	199	87.3	6	3.2	184	96.8
11 March	6	1.5	393	98.5	2	1.5	132	98.5
25 March	11	3.6	296	96.4	11	4.7	224	95.3
9 April	4	2.9	134	97.1	15	15.2	84	84.8
22 April	5	3.2	152	96.8	12	11.9	89	88.1

5.2.2 Trout abundance

Upper and lower dive sections

The dive counts for the upper and lower sections (excluding the confluence section) were combined to give estimates of trout per km. The dive results for 12 February 2001 were excluded, as an accurate assessment of the trout population was not possible due to the poor underwater visibility experienced during this dive.

Rainbow trout

Rainbow trout were very abundant in the Torepatutahi Stream with densities ranging from 218 trout per km on 9 April to 548 trout per km on 25 March 2001 (Table 5). Rainbow trout were least numerous in April.

The abundance of fingerling and small sized rainbow trout varied markedly over the study period, with both peaking on 25 March 2001 (Figure 6). The numbers of medium and large rainbow trout were not subject to the marked fluctuations recorded for the smaller size categories.

Table 5. The number and size categories of rainbow trout per km in the upper and lower sections (combined) in the Torepatutahi Stream, 25 February to 22 April 2001.

Date 2001	Fingerling	Small	Medium	Large	Sum
25 February	75	175	150	19	419
11 March	108	158	117	10	393
25 March	149	189	186	24	548
9 April	4	57	138	19	218
22 April	4	116	100	21	241

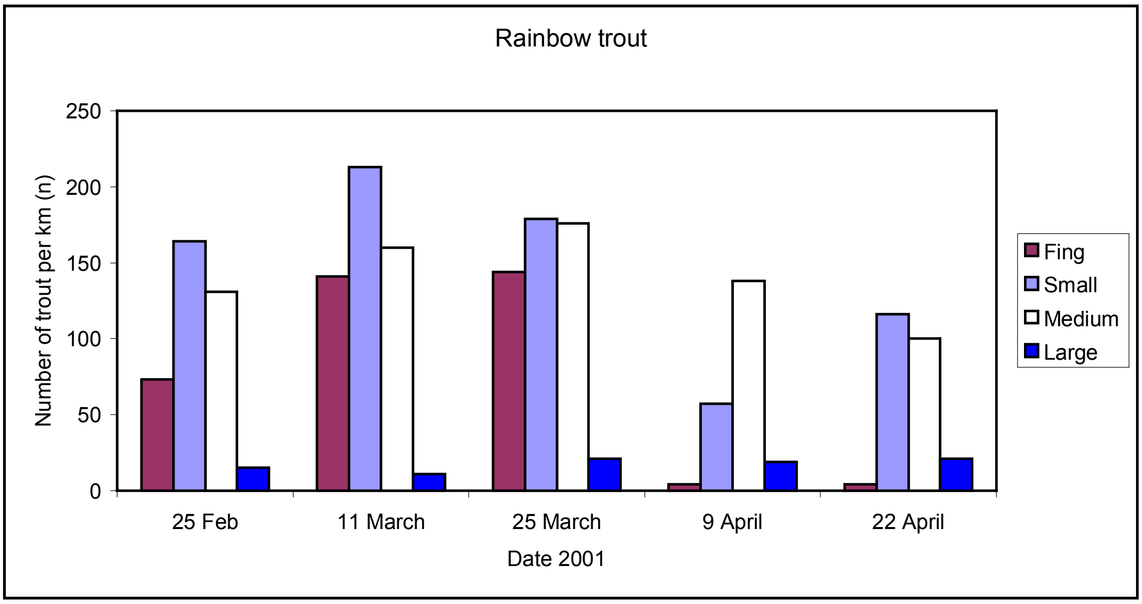

Figure 6. The number of rainbow trout counted in the Torepatutahi Stream (upper and lower sections), February to April 2001.

Brown trout
Brown trout were present at moderate densities ranging from 8 to 35 trout per km. In contrast to rainbow trout, fingerling and small sized brown trout comprised a very small proportion of the brown trout population (Table 6). Most brown trout recorded were of a large size (Figure 7).

Table 6. Size and number of brown trout per km in the upper and lower dive sections (combined) in the Torepatutahi Stream, 25 February to 22 April 2001.

Date 2001	Fingerling	Small	Medium	Large	Sum
25 February	0	8	13	14	35
11 March	0	0	6	2	8
25 March	0	0	7	16	23
9 April	3	2	16	14	35
22 April	0	0	7	15	22

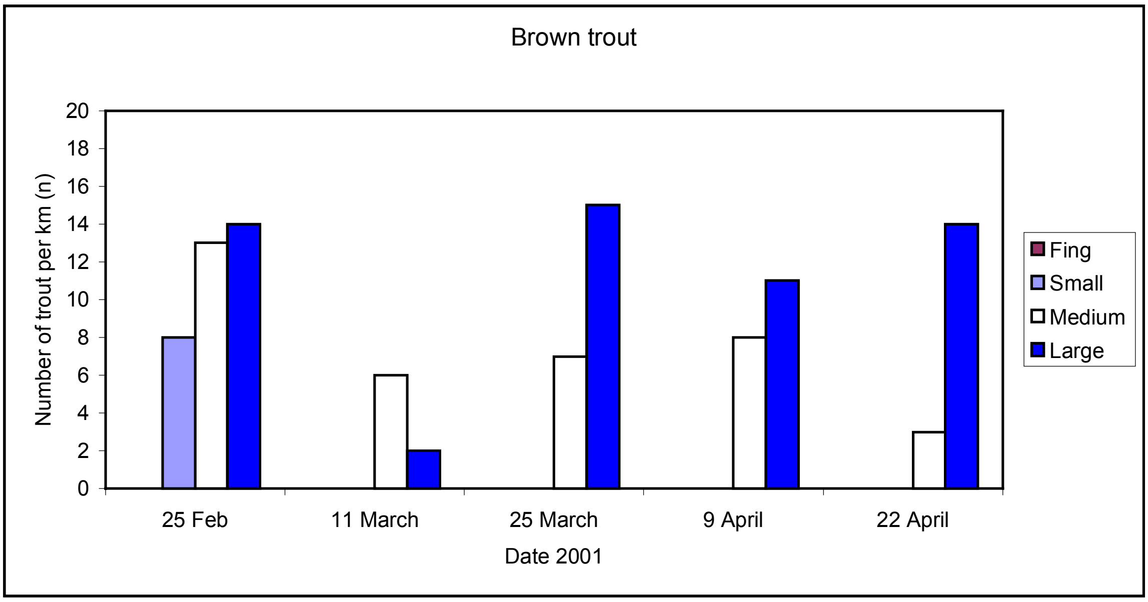

Figure 7. The number of brown trout counted in the Torepatutahi Stream (upper and lower dive sections), February to April 2001. No brown trout fingerlings were recorded during this study.

The Confluence Dive Section

Trout were easily observed and counted from the drifting boat, particularly during sunny overhead conditions and low water levels in the Waikato River. However, it was not possible to identify trout to species.

On average, low to moderate numbers of trout were present at the confluence section (Table 7). Trout numbers peaked in February at a very high 36 trout per 100m and gradually declined over the study period to 5 trout per 100m on 22 April 2001 (Figure 8). The majority of fish observed at this site were in the medium size category. Only 10 fingerlings were recorded at this section.

Table 7. Size and number of trout per 100m (data standardised to per 100m for comparison between dive sections) recorded at the confluence of the Torepatutahi Stream and Waikato River, 25 February to 22 April 2001.

Date 2001	Fingerling	Small	Medium	Large	Sum
25 February	2	11	19	4	36
11 March	0	10	18	1	29
25 March	5	10	10	4	29
9 April	3	2	8	3	16
22 April	0	0	4	1	5

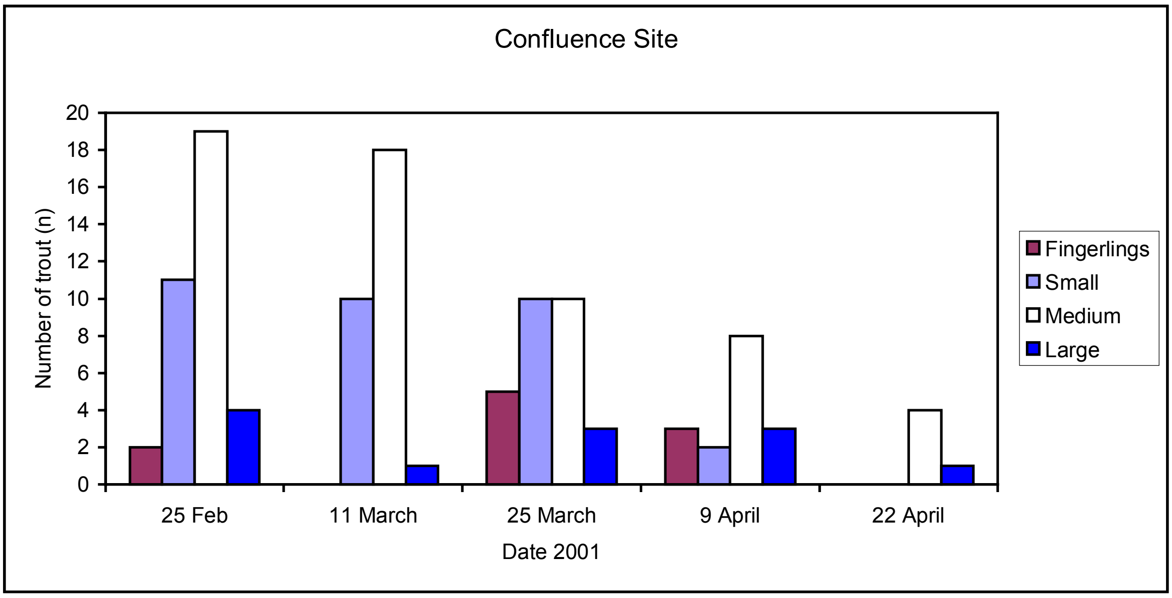

Figure 8. The number of brown trout counted at the Torepatutahi Stream confluence February to April 2001.

5.3 Water Abstraction and Stream Flow Monitoring

Data from the gaugings taken on 14, 15 and 20 December 2000 and on 21 February and 11 April 2001 supported the hypothesised lag of approximately 34 months between low rainfall seasons and low stream flow within the Torepatutahi Stream complex.

Gaugings also confirmed that the low flow assessment (Q_5 estimate) of 3.95 m3/s at Broadlands Road bridge currently being used by the Waikato Regional Council for allocation purposes is appropriate.

Irrigation abstraction was monitored during the periods when gaugings took place and a difference of between 9% and 12% was recorded in stream flow at Broadlands Road bridge between days with and without irrigation. However, reductions in stream flow as a result of irrigation abstraction were not consistently correlated with a consequent drop in stream level. Gauge board levels of 0.955m in September 2000 and 1.05m in April 2001 for the same flow at Broadlands Road bridge. This change in level does not appear to have been the consequence of any bed changes or increase in weed growth.

As discussed by Phillips (2000) and in this report, this water level effect at Broadlands Road bridge is largely the effect of fluctuations in the Waikato River level which, even at Broadlands Road bridge exceed any caused by the current level of water abstraction.

Gaugings and cross sectional analysis concurred with the conclusions made by Phillips (2000) that the daily fluctuation in stream level at Broadlands Road resulting from changes in the Waikato River is at least as large as that resulting from that likely to occur as a result of the current level of water abstraction (approximately 7cm).

5.4 Water Temperature

Average daily water temperature varied considerably between sites, however diurnal variation at most sites was less than 3 °C and at Plateau Road bridge was generally less than 1 °C.

Over the period of the study temperatures within the Waikato River showed the largest range and variance while temperatures in the upper Torepatutahi Stream at Plateau Road bridge were remarkably stable and showed little or no seasonal or diurnal variation (Table 8).

Temperature records from the Rautawiri Stream (the major tributary of the Torepatutahi Stream) at Earle Road bridge indicated that this stream had a larger diurnal variation and a slightly greater seasonal range than either the Plateau Road or Broadlands Road sites on the Torepatutahi Stream.

Table 8. Summary of Water Temperature data recorded at Waikato River and Torepatutahi Stream (and tributaries) locations (3/2/01 to 30/4/01). Sites are listed in an upstream direction from left to right on the table.

Temperature	100x10*	100x30**	Confluence	Vaile Road	Broadlands Road	Earle Road	Plateau Road
Max	24.12	23.31	Logger out of water	Logger out of water	17.38	19.89	12.48
Min	12.98	14.38	Logger out of water	Logger out of water	10.97	10.27	11.24
Average	18.09	19.09	15.62	15.55	14.12	14.85	11.87
Variance	4.31	3.15	7.22	8.13	1.71	3.87	0.05
Mode	18.66	19.67	13.09	13.19	13.13	13.37	11.86

*, ** = sites on the true right bank of the Waikato River 100 metres downstream of the confluence with the Torepatutahi Stream, 10 and 30 metres out from the bank respectively.

Graphs in Appendix 1 show the 24 hour temperature record for all sites on the days that drift dives and for the days on which no irrigation abstraction occurred.

It is notable that both the Confluence and Vaile Road data loggers recorded extremely high and low temperatures in the morning and afternoon of all of the days on which drift dives occurred, indicating that they were out of the water for large periods of this time. Similar patterns are not apparent in the records from the two days on which no abstraction takes occurred however, the temperature highs and lows correspond with river level fluctuations in the Waikato River on those days (Appendix 2) and the apparent association with irrigation abstraction is a coincidence rather than a result of the water abstraction.

Statistical analysis (two sided *t* test) of the differences between stream temperatures on each no take day (21/2/01 and 11/4/01) versus the days immediately before and after indicate that there were statistically significant differences in water temperature at some sites between days with and without irrigation abstraction. However, there was no discernible pattern to these differences and no connection between abstraction and higher stream temperatures. Furthermore none of the differences between sites were large enough to result in temperature differences that would adversely affect trout or trout habitat.

5.5 River Level Fluctuations

Over the period from 3 February to 30 April 2001 Waikato River levels recorded at Ohaaki fluctuated over a range of almost 2 metres. By way of an example, graphs in Appendix 2 show the fluctuations in river level on the days on which drift dives were undertaken in the Torepatutahi Stream and on days when no irrigation abstraction occurred.

Throughout the study period, the pattern of river level fluctuation was extremely variable (Figure 9). Maximum daily variations ranged from almost 2 metres to less than 15 centimetres and changes from high to low river levels occurred over periods ranging from 6 to 48 hours. River levels fluctuated within a 1 metre range for approximately 65% of the time with the more extreme fluctuations accounting for the remaining 35% of the time. There appeared to be no predictable pattern to the river levels which are manipulated by Mighty River Power according to generation demand, however, on days when a significant fluctuation occurred higher river levels generally occurred in the mid to late afternoon with a corresponding low in the early morning.

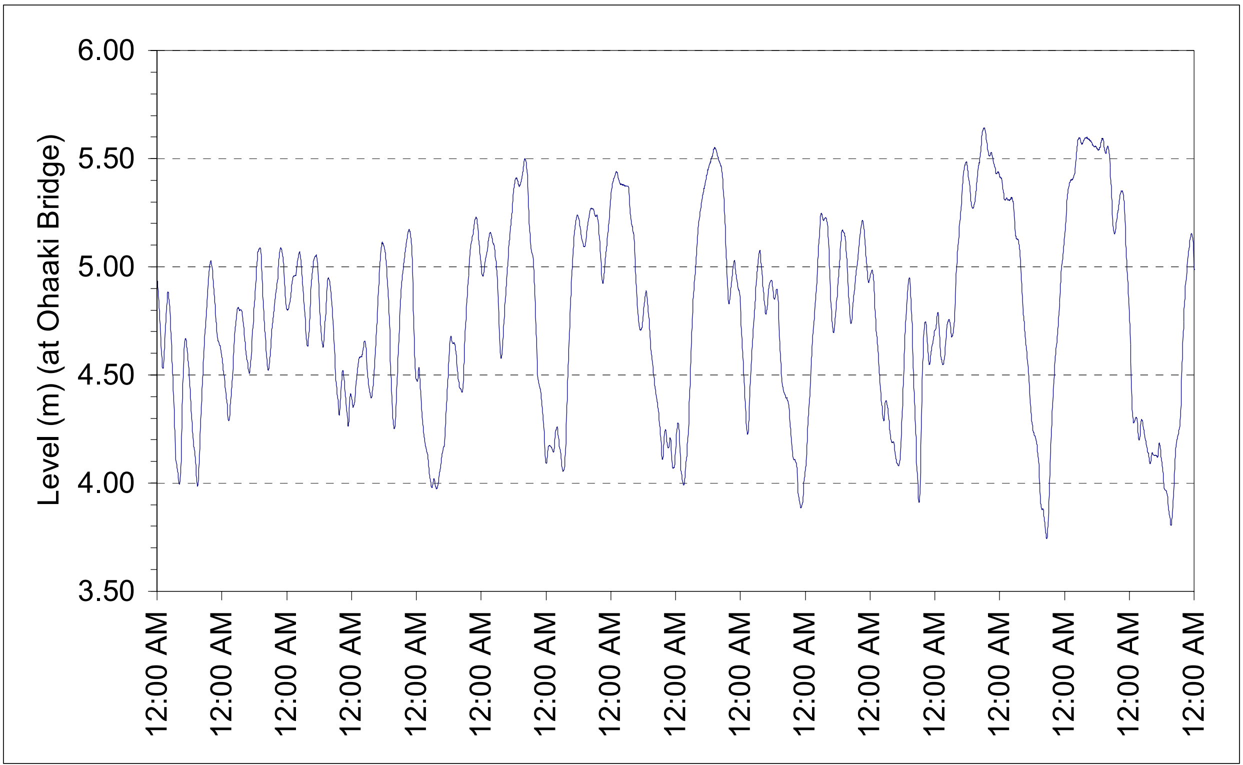

Figure 9: Waikato River level fluctuations at Ohaaki from 12.01am on 3/2/01 to 11.59pm on 30/4/01.

6 DISCUSSION

6.1 Trout abundance

The Torepatutahi Stream was found to support a remarkable abundance of rainbow trout. The mean count of 398 trout per km from the Torepatutahi Stream was far higher than those reported in the Eastern Fish and Game Council (EFGC) annual river monitoring program (pers. comm. R. Pitkethley). The average number of trout recorded in the EFGC monitoring program (5 rivers and 9 dive sites) was 23.4 trout per km (Table 9). Moreover, the highest estimate was 73 trout per km from the Ngamuwahine River, near Tauranga (Table 9).

Table 9. The abundance of trout recorded in 5 rivers (9 dive sites) in the Eastern Region summer/autumn drift diving program, 2001. (Drift dive data courtesy of EFGC).

River system	Trout per km
Waioeka lower	0.0
Waimana upper	4.0
Waimana middle	6.0
Waioeka upper	10.0
Opato River	22.4
Tarawera upper	24.3
Waioeka middle	33.0
Tarawera middle	37.8
Ngamuwahine	73.0
Torepatutahi Stream	**398**

There are a number of possible reasons for the high abundance of rainbow trout in the Torepatutahi Stream, these include; the year round stability of flow and temperature in the upper reaches, cold water refuge for Waikato River trout, excellent habitat for resident trout and a spawning and juvenile rearing stream for Waikato River trout. The relative significance of these potential reasons is discussed further below.

6.1.1 Cold water refuge

The Torepatutahi Stream has previously been suggested to be an important cold water refuge for Waikato River trout (Kusabs, 1996). Therefore, it is probable that the high densities of trout recorded in February and March are at least partially attributable to the movement of trout from the Waikato River into the cooler waters of the lower Torepatutahi Stream. However, a significant finding of this study was that trout remained present at high densities throughout the study period (February to April). Given the moderate water temperatures (≈17-19^{o}C) in the Waikato River in April, it is unlikely that the high trout density estimates in the Torepatutahi Stream obtained for April are entirely attributable to the cold water refuge hypothesis.

6.1.2 The Torepatutahi as habitat for trout

The Torepatutahi provides excellent habitat for all life-stages of trout. It has a stable flow of cool clean water, abundant macrophyte beds and low densities of predators. Moreover, the Torepatutahi Stream is known to support a moderate density (38 trout per km) of trout in the upper reaches (Kusabs, 1996). The high trout estimates recorded in the lower Torepatutahi are likely to be due to an abundant resident population of trout.

Stable flow regime

The geology of the central volcanic plateau has a profound influence on the hydrology of the Torepatutahi Stream. The ignimbrite and pumice plains on the Kaingaroa Plateau absorb excessive precipitation and prevent severe flooding. Furthermore, much of this water emerges as springs providing a stable flow of cool, clean water.

Because of behavioural differences between the two species rainbow trout are more severely impacted by floods than brown trout. Rainbow trout are often associated with open water about mid-way in the water column whereas brown trout are usually associated with in-stream cover and this was the case during this study. It is postulated that brown trout are better able to survive floods as they can more easily occupy positions that provide stable cover throughout a flood. Whereas rainbow trout are less able to find shelter and are displaced downstream. These behavioural differences were also evident in the Torepatutahi Stream and consequently, the very stable flow regime may explain the high density of rainbow trout.

Extensive macrophyte beds

Extensive beds of *Elodea canadensis* and *Lagarosiphon major* were present throughout the Torepatutahi Stream. These aquatic plants provide food, substrate and cover for stream invertebrates which are the main food source for trout in the Torepatutahi Stream (Mitchell, 1995). Given the lack of any stable bed substrate over the majority of the lower stream, it is likely that these macrophytes are the main source of invertebrate food in the stream. The maintenance of these macrophyte beds is therefore very important to the continued use of this stream as a trout habitat.

6.1.3 Trout spawning and juvenile rearing habitat

Trout populations are known to be highly variable in both time and space (Platts & Nelson, 1988). Seasonal changes in trout abundance are common, as trout are known to undertake extensive migrations for spawning, feeding and rearing. However, little is known about the movements of trout in the Torepatutahi Stream.

It is likely that the upper Torepatutahi Stream (Plateau Road) with its more stable gravel substrate, cool water temperatures, and near constant flow regime provides important spawning and juvenile rearing habitat for resident and Waikato River trout. Any significant changes in temperature or flow regime in this wide, shallow stream reach could significantly reduce its value to these fish.

The lower Torepatutahi Stream is functioning as a 'transitional' section of river - one through which maturing trout move on their way to upstream spawning grounds and through which juvenile trout move downstream in search of more suitable adult habitats. This would account for the high numbers of fingerling and small rainbow trout present in February and March, as well as the presence of large, maturing trout in late March and April.

6.2 Water Abstraction and River level fluctuations

A significant finding of this study was that trout were far more abundant in the Torepatutahi Stream, than in the cold water plume at its confluence with the Waikato River. Therefore, it is proposed that future water abstractions are more likely to impact trout in the upper and mid reaches of the Torepatutahi Stream than in the cold water plume in the Waikato River.

The water level and flow regime in the lower Torepatutahi Stream was heavily influenced by hydroelectric manipulation of the Waikato River, which resulted in daily fluctuations in water levels of up to 1.5 meters at the confluence of the two water ways. It is notable that these fluctuations in river and stream level did not affect the temperature of the Torepatutahi Stream above the Vaile Road bridge which remained relatively stable throughout the study period.

Apart from a “natural” gradual increase in average water temperature from the upper to lower reaches, the only significant temperature change in the Torepatutahi Stream appears to occur as a result of its confluence with the Rautawiri Stream which was consistently 2 - 4 °C warmer than the Torepatutahi. It is notable that the diurnal temperature range in the Rautawiri (Earle Road bridge – Appendix 1) was larger than that of the Torepatutahi Stream despite also being primarily spring fed. Some of this effect may be due to the absence of significant riparian vegetation and bank shading in the mid to lower reaches of the stream.

6.2.1 Mixing Zone and Cold Water Plume

Observation of the interaction between the Waikato River and the Lower Torepatutahi Stream revealed that when the Waikato River was low, the lower Torepatutahi Stream became narrow, water velocity increased and the stream was confined between the extensive aquatic macrophyte beds along the stream margins.

During these periods of low river level and increase local water velocity in the lower Torepatutahi Stream it was also noted that there was no defined cold water plume at the confluence with the Waikato River. Instead the divers experienced an eddying effect where lenses of cold water were interspersed with the warmer water of the Waikato and mixing occurred within a relatively short distance.

In contrast to this, when the Waikato River was high, the Torepatutahi Stream was substantially wider with complete submergence of the aquatic macrophyte beds. Higher water levels and interference by marginal macrophyte beds caused flows in the stream to be slower and reduced mixing of the colder water with the Waikato River. As a consequence, there was much more likely to be a cold water plume along the true right bank of the Waikato River during periods of high water level than there was during periods of low level.

These observations indicate that effects on the cold water plume in the Waikato River resulting from current water abstractions in the Torepatutahi Stream are insignificant in comparison to the extensive changes to the plume as a result of water level fluctuations in the Waikato River.

6.2.2 Water Level Effects

The greatest impact of future water abstractions is likely to be on the shallow stream margins and surrounding wetlands in the mid to upper reaches of the stream. Little is known about the ecology or hydrology of these stream margins and wetlands. Phillips (2000) hypothesised that there are a large number of springs interspersed throughout the wetlands and that as a consequence they are not reliant on flooding from the Torepatutahi Stream to maintain water levels. However, the presence and size of these springs has not been confirmed. Consequently, any level changes induced by further abstraction must be placed in the context of maintaining water levels in the wetlands with the assumption that their maintenance requires inundation from the stream.

If the springs did prove to be self sustaining in terms of water levels, inundation by the stream would still be required in order to allow juvenile trout and bullies access to and from these areas, however, it may not be necessary to maintain this level at all times and a greater level of abstraction from the stream may be possible.

Flow gauging data and cross sectional data taken from Phillips (2000) and Waikato Regional Council records indicates that at Q_5 flow, increases in abstraction from the current 12% of Q_5 at Broadlands Road bridge would result in the following further reductions in stream level:

- 15% = a flow of 3.36 m^3/s and a further level reduction of approximately 7 cm
- 20% = a flow of 3.16 m^3/s and a further level reduction of approximately 13 cm
- 30% = a flow of 2.77 m^3/s and a further level reduction of approximately 24 cm

Given a probable daily fluctuation of up to 7 cm as a result of Waikato River level further changes in the daily stream level range relative to the present situation at Q_5 flows at each of the allocation levels above are therefore:

- 0-14cm,
- 6-20cm and
- 17-31cm.

7 CONCLUSIONS AND RECOMMENDATIONS

- This study provides valuable baseline data on the trout population in the lower Torepatutahi Stream and it's confluence with the Waikato River. The lower Torepatutahi Stream was found to support a remarkably high abundance of trout. Moreover, trout were present at high densities throughout the study period, from February to April.

- The abundant trout population in the Torepatutahi Stream is likely to be due to a combination of the following: (1) it is used as a cold water refuge for Waikato River trout (2) it provides excellent habitat for resident trout and (3), it is an important spawning and juvenile rearing habitat for Waikato River trout.

- Water level fluctuations in the Waikato River significantly alter the water level in the lower Torepatutahi Stream but have little or no effect on water temperatures. However, these level fluctuations change the mixing regime at the confluence of the two water bodies and, during low level periods, significantly reduce the size and extent of the cold water plume in the Waikato River. The fact that these low level periods, and consequent plume loss, generally coincide with the warmer period of each day may account for the heavy reliance of trout on the lower Torepatutahi Stream rather than the Waikato River confluence, for cold water refuge.

- The Rautawiri Stream is significantly warmer than the Torepatutahi Stream and appears to account for a large portion of the 3°C temperature rise between the Plateau Road and Broadlands Road bridges on the Torepatutahi Stream. Future options for mitigating temperature effects on the Torepatutahi Stream may instead be better directed at reducing temperatures in the Rautawiri Stream.

- It is difficult to predict the effects of future water abstractions on trout in the lower Torepatutahi Stream and Waikato River. Nevertheless, it is proposed that, relative to the effects of river fluctuations, any effects associated with moderate future water abstractions from the Torepatutahi Stream on trout in the Waikato River and cold water plume area will be no more than minor.

- The effect of future water abstractions on the stream margins and surrounding wetlands in the mid reaches of the Torepatutahi Stream is the major ecological effect to be considered. Little is known about the ecology of these habitats and their importance to the trout population. However it is considered that any increase in abstraction is likely to result in a reduction in the frequency with which the entire current wetland area is inundated. At worst this could result in an increased invasion of grey willow and a loss of permanent wetland area. At best it may prove that the wetland area is independently spring fed and will suffer no adverse effect from the loss of inundation from the main stream.

- It is suggested that, while there is little information on these wetland areas an increase in abstraction to 15% of Q_5 would have no significant adverse effect. Even with the current Waikato River level fluctuations the wetland area would be entirely inundated during high river levels and the extreme low would only occur in years when Q_5 conditions corresponded to high summer irrigation demand. Due to the delay of 34 months between low summer rainfall and low flow events this situation is unlikely to occur again until approximately 2013.

- The reach of the Torepatutahi Stream upstream of the spring area between Plateau Road Bridge and the Otonga Stream (approximately NZMS 260 U17: 053-950) is a wide shallow channel with coarse gravel's and excellent trout spawning and juvenile habitat. Because of this shallow nature any reductions in stream flow would result in significant losses of water depth and in-stream habitat. Consequently it is recommended that no further abstraction of water be permitted in this reach.

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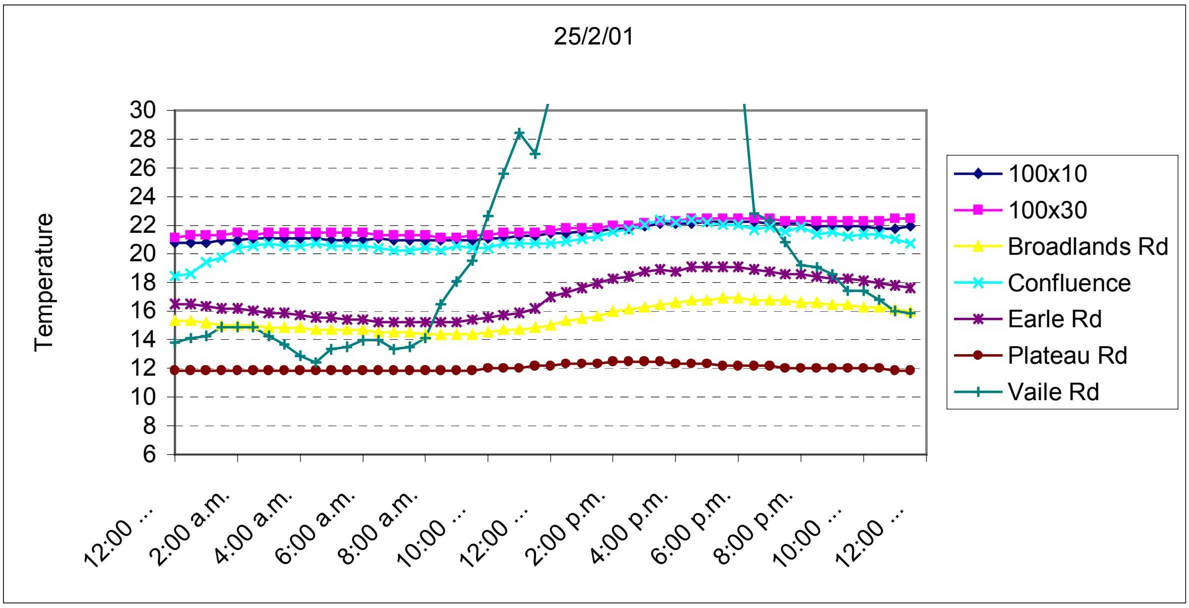
Appendix 1: River and Stream Temperatures



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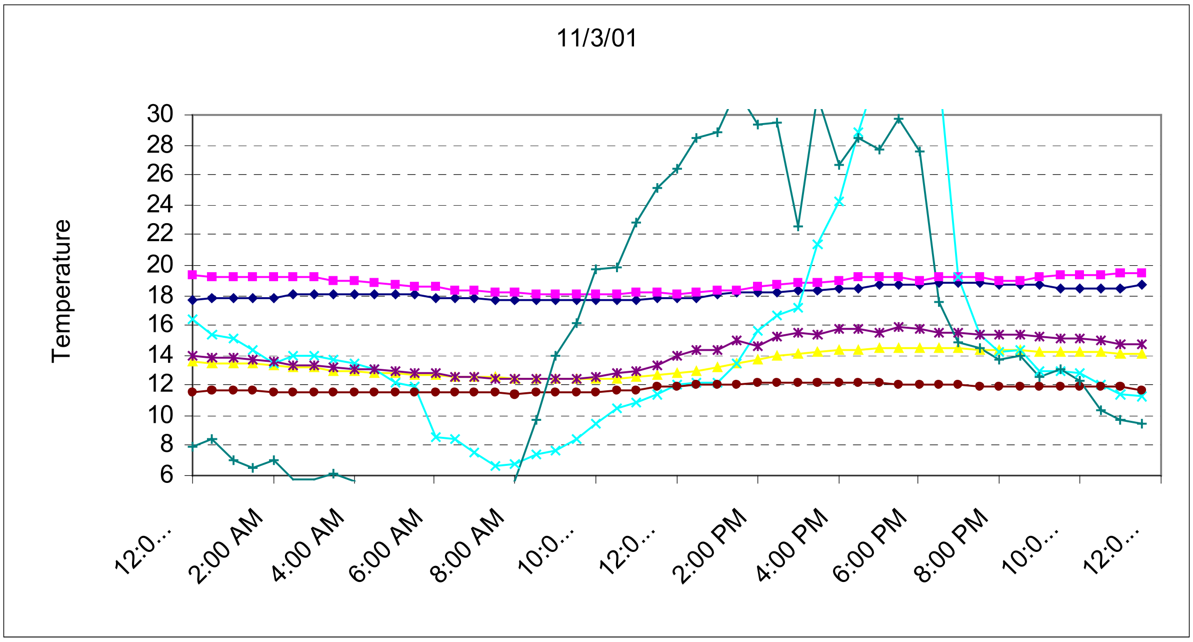

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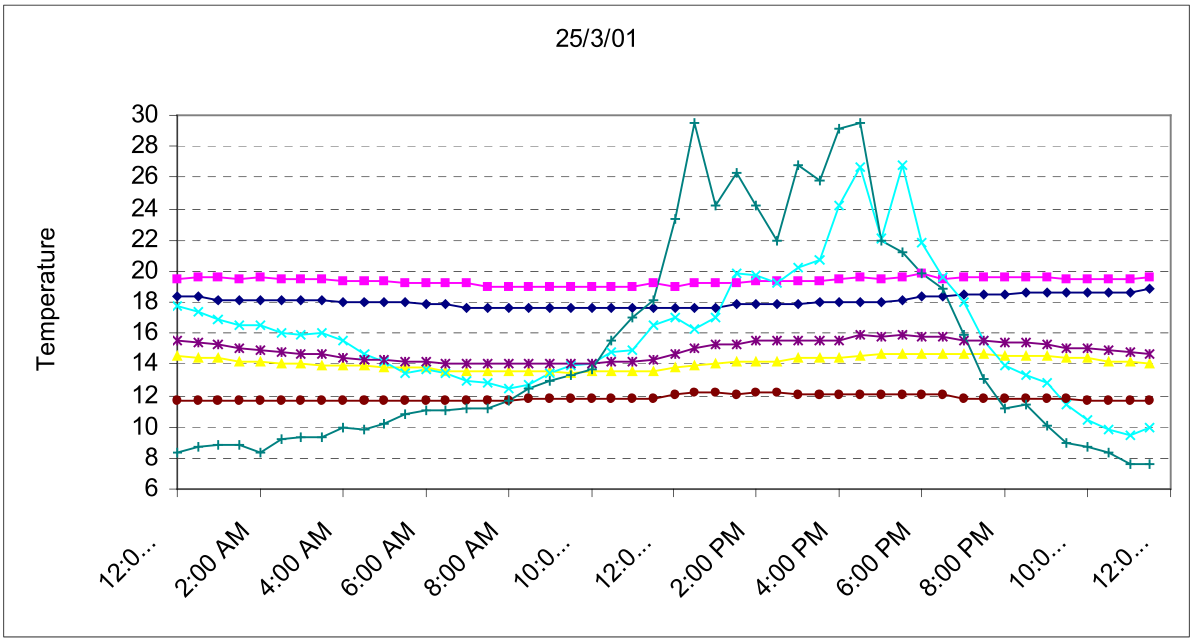

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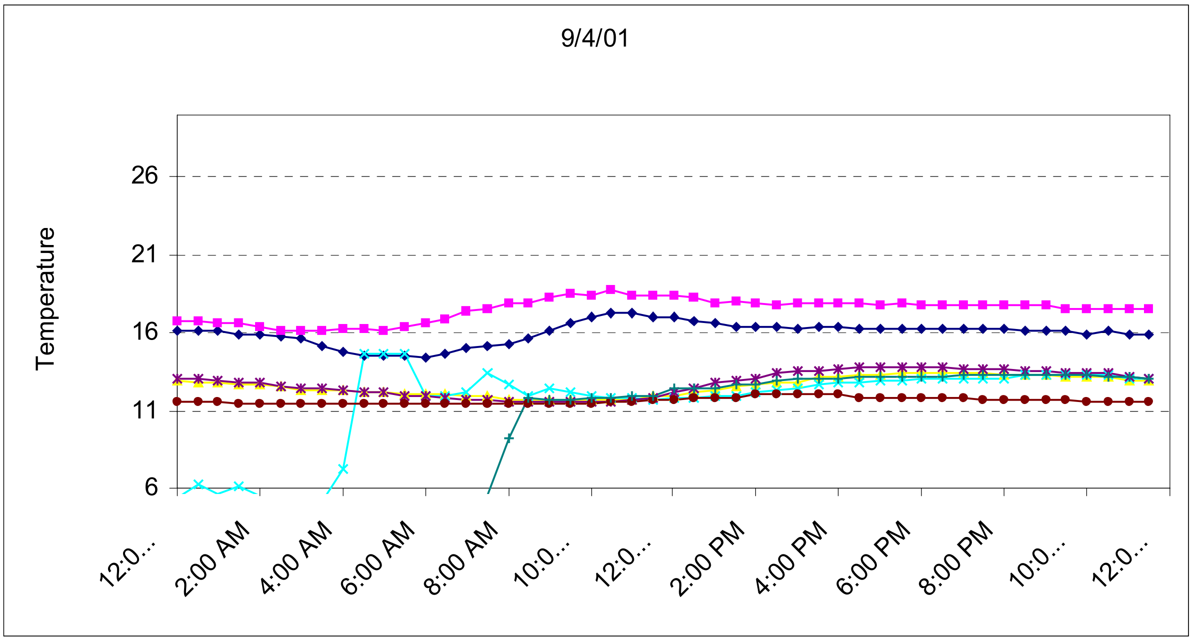

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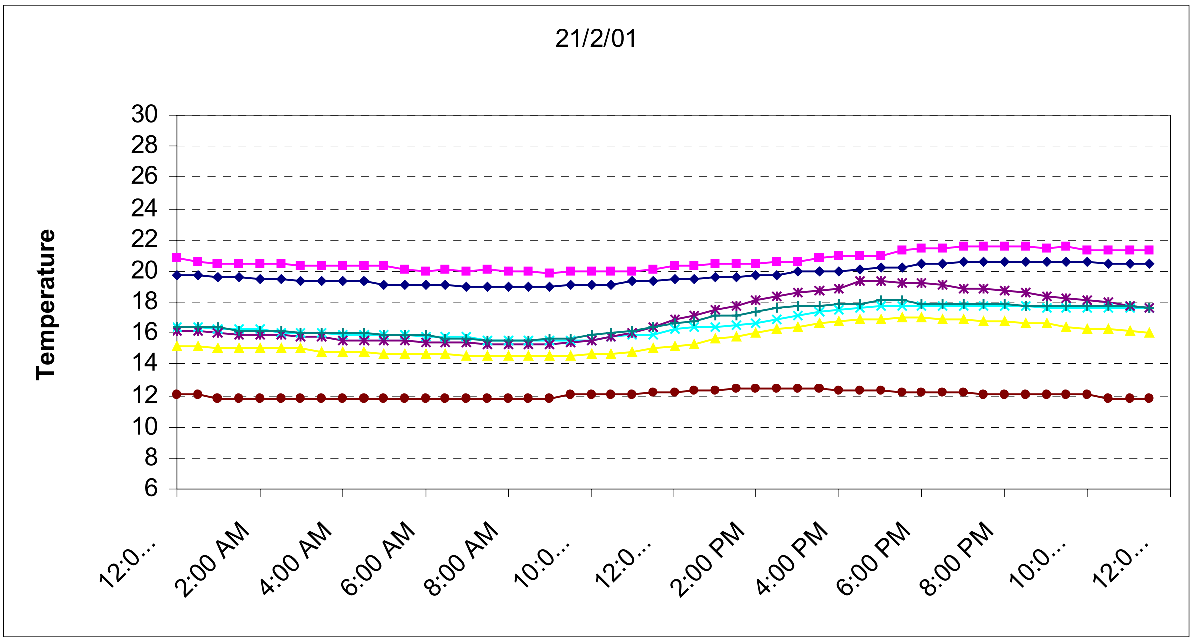
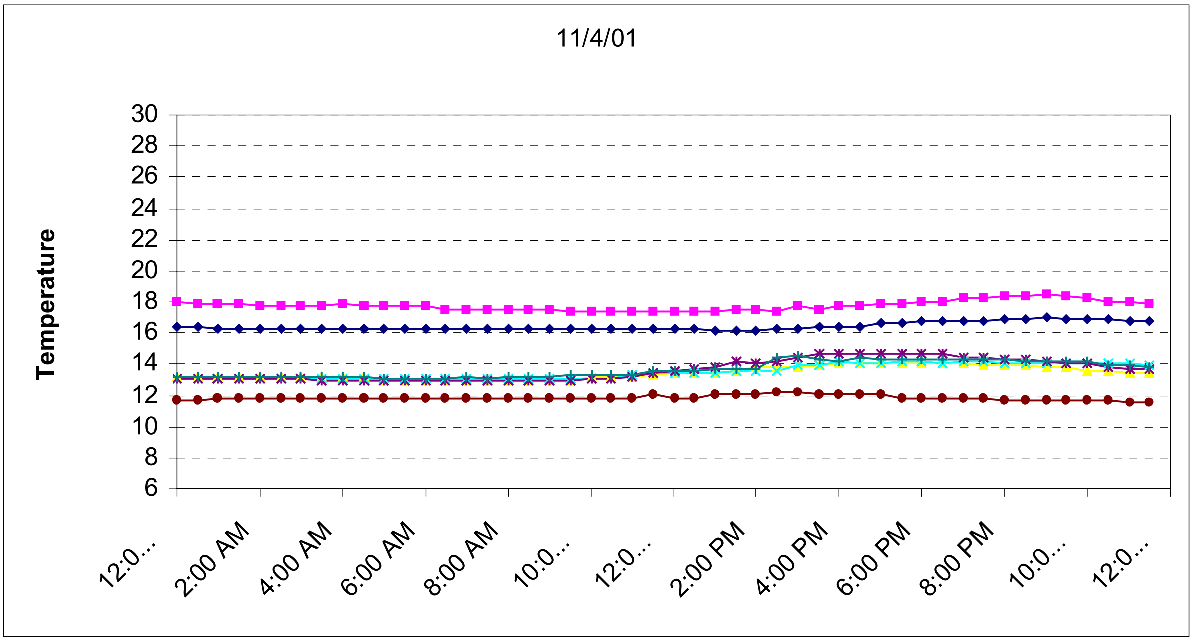


No Irrigation Take Day 1



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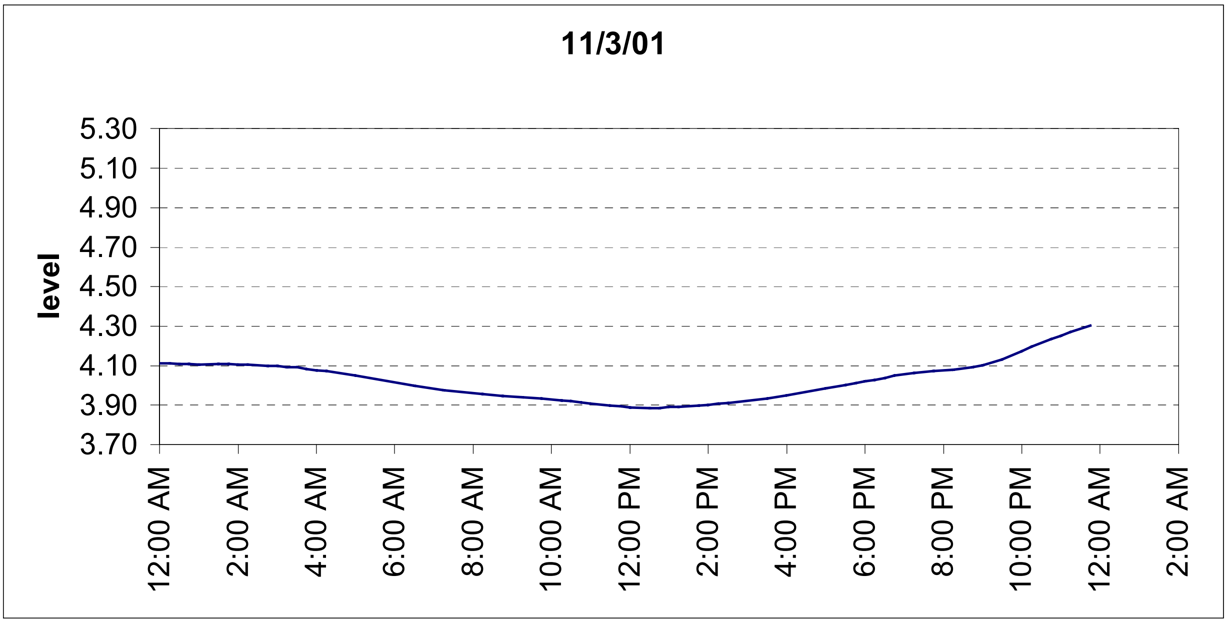
Appendix 2: Waikato River Levels



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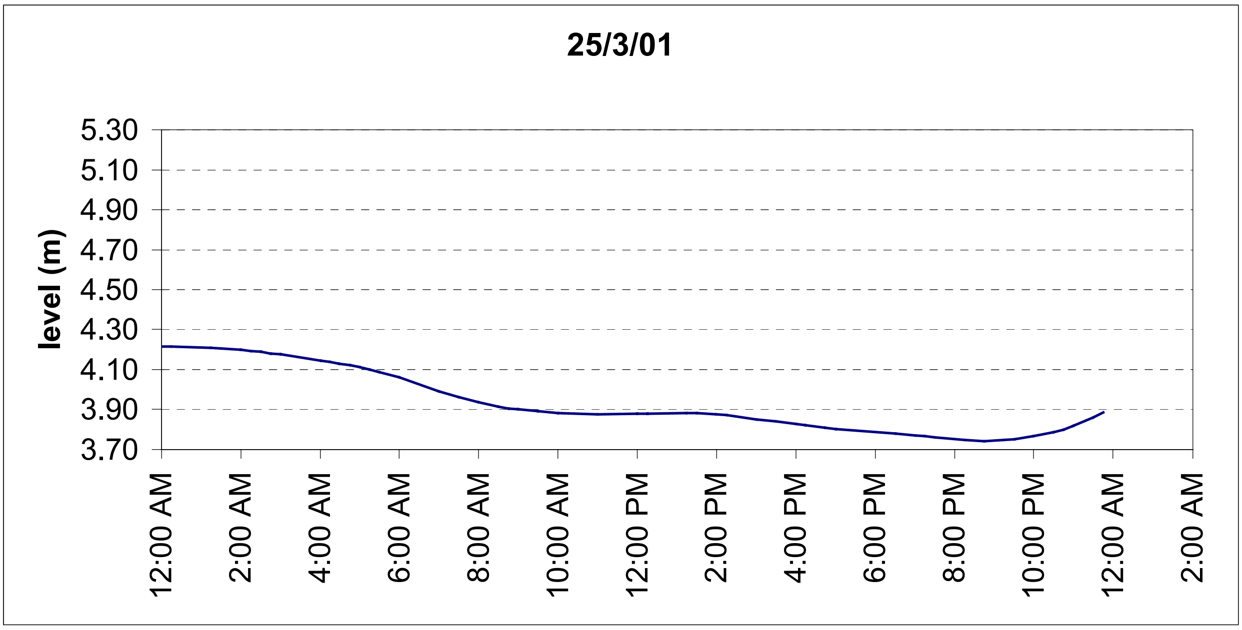

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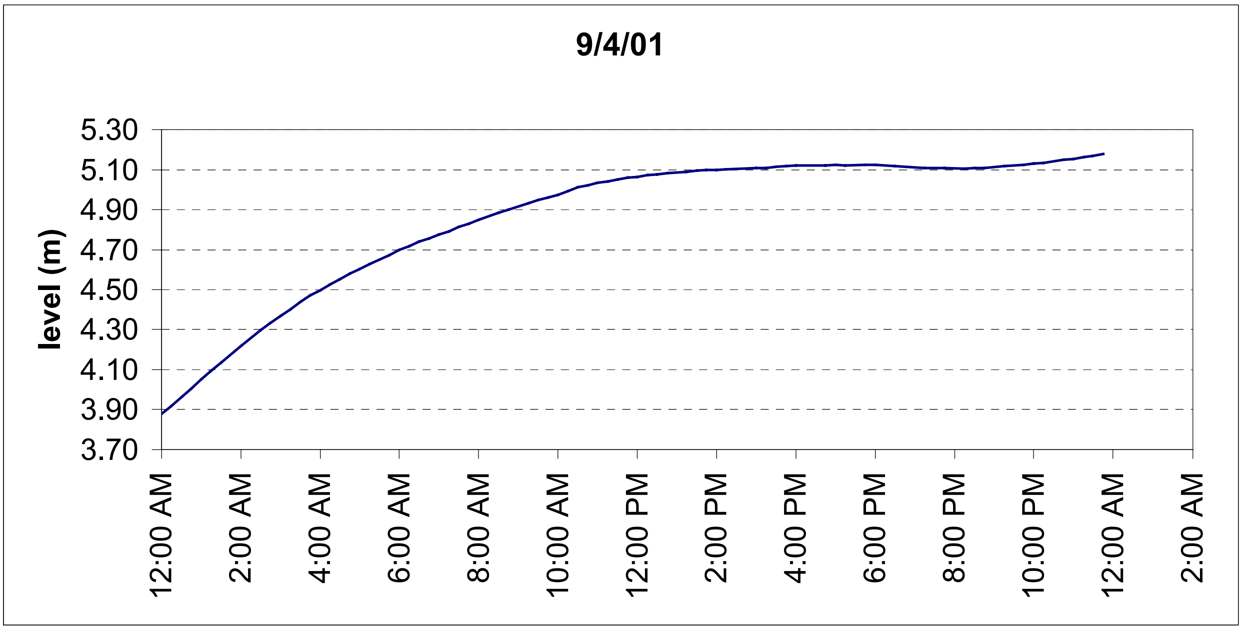

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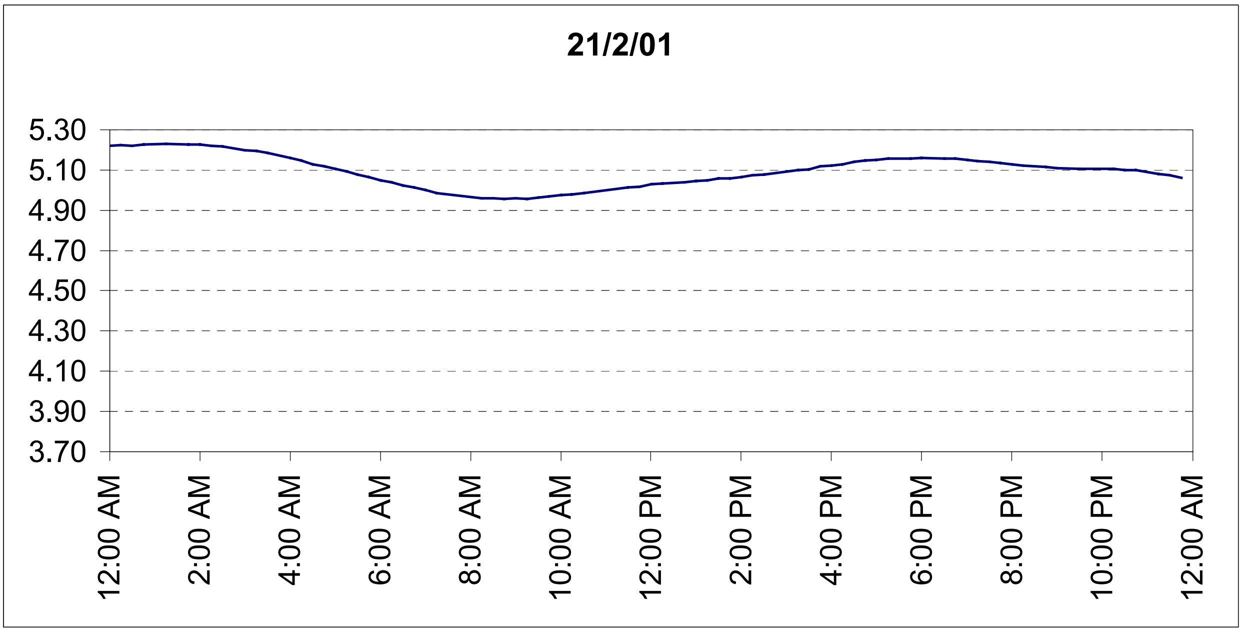

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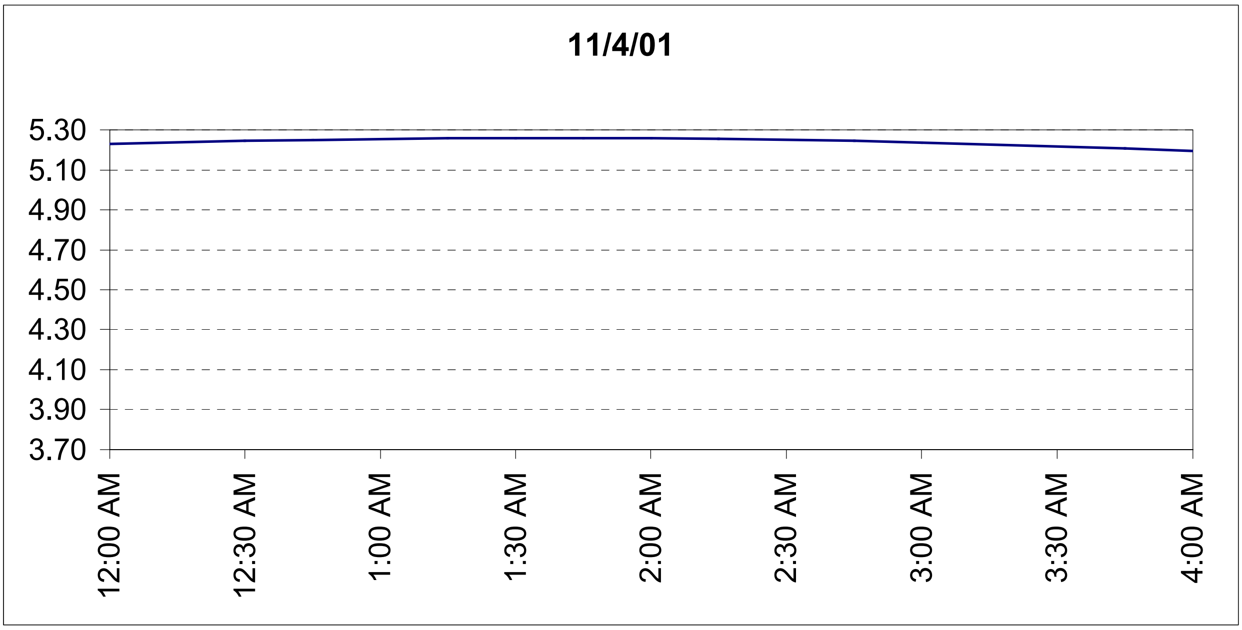

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