Instream flow assessment for Papawai Stream

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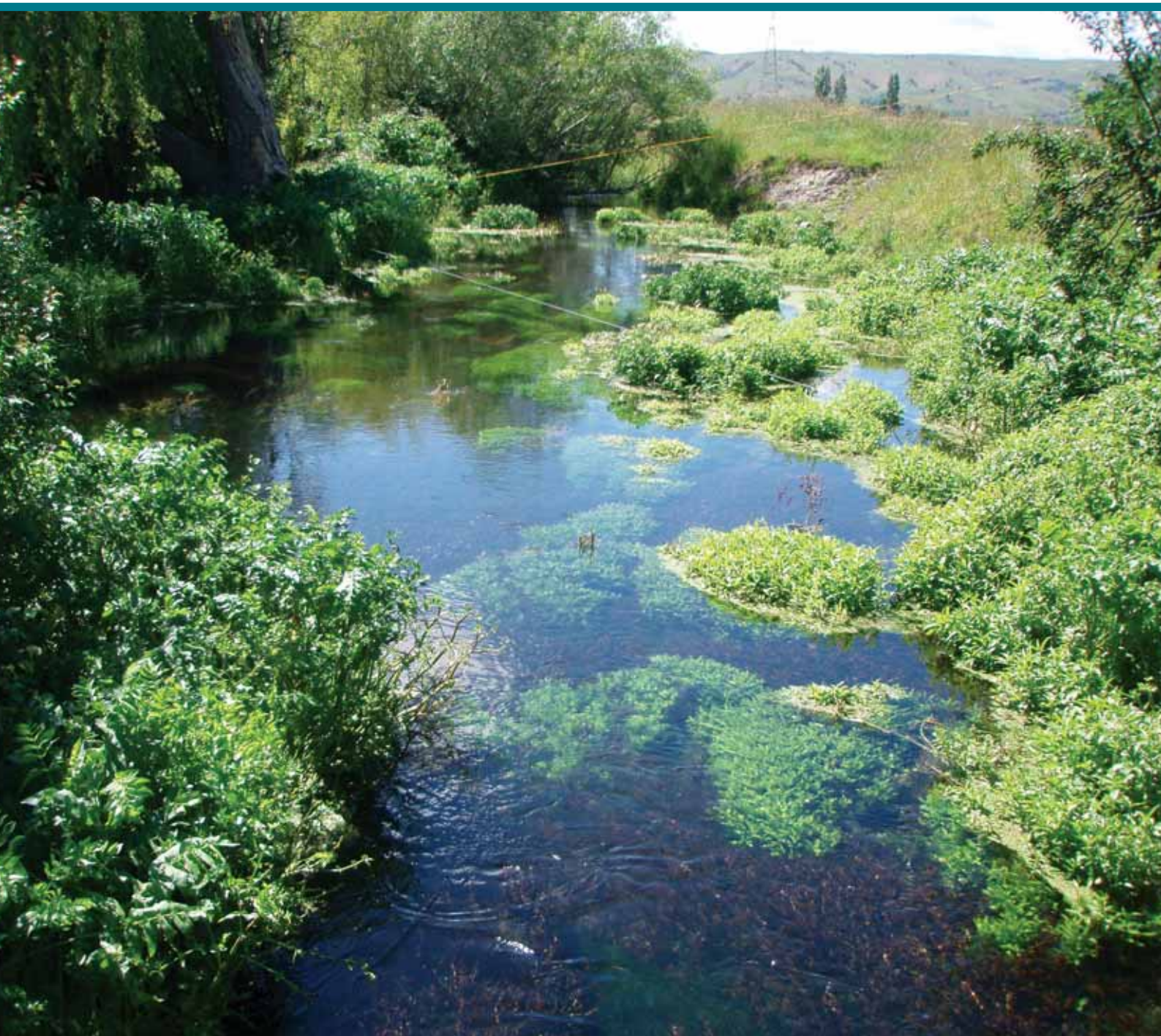

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Instream flow assessment for Papawai Stream

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Executive summary

This report investigates flow requirements for sustaining key 'instream' values of the Papawai Stream and its tributary, Tilson's Creek, to aid in proposing minimum flow and water allocation policies for the catchment. Currently there is no minimum flow for this catchment specified in the Regional Freshwater Plan.

The ecological, recreational and cultural instream values of Papawai Stream and Tilson's Creek have been degraded due to factors such as excessive accumulation of fine sediment on the streambeds, the dominance of aquatic macrophytes and restriction of flow by crack willow, and reduced water quality (due to rural runoff, urban stormwater, and treated wastewater entering the stream). Despite these factors, the Papawai Stream has important values due to its historical significance, potential recreational use, and population of longfin eel. The stream also supports other fish populations, such as brown trout, and there may be giant kokopu (a threatened species of native fish) present.

There is a high demand for water from the Papawai catchment, and at times water takes (both from the streams and from connected groundwater systems) may be reducing flows by considerably more than 50%. Given the instream values, it is important that appropriate minimum flows are set for Papawai Stream and Tilson's Creek, below which consented water abstractions should cease.

Analysis was carried out to determine minimum flows for achieving three instream flow objectives: to protect longfin eel habitat, to maintain dissolved oxygen above aquatic ecosystem guidelines, and to ensure flows are sufficient for recreational use (particularly for swimming at the Papawai Marae swimming hole). A minimum flow of 80% of the 1-day MALF is expected to achieve the instream flow objectives. This equates to a flow of 160 L/s in the Papawai Stream above the Tilson's Creek confluence and 110 L/s in Tilson's Creek at Tilson's Road.

In addition to these suggested minimum flows, a number of recommendations are made relating to future water management policies for Papawai Stream and Tilson's Creek, for assessing resource consent applications to take water from the catchment, and for ongoing monitoring. In particular, it is recommended that:

- Environmental monitoring, both of stream flows and dissolved oxygen, continues;
- Continuous monitoring of consent abstractions is implemented;
- A core allocation is set that applies to both direct water takes from the stream and groundwater takes that are shown to reduce stream flows; and
- Clear policies are developed for managing groundwater takes that result in stream flow depletion.

Additional recommendations relating to reducing the instantaneous water allocation, or for reducing the impacts of a large core allocation, are made.

Contents

Executive summary **i**

1. Introduction **1**

2. Characteristics of Papawai Stream and its catchment **2**
2.1 Channel characteristics 2
2.2 Hydrology and hydrogeology 4
2.3 Low flow characteristics of Papawai Stream and Tilson's Creek 5
2.4 Water quality 6

3. Water abstraction from Papawai Stream and Tilson's Creek **10**

4. Instream values of Papawai Stream and Tilson's Creek **12**
4.1 Ecological values 12
4.2 Cultural values 14

5. Setting a minimum flow to protect instream values **16**
5.1 Instream flow objectives 16
5.2 Flows for protecting longfin eel habitat 16
5.3 Flows for achieving dissolved oxygen guidelines 18
5.4 Flows for protecting recreational values 22

6. Considerations for water management and monitoring **24**
6.1 Minimum flows 24
6.2 Core allocation 24
6.3 Environmental monitoring 25
6.4 Monitoring water use 25
6.5 Managing groundwater use in connected aquifers 26

7. Conclusions and recommendations **27**
7.1 Recommendations 27

8. References **29**

Acknowledgements **31**

Appendix 1: Naturalised flow records for Papawai Stream **32**

1. Introduction

This report investigates flow requirements for sustaining key 'instream' values of the Papawai Stream and its tributary Tilson's Creek. Instream values are the values relating to a river or stream's environment, and include ecological, recreational and Maori cultural values.

The Papawai Stream and Tilson's Creek are under pressure from water abstraction, both directly from the stream and from surrounding groundwater systems that are connected to the stream. However, there is no core allocation or minimum flow for the streams in Greater Wellington's Regional Freshwater Plan (RFP) (Wellington Regional Council 1999). A 'capped allocation limit' was applied to the streams in Plan Change 3 to the RFP in 2007, to prevent further allocation of water until appropriate policies have been developed.

A review of the RFP is commencing in 2009/10. This will include the proposal of policies relating to water allocation and minimum flows for many rivers and streams in the Wellington region. Knowledge of the instream values, and flow requirements for protecting those values, is important for proposing such policies. The information gathered for this report will therefore be taken into consideration when a new RFP is proposed.

The report contains:

- A background description of the characteristics of Papawai Stream and Tilson's Creek;
- Information on consented water abstraction from the streams;
- An assessment of the instream values;
- An assessment of minimum flow requirements to achieve objectives that relate to the key instream values (known as an 'instream flow assessment'); and
- Recommendations relating to water allocation and minimum flow policies for the streams.

2. Characteristics of Papawai Stream and its catchment

The Papawai Stream rises from springs, immediately south-east of Greytown. Two main springs join together to form the main stem of the Papawai Stream, a short distance upstream of Fabians Road. The stream is also fed by minor tail races of the Moroa Water Race in this vicinity. Downstream of Fabians Road the stream flows in a south-easterly direction towards the Ruamahanga River. At Papawai Road it is joined by a major tributary, Tilson's Creek, which rises from a spring along Jellicoe Street to the east of Greytown. Downstream of the Tilson's Creek confluence, the Papawai Stream receives treated wastewater from the Greytown oxidation ponds. The stream then flows for a further 1.4 km to its confluence with the Ruamahanga River (Figure 2.1). The total length of Papawai Stream is approximately 6 kilometres, and Tilson's Creek is about 4 kilometres to its confluence with Papawai Stream.

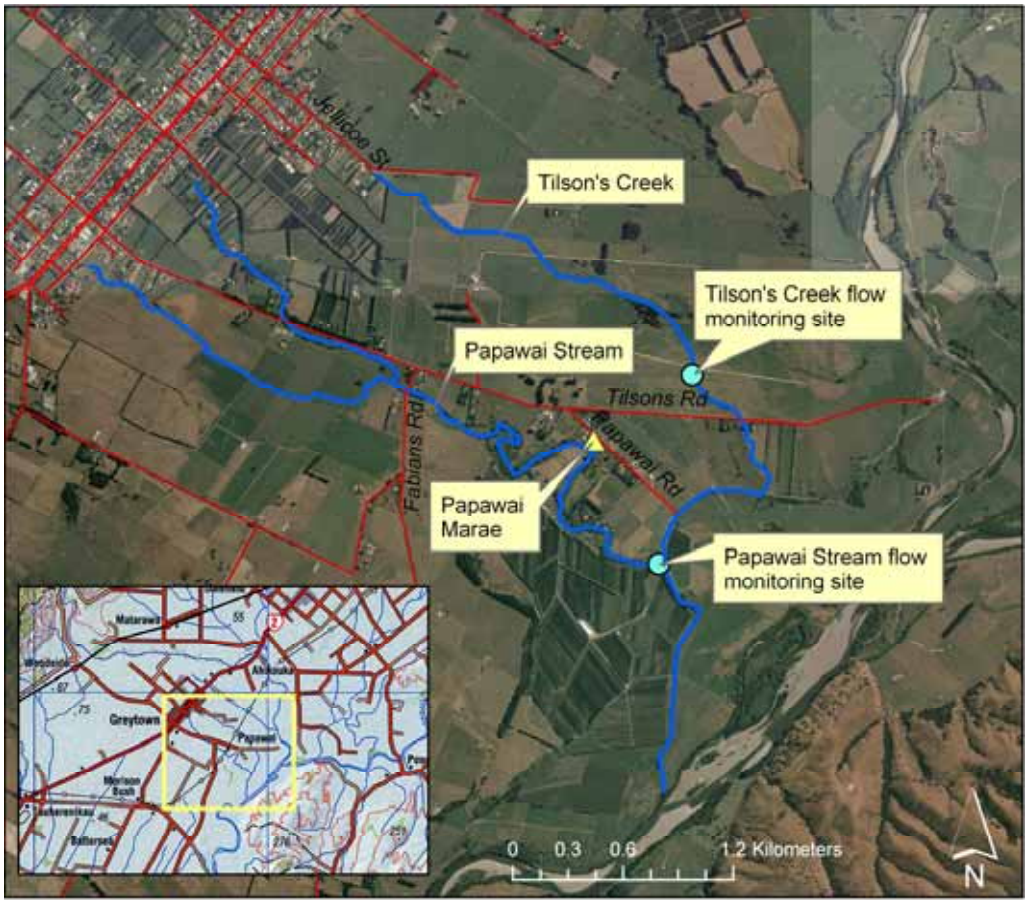

Figure 2.1: Location of Papawai Stream and its tributary, Tilson's Creek

The main land uses in the Papawai Stream catchment are dairy farming, pastoral farming, lifestyle blocks, a large orchard, and some cropping. The stream also flows through the low-intensity residential area of Papawai, which includes the Papawai Marae.

2.1 Channel characteristics

In their upper reaches, Papawai Stream and Tilson's Creek are generally lacking in riparian cover as they flow through farm land (Figure 2.2).

Downstream of Fabians Road, the Papawai Stream channel becomes deep and meandering, and is constricted by dense crack willow (although some willows have been removed and there are plans for further removal and stream bank revegetation). The willows and other riparian vegetation provide shade until a short distance upstream of Papawai Road.

Figure 2.2: Papawai Stream upstream of Fabians Road (top photo), and Tilson's Creek upstream of Tilson's Road (bottom photo)

Although the streams have a cobble base, in most places the stream beds are covered by a thick layer of fine sediment. The sediment is likely to accumulate as a result of bank erosion and stock access, and is not regularly flushed from the system due to the generally low variation in flow.

Papawai Stream and Tilson's Creek support a diverse range of submerged and emergent aquatic macrophytes (Figure 2.3). A survey at Papawai Road found 94% of the streambed was covered by macrophytes, including willow weed, sedge and rush (Kingett Mitchell 2006).

Figure 2.3: Papawai Stream looking downstream from Fabians Road, showing dense and diverse aquatic macrophytes

2.2 Hydrology and hydrogeology

The two main springs that join to form Papawai Stream at Fabians Road gain a significant amount of flow from groundwater in this area. There is a good hydraulic connection between the stream and the surrounding shallow groundwater system (which extends to a depth of approximately 10 metres). Downstream of Fabians Road the stream tends to gain flow, lose flow, or be fairly neutral depending on groundwater levels. For example, when groundwater levels are low, there appears to be a flow loss from the stream.

Tilson's Creek rises from a spring along Jellicoe Street to the east of Greytown. The creek gains flow from groundwater for the first 1.5 km. It joins the Papawai Stream about 1.4 km upstream of the confluence with the Ruamahanga River.

Flow in Papawai Stream is also affected by input from tail races of the Moroa Water Race, although it appears that during times of low flow this input is

extremely minor. During wet periods, stormwater from Greytown adds considerable flow to the Papawai Stream. This, along with runoff and increased groundwater recharge to the stream following significant rainfall, can result in occasional small 'freshes'. However, overall the stream flow is characteristic of a springfed stream with little variation compared to predominantly runoff-fed rivers and streams.

Greater Wellington operates a continuous flow monitoring site on the Papawai Stream immediately upstream of the Tilson's Creek confluence, and on Tilson's Creek about 1.7 km upstream of the Papawai Stream confluence (see Figure 2.1). These monitoring sites were installed in late 2005, primarily for the purpose of investigating low flow characteristics. Due to channel siltation and weed growth, the Tilson's Creek monitoring site record quality is relatively low. Flow records for both sites are affected by consented abstractions (details of which can be found in Section 3). As well as the collection of continuous flow data, numerous flow gaugings have been carried out at various locations in the catchment; notably of Papawai Stream at Fabians Road (which was historically used as the site for monitoring low flows for issuing water abstraction restrictions).

2.3 Low flow characteristics of Papawai Stream and Tilson's Creek

The available continuous flow records for Papawai Stream and Tilson's Creek are relatively short (approximately four years), and are affected by abstraction. In order to derive an accurate estimate of the mean annual low flow (MALF) of the Papawai Stream, the flow record was naturalised by removing the estimated impact of the consented abstractions[1]. Graphs of the naturalised records for the 2005 – 2009 irrigation seasons are contained in Appendix 1. The lowest 1-day average flows, both measured and naturalised, are shown in Table 2.1. On average during the years 2005 – 2009 the measured lowest flows are about 40% of the estimated naturalised lowest flows, indicating that abstraction may be reducing the stream flow by considerably more than one half at times.

Table 2.1: Measured and naturalised 1-day lowest mean flows in the Papawai Stream above Tilson's Creek, 2005-2009

Year	Measured 1-day lowest mean flow (L/s)	Estimated natural 1-day lowest mean flow (L/s)
2005/06	42	175
2006/07	95	180
2007/08	51	130
2008/09	70	145

To derive an estimate of the long-term MALF, a correlation was developed between the naturalised Papawai Stream flow record and the groundwater level

[1] The take WAR930087 is obvious in the stream flow records, and can therefore easily be accounted for. The groundwater take WAR030132 has a delayed impact on the stream and is not so obvious. It was accounted for by comparing records from the Greater Wellington groundwater monitoring site S27/0225, located on the same property, to the Papawai Stream flow records.

record from Greater Wellington's monitoring site 'Greytown Groundwater Zone at Perry'[2]. The correlation was then used to synthesise a flow record for the Papawai Stream for the period 1990-2005. Combining this with the 2005-2009 measured record gives a MALF (1-day duration) for 1990-2009 of 202 L/s. Given that the correlation with the groundwater level records was not particularly good ($r^2 = 0.51$), it is acknowledged that the final MALF estimate contains some uncertainty. However, it is consistent with previous work to estimate the stream's MALF upstream of the Tilson's Creek confluence (Butcher 2007), and current investigations into outflows from the Greytown shallow aquifer (McAlister & Gyopari, in press).

The Tilson's Creek flow record is similarly short (2005-2009) and is affected by groundwater abstraction and build-up and clearance of weed. Because of the large impact of channel weed it is very difficult to naturalise the flow record. Butcher (2007) estimated the MALF of Tilson's Creek at Tilson's Road (a short distance downstream of Scott Culvert) to be 135 L/s, and this estimate has been adopted for this study. Concurrent gaugings indicate that, in the absence of water abstraction, there are no significant losses or gains between Tilson's Road and the Papawai Stream confluence.

The estimated 1-day MALF statistics for the Papawai Stream catchment are shown in Table 2.2.

Table 2.2: Estimated 1-day mean annual low flow statistics for various locations in the Papawai Stream catchment

Location	1-day MALF (L/s)
Papawai Stream above Tilson's Creek	200
Tilson's Creek at Scott Culvert	135
Tilson's Creek above Papawai Stream	140
Papawai Stream at confluence	340

2.4 Water quality

Greater Wellington does not conduct any routine water quality monitoring of Papawai Stream or Tilson's Creek. Monthly water sampling was carried out upstream and downstream of the Greytown wastewater discharge, but this ceased when the current discharge permit was granted in 2001. Since that time, South Wairarapa District Council (SWDC) has carried out water quality monitoring as a condition of their resource consent for the discharge; this requires biannual water samples to be taken from Tilson's Creek, Papawai Stream upstream and downstream of the Tilson's Creek confluence, and downstream of the oxidation pond discharge. The samples are analysed for pH, temperature, ammoniacal nitrogen, dissolved reactive phosphorus, and *E. coli*. Macroinvertebrate monitoring at these locations is also carried out twice a year; these results are discussed in Section 4.

[2] Because the Papawai Stream is primarily spring-fed, the flow record is likely to correlate with groundwater level records.

The water quality results collected by SWDC (Coffey 2007a, Coffey 2007b, Coffey 2008) are of limited use for characterising the streams because sampling is only conducted twice per year. In addition, the upstream sampling locations have varied. However, bearing these limitations in mind, the results indicate that:

- At times, breaches of the ANZECC (2000) guidelines[3] for ammoniacal nitrogen and dissolved reactive phosphorus concentrations occur, in both the Papawai Stream and Tilson's Creek;

- The stream had elevated *E. coli* counts, in the range 180 – 450 cfu/100 mL over the years 2006-2008. Counts in this range exceed the guideline value (<100 cfu/100 mL) for stock drinking water (ANZECC 2000) and fall within the 'alert' range for contact recreation (Ministry for the Environment and Ministry of Health 2003);

- Tilson's Creek has poorer water quality than the main stem of the Papawai Stream, based on both nutrient and aquatic macroinvertebrate community monitoring[4].

As part of this instream flow assessment, Greater Wellington has been carrying out continuous monitoring of dissolved oxygen concentrations and temperature of the Papawai Stream, at the flow monitoring site above the confluence with Tilson's Creek. Monitoring commenced in January 2007. Some temporary water temperature monitoring was also conducted in Tilson's Creek (at the flow monitoring site 'Scott Culvert') from November 2008 to the end of January 2009.

Continuous monitoring shows that water temperature in the Papawai Stream displays a diurnal variation, with peak temperatures tending to occur between 4 pm and 6 pm. During the December to February period, the maximum daily water temperature was found to frequently exceed 20°C, although it did not reach the incipient lethal temperature for brown trout of 24.7°C (Hay 2008).

Although water temperature records for Tilson's Creek are shorter than those for the Papawai Stream, within the overlapping period of record the daily maximum water temperatures are similar to those observed for the Papawai Stream (Figure 2.4). In January the temperature frequently exceeded 20°C, and the highest recorded temperature was 21°C. Comparison of the water temperature records with air temperature recorded at Wairarapa College (Masterton) suggests that water temperatures in the streams are strongly related to air temperatures (Figure 2.4). However, low flows may exacerbate the water temperatures during the peak summer months.

[3] The guidelines are actually "trigger values" representative of what typical New Zealand lowland streams would meet: ammoniacal nitrogen <0.021 mg/L, dissolved reactive phosphorus <0.01 mg/L. (from Table 3.3.10 of ANZECC (2000)).

[4] It is not possible to thoroughly analyse the differences in water quality between Papawai Stream and Tilson's Creek, because the sampling sites upstream of the confluence were removed from the SWDC sampling programme in 2008, and replaced with a single 'upstream of SWDC discharge' site.

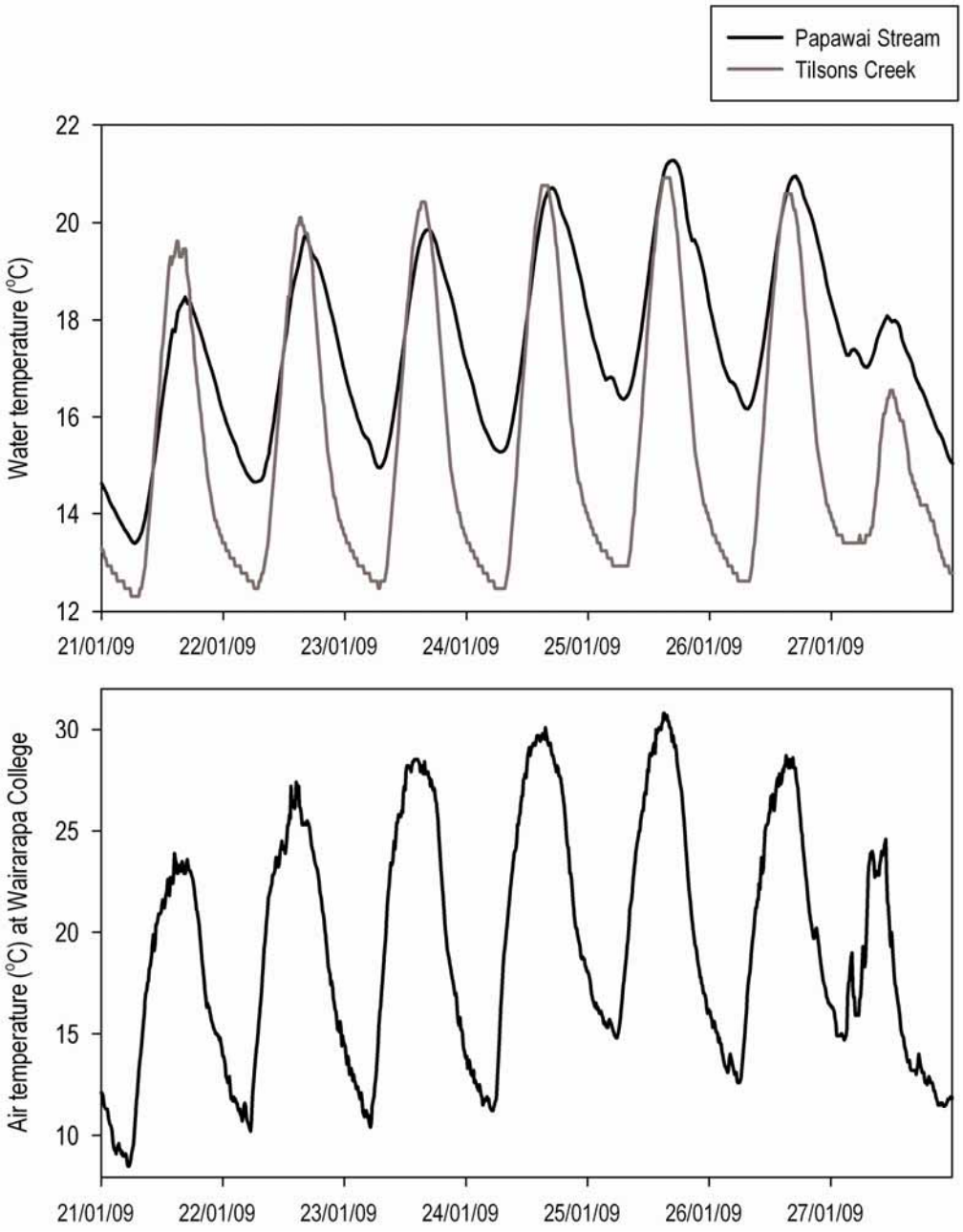

Figure 2.4: Water temperature in Papawai Stream above Tilson's Creek confluence and Tilson's Creek at Scott Culvert, during a one week period in January 2009 (top graph), and air temperature recorded in Masterton at Wairarapa College over the same period (bottom graph)

Continuous monitoring of dissolved oxygen in Papawai Stream indicates that this parameter also displays a strong diurnal variation (Figure 2.5). The typical diurnal range in concentrations appears to be around 3.5 mg/L, with the peak occurring at about midday and the minimum at between about midnight and 3 am. The variation over 24 hours is related to the high amount of macrophyte growth in the Papawai Stream, which causes net photosynthetic oxygen production during the day and net consumption at night (from respiration). The average daily minimum dissolved oxygen concentration for the months

December to March inclusive was 8.5 mg/L, but on occasions the daily minimum was below 6 mg/L and was frequently below 80% saturation[5]. While the daily minimum dissolved oxygen is affected by the amount of plant growth and water temperature, it is also likely to be affected by stream flow; this is discussed further in Section 5.3.

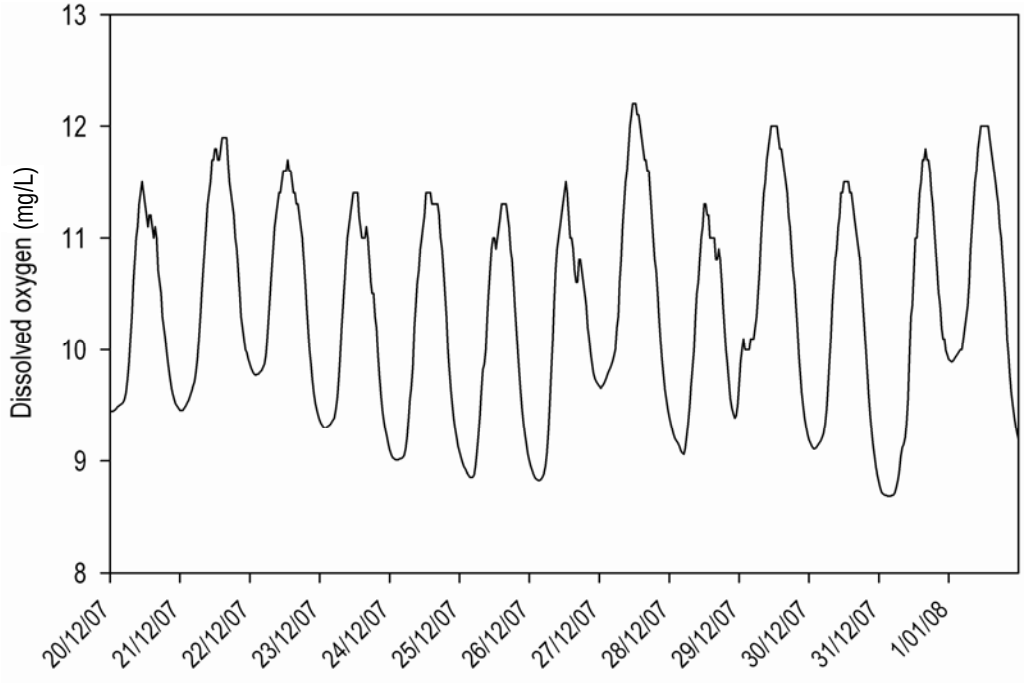

Figure 2.5: Dissolved oxygen concentrations in Papawai Stream above Tilson's Creek confluence, December 2008 to January 2008

In summary, the water quality of Papawai Stream and Tilson's Creek cannot be fully assessed due to a lack of monitoring data. However, it appears that at times the water quality is compromised, with high nutrient concentrations and *E. coli* (indicating bacteriological contamination) and low dissolved oxygen concentrations. The factors likely to be reducing water quality are:

- Rural runoff and direct stock access;
- Inflows from the Moroa Water Race and stormwater from Greytown;
- A high amount of macrophyte growth, which may contribute to low dissolved oxygen concentrations; and
- In the Papawai Stream's lower reach, the wastewater discharge from the Greytown oxidation ponds.

However, based on the limited data available, the streams (upstream of the wastewater discharge) probably have better water quality than other lowland streams of the Wairarapa, such as Parkvale and Otukura streams. This is likely to be because of the relatively short distance that Papawai Stream and Tilson's Creek flow overland.

[5] The guideline of 6 mg/L is from ANZECC (1992), and 80% saturation is the 'bottom line' value specified in the Third Schedule of the RMA 1991

3. Water abstraction from Papawai Stream and Tilson's Creek

There are currently three resource consents that allow water to be taken directly from Papawai Stream and Tilson's Creek, and two resource consents to abstract groundwater from bores located very near to the streams (Table 3.1). Although the two groundwater abstractions are known to have an effect on flows in the streams, the actual effect is uncertain. The estimated impact is shown in Table 3.1. A more thorough assessment of the stream flow depletion may be possible when adequate flow and abstraction data are available.

Table 3.1: Details of resource consents for water abstractions that affect flow in the Papawai Stream or Tilson's Creek

Consent number	Source	Rate of take (L/s)	Comment
WAR930087	Papawai Stream	150^	Can only operate 12 hours/day
WAR030132	Bores adjacent to Papawai Stream	20-60*^	Effect on stream flow is uncertain
WAR030055(1)	Tilson's Creek	45#	Can only operate 8 hours/day
WAR030055(2)	Tilson's Creek	12#	
WAR040115	Bore adjacent to Tilson's Creek	Approx. 15*	Effect on stream flow is uncertain

*Estimated stream flow depletion effect of groundwater take
^ Must not operate simultaneously
# Must not operate simultaneously

The total consented allocation from Papawai Stream and Tilson's Creek, including the estimated stream flow depletion from groundwater abstractions, is about 280 L/s. However, because certain abstractions are not permitted to occur at the same time, the actual maximum total rate of take is about 210 L/s. Of this amount, 150 L/s is from the Papawai Stream above the Tilson's Creek confluence and 60 L/s from Tilson's Creek. This equates to 75% and 43% of the Papawai Stream and Tilson's Creek 1-day MALF, respectively, and 62% of the overall Papawai Stream 1-day MALF.

Plan Change 3 to the RFP, made in 2007, 'capped' the total allocation from the Papawai Stream (including Tilson's Creek) at 200 L/s. The current consented surface water allocation is 195 L/s, although this does not include the estimated impact of the groundwater abstractions.

There is currently no minimum flow policy for the Papawai Stream and Tilson's Creek in the RFP, and water restrictions are applied according to resource consent conditions. The restrictions applied are:

- Consent WAR930087 reduces to 60 L/s when flow in the Papawai Stream at Fabians Road drops below 190 L/s, and no more than 50% of the flow can be taken at any time;

- Consent WAR030132 reduces to 12 hours per day (from 24 hours) when flow in the Papawai Stream at Fabians Road drops below 190 L/s;

- Consent WAR030055 reduces when flow in Tilson's Creek at Scott Culvert drops below 120 L/s, and ceases when flow drops below 114 L/s;

- Consent WAR040115 reduces to 12 hours a day (from 24 hours) when flow in Tilson's Creek at Scott Culvert drops below 114 L/s.

Some issues relating to the RFP policies and assessment of resource consent applications for water takes in the Papawai catchment are discussed in Section 6.

4. Instream values of Papawai Stream and Tilson's Creek

Instream values of a waterway include ecological, landscape, recreational, and Maori customary and traditional values (Ministry for the Environment, 1998). There can be considerable overlap in these values. For example, for the Papawai Stream, many of the Maori customary and traditional values overlap with recreational and ecological values.

Ecological value refers to the value of all vegetation and fauna within a river system. The matters in Part II of the Resource Management Act (1991) that relate directly to ecological values are:

- Section 5(2)(b): The life-supporting capacity of water and ecosystems.
- Section 6(c): Significant habitats of fauna.
- Section 7(d): Intrinsic values of ecosystems.
- Section 7(f): Maintenance and enhancement of the quality of the environment.
- Section 7(h): The protection of the habitat of trout and salmon.

Recreational value refers to the value of the waterway for activities such as canoeing, kayaking, rafting, angling, swimming, and picnicking. *Maori customary and traditional values* include the mauri of a water resource ('life force' and life-supporting capacity), importance for mahinga kai (food sources), and waahi tapu (places of special spiritual significance). In this report, because of the strong overlap in values in this case, these are combined into a category of 'cultural values'.

4.1 Ecological values

Indicators of the ecological values of the Papawai Stream and Tilson's Creek include the abundance and diversity of fish and aquatic macroinvertebrate communities, and the quality and diversity of instream habitat.

Macroinvertebrate sampling carried out upstream of the Greytown wastewater discharge (below the Tilson's Creek confluence) during summer over the years 2006 to 2008 has shown average Macroinvertebrate Community Index (MCI) results in the range of 68 to 83 (using the soft-bottomed tolerance values of Stark & Maxted 2007) (Coffey 2008). The results fall into the 'poor' to 'fair' categories of Stark & Maxted (2007). Sensitive macroinvertebrate taxa (e.g., mayflies, caddisflies and stoneflies) are generally rare or absent. However, as noted in Section 2.4, the MCI results for the Papawai Stream upstream of Tilson's Creek confluence tend to be slightly better, in the range 95 to 101 which fall into the 'fair' to 'good' categories of Stark & Maxted (2007).

Recent fishing by Greater Wellington staff has indicated a low diversity of fish species in the Papawai catchment (A. Perrie[6], pers. comm.). At most of the locations surveyed only koura, common bullies, and longfin eels were found. However, at one location (Papawai Stream just upstream of the Tilson's Creek confluence) abundant juvenile trout and one adult trout were observed, and there is anecdotal evidence of trout in other locations of the catchment, for example, in a pool of Tilson's Creek near the Tilson's Road culvert. In addition, there was an unconfirmed sighting, by a Greater Wellington staff member, of a giant kokopu in the Papawai Stream behind the Papawai Marae in early 2009.

An assessment of the instream habitat quality shows that the habitat is degraded due to a number of factors, including:

- The excessive accumulation of fine sediment on the stream bed;
- The dominance of aquatic macrophytes (which can reduce habitat and dissolved oxygen);
- A lack of hydraulic diversity, in particular 'riffle' habitat; and
- At times, low flows exacerbated by water abstraction. Low flows may cause a reduction in available habitat, as well as secondary impacts on water quality (e.g., increased water temperature, reduced dissolved oxygen, and increased concentration of contaminants).

Overall, the limited ecological monitoring and habitat quality assessment indicate that ecological values of the streams are low in their current state. However, the local people value the streams highly for their populations of longfin eel and several residents regularly feed the eels (Figure 4.1). In addition, there may be localised important trout spawning areas in the streams (e.g., in the riffle upstream of the Tilson's Creek confluence) and nationally threatened species in the catchment (e.g., giant kokopu).

[6] Alton Perrie, Environmental Scientist, Greater Wellington

Figure 4.1: Feeding longfin eels in Papawai Stream

4.2 Cultural values

Sources of information relating to cultural values associated with the Papawai Stream include Greater Wellington's iwi consultation database, notes made at a meeting of the Papawai Stream Community Group at Papawai Marae in November 2008, and information provided by the Papawai Community Trust (pers. comm.[7]).

Important values of the Papawai Stream identified are:

- The mauri, or 'life force', of the stream and connected waterways including groundwater systems;
- The puna (springs) in the area, particularly those in the vicinity of the marae which were historically important for cultural reasons;
- Mahinga kai (food gathering), particularly for koura, kakahi (freshwater mussels) and watercress;
- The presence of a healthy tuna (eel) population;
- Recreational use, particularly for swimming at the marae and canoeing from Fabians Road to the Tilson's Creek confluence;
- Although not specifically identified, there are likely to be waahi tapu sites associated with the stream either within or in close proximity. Because Papawai Stream flows through Papawai Marae it is intricately linked with the peoples' history; and
- High amenity and landscape value.

[7] Notes emailed from Papawai Community Trust via Peter Handford, 10 June 2009

The stream was historically very important as a transportation route to the Ruamahanga River, as a water source for irrigating crops, for mahinga kai, and as a place of recreation.

Factors which adversely affect the cultural values associated with the stream are:

- The discharge of human wastewater to the stream;
- Discharge of contaminants and sediment via stormwater, the Moroa Water Race, and runoff from agricultural land, which have affected the suitability of the stream for food gathering and swimming;
- Restriction of the stream by crack willow resulting in sediment accumulation and hindering recreational use (e.g., canoeing);
- Water abstraction, which may contribute to low flows that will potentially affect recreational use and the ability to maintain healthy fish populations; and
- Groundwater abstraction, which may threaten the flow and health of springs.

The Papawai Stream Community Group – which has strong linkages with Papawai Marae – is undertaking works to restore the Papawai Stream in the reach from Tates Reserve (near its source) to the Tilson's Creek confluence. There are plans to enhance the stream banks at the marae, in conjunction with willow removal (some of which has already occurred). This will include landscaping around the swimming hole (Figure 4.2).

Figure 4.2: A swimming hole in the Papawai Stream at Papawai Marae

5. Setting a minimum flow to protect instream values

The description of Papawai Stream and Tilson's Creek and their values found that although the streams have important ecological and cultural values, these have been degraded. There are many factors that have affected the values, most of which are not related to water abstraction and stream flows. However, it is still important that policies relating to allocation limits and minimum flows are developed, so that other restoration efforts being carried out (such as willow removal, riparian restoration and education) can be successful in protecting and enhancing the streams' values.

5.1 Instream flow objectives

In order to develop an appropriate minimum flow, instream flow objectives should first be developed. These do not replace the water quality objectives set out for the region's rivers and streams in the RFP; rather, they provide more specific guidance for assessing an appropriate minimum flow.

The proposed instream flow objectives for the Papawai Stream (and its tributaries) are:

1. To protect instream habitat conditions for longfin eels;

2. To maintain dissolved oxygen concentrations above aquatic ecosystem guidelines; and

3. To ensure flows are sufficient for recreational use, particularly for swimming at the marae.

The first two objectives relate to protecting ecological values and recognise the high value of the stream for its eel population (although it is acknowledged that flow management alone will not be sufficient to completely restore the ecological values). The third instream flow objective reflects the importance of the stream for recreational use, as identified by the Papawai Community Trust, including their desire to restore this aspect of the stream's value.

5.2 Flows for protecting longfin eel habitat

Wairarapa iwi have expressed a desire to restore the eel fishery in the Wairarapa, and it is obvious that the Papawai community highly values the Papawai Stream for its eel population. It is therefore important that a minimum flow be adequate for protecting eel habitat.

Possible flow-related factors to be considered in this instream flow objective include water temperature, dissolved oxygen and physical habitat availability. The latter is the main focus of this section. Water temperature in Papawai Stream and Tilson's Creek was discussed in Section 2.4; it is apparent from the monitoring data that temperature is not significantly flow-related in these streams. Setting minimum flows to achieve dissolved oxygen standards for the protection of aquatic life is discussed in Section 5.3.

5.2.1 Methods for assessing flow – habitat relationships

Low flows can cause a reduction in habitat availability for fish, and therefore the relationship between habitat availability and flow is an important consideration in setting a minimum flow. Hydraulic habitat methods, such as the Instream Flow Incremental Methodology (IFIM), are often used to assess the expected change in habitat with flow. These rely on hydraulic data for the stream (such as wetted perimeter, width, depth and velocity) and habitat preference information for the particular fish or macroinvertebrate species of interest. Such methods do not derive a minimum flow on their own; rather, the information obtained on predicted habitat changes with flow is used to make an informed decision on an 'acceptable' degree of habitat loss.

Unless instream ecological values are significantly high, and abstraction pressure is high, detailed IFIM studies are not justified because they are very resource-intensive. As an alternative, generalised habitat models can be used to assess the relationship between flow and habitat. These predict a habitat value based on simple width – discharge relationships.

Springfed streams that tend to have a U-shaped channel, such as Papawai Stream and Tilson's Creek, are problematic for applying habitat methods such as generalised habitat models. This is because in these streams the habitat response to flow is generally quite different than in open, gravel bed streams from which data for the method were taken (J. Hay[8], pers. comm.). Therefore it is not recommended that such habitat methods be applied to springfed streams (Beca 2008).

5.2.2 Ecological relevance of the mean annual low flow

The MALF is often used as a statistic for deriving a minimum flow (e.g., by retaining a proportion of habitat available at MALF). The MALF is closely correlated with annual flow events, and therefore provides an indication of the annual lower limit to physical space available to adult trout (which have annual cohorts). Hay & Hayes (2007) suggest that the MALF is similarly ecologically relevant to long-lived native fish species, such as longfin eel. This has been demonstrated by detailed habitat studies that have shown eel habitat availability to decline with flows below MALF (e.g, Hay 2009; Wilding 2007a; Wilding 2007b).

Setting a minimum flow to provide for the protection of eel habitat relative to MALF is therefore a logical progression. In this case it is difficult to do, due to the lack of information on habitat – flow relationships. In reality, however, the U-shaped channel of the Papawai Stream means that a large change in flow would be required to cause a significant change in the availability of habitat. For example, studies of small streams in the Coromandel and Waikato found that to retain about 90% of the longfin eel habitat available at MALF, an appropriate minimum flow would be in the range of approximately 50-75% of MALF.

[8] Joe Hay, Freshwater Biologist, Cawthron Institute

Due to the high community interest in ensuring eel habitat is protected in the Papawai Stream, and the nationally threatened status of longfin eel, a relatively high level of protection is warranted. A minimum flow equal to 80% of naturalised 1-day MALF should provide for this high level of protection. This level of protection is also justified because the Papawai Stream provides habitat – and possibly spawning areas – for brown trout, and may support other threatened native fish species such as giant kokopu.

The proposed 80% of MALF minimum flow is slightly less conservative than the 90% of MALF 'default' minimum flow in the proposed National Environment Standard (NES) on Ecological Flows and Water Levels (Ministry for the Environment 2008). However, the proposed default minimum flow is intended to apply to any small river or stream for which there is limited environmental information. As previously mentioned, a stream with an incised channel, such as Papawai Stream, is unlikely to experience large habitat loss with small decreases in flow, and a 20% reduction in flow from MALF conditions is unlikely to cause an equivalent degree of habitat loss for longfin eel.

The proposed minimum flow of 80% of 1-day MALF for protecting longfin eel habitat in Papawai Stream equates to 160 L/s at the Greater Wellington flow monitoring station above the Tilson's Creek confluence. An equivalent minimum flow for Tilson's Creek is approximately 110 L/s at the Scott Culvert monitoring site.

5.3 Flows for achieving dissolved oxygen guidelines

Water temperature and dissolved oxygen are two of the most directly relevant water quality parameters to fish and aquatic invertebrates (Hay 2008). Low dissolved oxygen concentrations are stressful to aquatic life, and low stream flows may exacerbate this by reducing the re-aeration rate (Wilding 2007a).

5.3.1 Dissolved oxygen monitoring results

The continuous monitoring carried out by Greater Wellington from January 2007 to April 2009[9] shows that dissolved oxygen concentrations in the Papawai Stream exhibit a large diurnal variation (as noted in Section 2.4). During the months November to March the average range is approximately 3.5 mg/L about a mean of 10.1 mg/L. The minimum tends to occur late at night or very early morning, and at times falls below the guidelines for the protection of aquatic life of 6 mg/L (ANZECC 1992) or 80% saturation (Resource Management Act 1991). The patterns indicate that dissolved oxygen concentrations in the Papawai Stream are driven by photosynthesis, which is to be expected given the dominance of aquatic macrophytes in this stream.

The diurnal variation in dissolved oxygen concentrations tends to be greatest when there is a large diurnal variation in flow (which is generally related to water abstraction) (e.g., Figure 5.1), although this finding is based on visual examination of the records only. It is logical that rapid decreases in flow, at

[9] Although the monitoring is ongoing, only data up to April 2009 were included in the analysis for this report

times when macrophytes are removing oxygen from the stream, are likely to result in more pronounced variations and overall lower minimum dissolved oxygen levels.

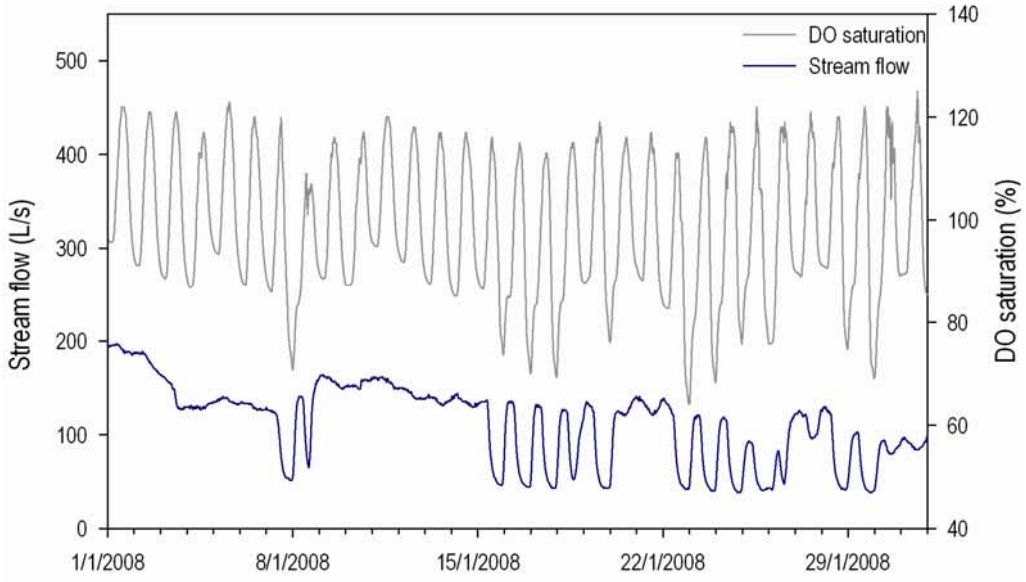

Figure 5.1: An example of diurnal variation in dissolved oxygen (DO) saturation and flow in the Papawai Stream above Tilson's Creek confluence, January 2008

To further investigate the relationship between flow and dissolved oxygen levels in the Papawai Stream, the daily minimum dissolved oxygen (concentration and saturation) data were compared to the recorded minimum stream flows for the same day. These data show:

- Daily minimum dissolved oxygen tends to be related to flow, with the concentrations starting to decrease as daily minimum stream flow drops below about 300 L/s and declining sharply with daily minimum flows below about 100 L/s (Figure 5.2);

- All recorded non-compliances with the dissolved oxygen concentration guideline (6 mg/L) during the summer months (December to March) occurred when the daily minimum flow was less than 50 L/s (Figure 5.3);

- Although breaches of the 80% saturation guideline occurred during a range of flow conditions during December to March, most breaches occurred when flow was below 200 L/s (approximately equal to the MALF), and for daily minimum flows less than 50 L/s the median observed daily minimum dissolved oxygen saturation (74%) was below the 80% guideline.

The relationship between flow and dissolved oxygen concentrations in the Papawai Stream was not modelled as part of this investigation. However, it is apparent from the monitoring records that aquatic life may at times be compromised by low dissolved oxygen levels during flows less than about the 1-day MALF (200 L/s) and that breaches of the dissolved oxygen guidelines are more likely with extreme low flows.

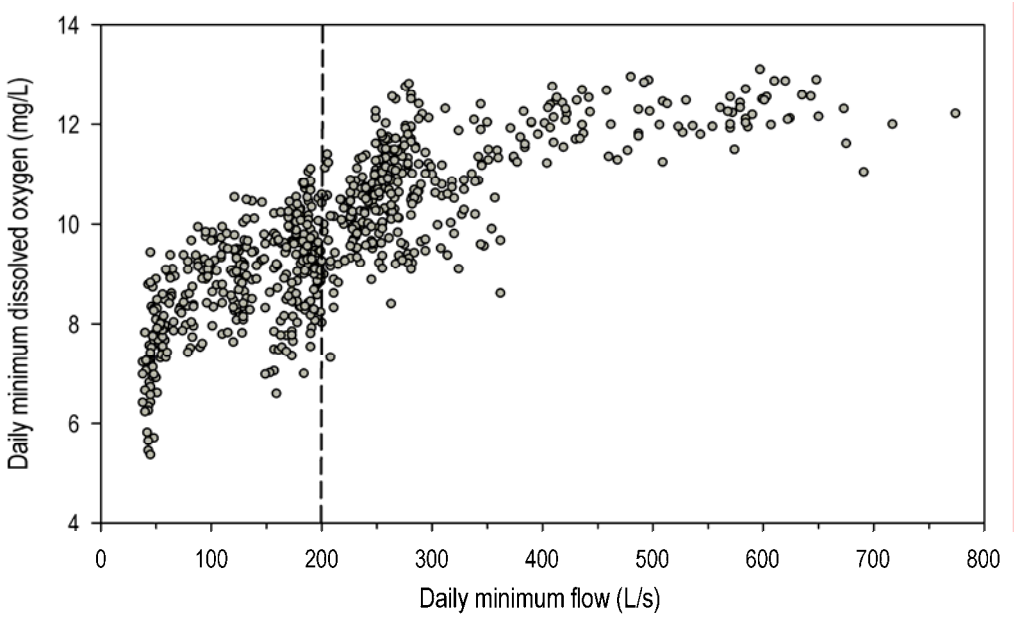

Figure 5.2: Daily minimum dissolved oxygen concentrations and flow in the Papawai Stream, January 2007 to March 2009. The dashed line represents estimated 1-day MALF.

Although such relationships vary from stream to stream, these results are similar to those modelled for the nearby Otukura Stream, where it was found that breaches of dissolved oxygen concentration guidelines occurred with flows lower than the MALF, depending on climate conditions (Watts 2008). Similarly, a study of a Waikato springfed stream, with similar characteristics to Papawai Stream, found that breaches of the 6 mg/L guideline occurred as flow dropped below the MALF (Wilding 2007a).

There are no dissolved oxygen records available for Tilson's Creek. However, given the similar characteristics between the streams, in particular the springfed nature and dominance of aquatic macrophytes, it is likely that Tilson's Creek displays similar flow/dissolved oxygen relationships to those of the Papawai Stream.

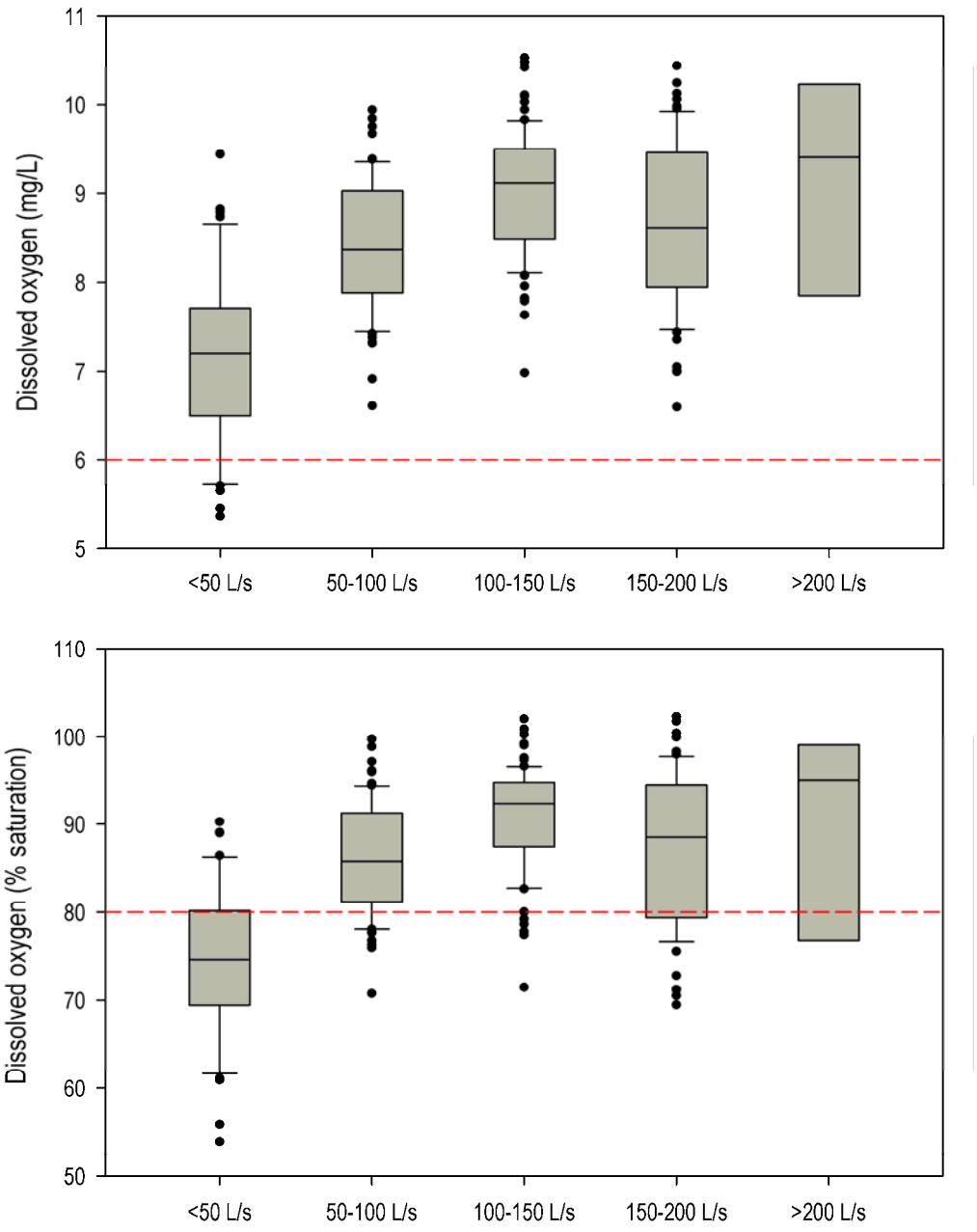

Figure 5.3: Observed daily minimum dissolved oxygen (concentration and % saturation) in the Papawai Stream above Tilson's Creek grouped by daily minimum flow, 2007-2009 (months December to March inclusive). The dashed lines indicate the lower guideline for aquatic ecosystem protection (ANZECC 1992)

5.3.2 Setting a flow to achieve dissolved oxygen guidelines

While it is recognised that breaches of the dissolved oxygen guidelines may occur during any flow conditions, low flows in the Papawai Stream appear to increase the probability of these occurring. It is therefore appropriate to ensure that a minimum flow is set to avoid contributing to low dissolved oxygen levels in the stream.

In Section 5.2, a minimum flow of 80% of MALF (160 L/s above the Tilson's Creek confluence) was recommended for protecting eel habitat. While the monitoring data do not show an exact flow below which dissolved oxygen concentrations will be compromised, the flow of 160 L/s should also ensure the risk of breaching the dissolved oxygen guidelines is reduced. During the monitoring conducted between 2007 and 2009, approximately 80% of the breaches of the Resource Management Act 1991 'bottom line' guideline for dissolved oxygen (80% saturation) occurred with daily minimum flows below 160 L/s. No breaches of the 6 mg/L ANZECC (1992) guideline occurred at flows above 160 L/s.

The first instream flow objective for the Papawai Stream relates to the protection of longfin eel habitat. Research suggests that New Zealand native fish may be relatively tolerant of low dissolved oxygen concentrations (Dean & Richardson 1999). Therefore the guidelines used in this analysis (6 mg/L or 80% saturation) are considered appropriate and conservative for ensuring adequate dissolved oxygen for eels.

Note that the relationship between stream flow and dissolved oxygen in the Papawai Stream may change with the removal of crack willow in the reach between Fabians Road and the Tilson's Creek confluence. A greater amount of light penetration (at least until riparian vegetation is restored) could mean increased growth of aquatic macrophytes and increased water temperatures, both of which could reduce dissolved oxygen concentrations. The proposed minimum flow for protecting dissolved oxygen is therefore, again, considered conservative.

5.4 Flows for protecting recreational values

The instream flow objective for protecting recreational values relates to maintaining sufficient flows for swimming at the marae. A desirable minimum water depth of 1.5 metres has been identified by the Papawai Community Trust (pers. comm.).

As part of this study, water depth measurements were taken in the swimming hole at Papawai Marae. However, due to the timing of works to remove crack willow from the stream, measurements could not be taken until spring 2009. The first measurements were taken in mid-November 2009, and at a flow of 348 L/s the maximum water depth in the swimming hole was found to be 1.6 metres. A second site visit at the end of November, when flow had dropped by approximately 20% (to around 285 L/s), found that the water depth in the swimming hole had not measurably changed.

Due to unstable weather conditions and relatively high flows during late spring and early summer 2009, insufficient data were collected to enable estimation of likely water depth during times of low flow. However, based on the limited measurements taken:

- The water depth in the swimming hole is unlikely to be significantly affected by small reductions in flow; and

- A minimum flow of 80% of MALF, as proposed in Section 5.2, is likely to protect water depths for swimming at the Papawai Marae.

It is recommended that follow-up measurements of water depth in the swimming hole be taken later in the 2009/10 summer, during times of low flow or when the flow is near to the proposed minimum flow of 160 L/s above the Tilson's Creek confluence.

6. Considerations for water management and monitoring

In this section, issues relating to water quantity management of the Papawai Stream and Tilson's Creek are outlined. These issues should be considered during the review of the RFP, and during the assessment of resource consent applications to take water from the streams.

6.1 Minimum flows

It is important that minimum flows for Papawai Stream and Tilson's Creek are specified in the RFP, to ensure environmental needs of the streams are protected and water use is managed consistently within the catchment.

The instream flow assessment in Section 5 concluded that a minimum flow of 160 L/s at the Papawai Stream flow monitoring site should be appropriate for protecting longfin eel habitat, water depth for swimming, and achieving dissolved oxygen guidelines in the Papawai Stream. Although less information exists for Tilson's Creek, an equivalent minimum flow of 110 L/s at Scott Culvert is recommended.

While the proposed minimum flow may be seen as relatively conservative, given the high level of allocation from the streams and uncertainty over flow statistics, this conservatism is justified.

It is not possible to carry out a security of supply analysis, to assess the likely frequency of water abstraction restrictions with the proposed minimum flows. This is because the flow records for Papawai Stream and Tilson's Creek are relatively short and because they are significantly affected by upstream abstraction (and abstraction records are not available).

6.2 Core allocation

There is no core allocation identified for Papawai Stream and Tilson's Creek in the RFP, and it is recommended that one is proposed as part of the plan review process. Greater Wellington has not yet determined if there will be a 'rule-of-thumb' for setting core allocation limits, and so a core allocation is not being suggested here. However, it is recommended that the core allocation is not necessarily set equal to the 'capped allocation limit' of 200 L/s that was added to the RFP as part of Plan Change 3. This limit is a very high proportion (nearly 60%) of the estimated MALF of the Papawai Stream at the Ruamahanga River confluence. In addition, the limit was proposed without accounting for stream flow depletion caused by groundwater abstraction.

It is recommended that the maximum instantaneous water abstraction from the catchment is reduced below the current level of 210 L/s (as estimated in Section 3) and a core allocation is proposed that reflects this. Abstraction may be able to be reduced by ensuring flow-sharing between water takes, or by reducing the rate of take specified in the resource consents.

If the maximum instantaneous allocation is not reduced, then options for reducing the impacts of a high degree of allocation from the catchment include:

- Consideration of the timing of takes, e.g., avoiding large flow reductions (caused by large abstractions) during the evening when dissolved oxygen concentrations are starting to decrease;

- Intermittent pumping of groundwater takes to reduce the degree of stream flow depletion; and

- Measures to mitigate the effects on the stream, e.g., riparian planting to improve stream shading and therefore reduce aquatic macrophyte growth (this has already been required for some consented abstractions in this catchment).

6.3 Environmental monitoring

To ensure restrictions on consented water abstraction are applied when necessary it is vital that flow monitoring of the streams continue. The proposed minimum flows are related to the MALF. It is acknowledged that there is a degree of uncertainty in the MALF estimates and ongoing flow monitoring is important for confirming these. In addition to this, records of the actual amount of water taken are required in order to naturalise the flow records. This is discussed further in Section 6.4.

However, as noted in Section 2.2, there have been ongoing problems with the quality of the flow records from Tilson's Creek due to channel siltation and the build-up and clearance of aquatic macrophytes. If a flow correlation were to be developed between Tilson's Creek and Papawai Stream it is possible that continuous flow monitoring of Tilson's Creek will no longer be required (i.e., minimum flows could be managed for the entire catchment using the flow monitoring site on the Papawai Stream upstream of the Tilson's Creek confluence).

To ensure the anticipated environmental outcomes are achieved, additional monitoring may be required. In particular, the continuous dissolved oxygen monitoring of Papawai Stream should continue for at least two low flow seasons following the implementation of a minimum flow. This will determine whether or not the proposed minimum flow is appropriate for avoiding breaches of the dissolved oxygen guidelines. The proposed minimum flow for Papawai Stream was also assessed as appropriate for protecting recreational values, but flow conditions meant that measurements of water depths could not be taken during low flows. If water depth during low flows is an ongoing concern for Papawai Community Trust then Greater Wellington should ensure measurements are taken during minimum flow conditions.

6.4 Monitoring water use

Accurate records of the amount of water taken from Papawai Stream and Tilson's Creek are important to enable naturalisation of flow records. In addition, such records are required to ensure compliance with resource consent conditions can be fully assessed, and for analysing environmental impacts of abstraction (e.g., for confirming the degree of stream flow depletion caused by groundwater takes).

If resource consent conditions specify flow-sharing between users, it would be useful if abstraction records are available in real-time and accessible online to all users in the catchment.

6.5 Managing groundwater use in connected aquifers

This study has highlighted the interconnectedness of groundwater and surface water in the Papawai area. It is obvious that the two resources need to be co-managed to ensure flows are protected in Papawai Stream and Tilson's Creek.

When assessing resource consent applications to take groundwater from the shallow aquifer at locations near to Papawai Stream or Tilson's Creek, it is important that a thorough analysis of likely effects on stream flow is carried out. This will ensure that the effects on the environment and on downstream users can be considered.

Some groundwater policy-related issues that should be considered in the upcoming review of the RFP are:

- When reviewing the 'safe yield' of the Greytown groundwater zone, this should take into account the need to sustain spring flows into Papawai Stream and Tilson's Creek; and

- The need to develop clear policies for managing groundwater takes that result in stream flow depletion.

In relation to the second point, the policies should include direction on whether or not such groundwater takes will be considered as part of the core allocation of the affected stream, and how any restrictions will be applied during times of low flow. It is strongly recommended that groundwater takes that are shown to reduce flows in the Papawai Stream or Tilson's Creek are considered as part of a core allocation and be subject to minimum flow restrictions.

7. Conclusions and recommendations

The ecological and cultural instream values of Papawai Stream and Tilson's Creek have been degraded due to factors such as excessive accumulation of fine sediment on the streambeds, the dominance of aquatic macrophytes and restriction by crack willow, and reduced water quality (due to rural runoff, urban stormwater, and treated wastewater entering the stream). Despite these factors, the Papawai Stream has important values for the local people due to its historical significance, recreational use, and population of longfin eel.

Due to its springfed nature, Papawai Stream and Tilson's Creek are not naturally subject to extreme low flows. However, high abstractive demand for water from this catchment – both directly from the streams and from nearby shallow groundwater bores – has been shown to exacerbate low flows. It is therefore important that appropriate minimum flows and allocation limits are put in place so that the existing and potential instream values are protected.

The instream flow assessment considered minimum flow requirements for protecting longfin eel habitat, achieving dissolved oxygen guidelines, and protecting recreational values (for swimming). A minimum flow of 80% of the naturalised 1-day MALF is expected to achieve these objectives. This is equivalent to a flow of 160 L/s in the Papawai Stream above the Tilson's Creek confluence and 110 L/s in Tilson's Creek at Tilson's Road.

Ongoing monitoring is required to ensure the proposed minimum flows, if adopted, are effectively implemented and achieve the anticipated outcomes. This includes continuous flow monitoring (both to ensure compliance with the minimum flow and for confirming the MALF estimate), dissolved oxygen monitoring, and possibly monitoring of water depth at the marae swimming hole. In addition, it is recommended that consented water abstractions in the catchment are measured and telemetered to allow flow records to be 'naturalised' and to ensure compliance with any flow-sharing conditions.

A core allocation has not been recommended as part of this study. However, it is apparent that the amount of water allocated is very high, even when taking into account the current flow-sharing arrangement between consented takes. Options for reducing the amount of water taken from the streams should be considered, and be reflected in any proposed core allocation policy.

7.1 Recommendations

The results of this study should be taken into account when the RFP is reviewed and when assessing consent applications to take water from the catchments. In particular, it is recommended that:

1. Minimum flows of 160 L/s in the Papawai Stream above the Tilson's Creek confluence and 110 L/s in Tilson's Creek at Tilson's Road are adopted;

2. A core allocation is set that applies to both direct surface takes and groundwater takes that are shown to deplete stream flows;

3. Clear policies are developed for managing groundwater takes that result in stream flow depletion;

4. Monitoring of stream flow and dissolved oxygen concentrations in the Papawai Stream continues; and

5. Consented water abstractions from the streams, and groundwater abstractions that are known to affect stream flows, are continuously measured and telemetered.

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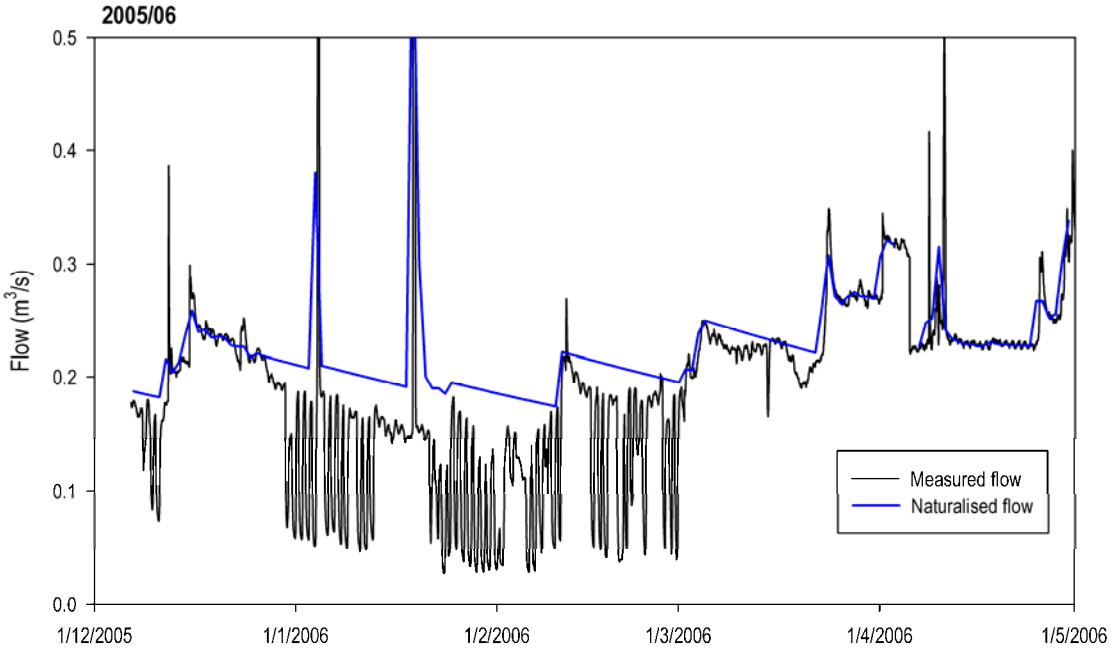
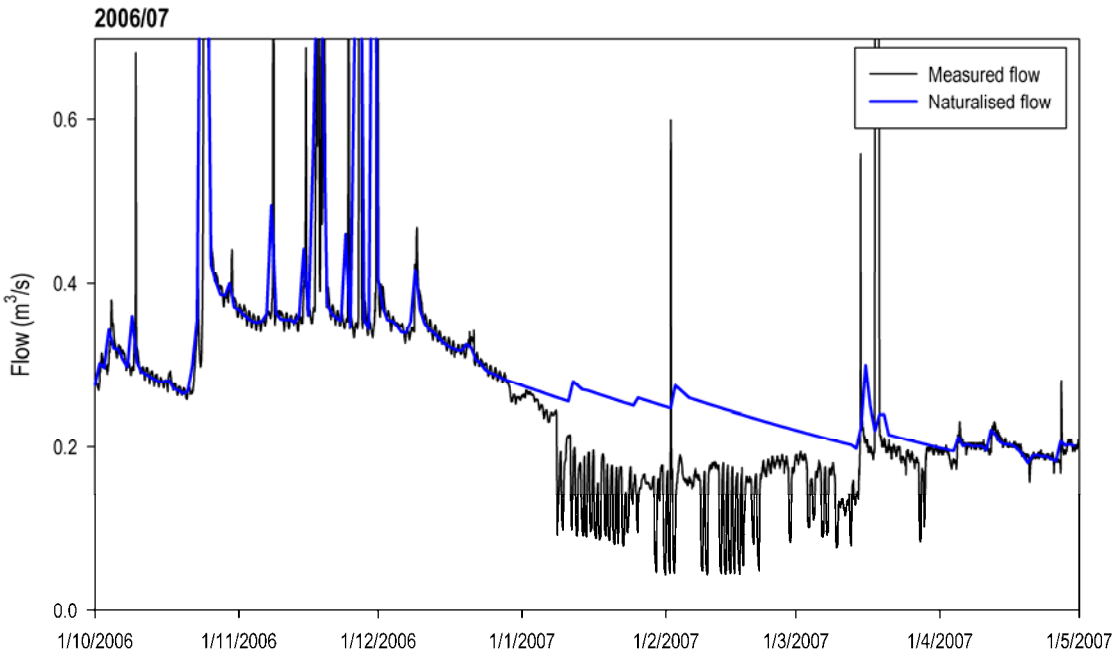
Acknowledgements

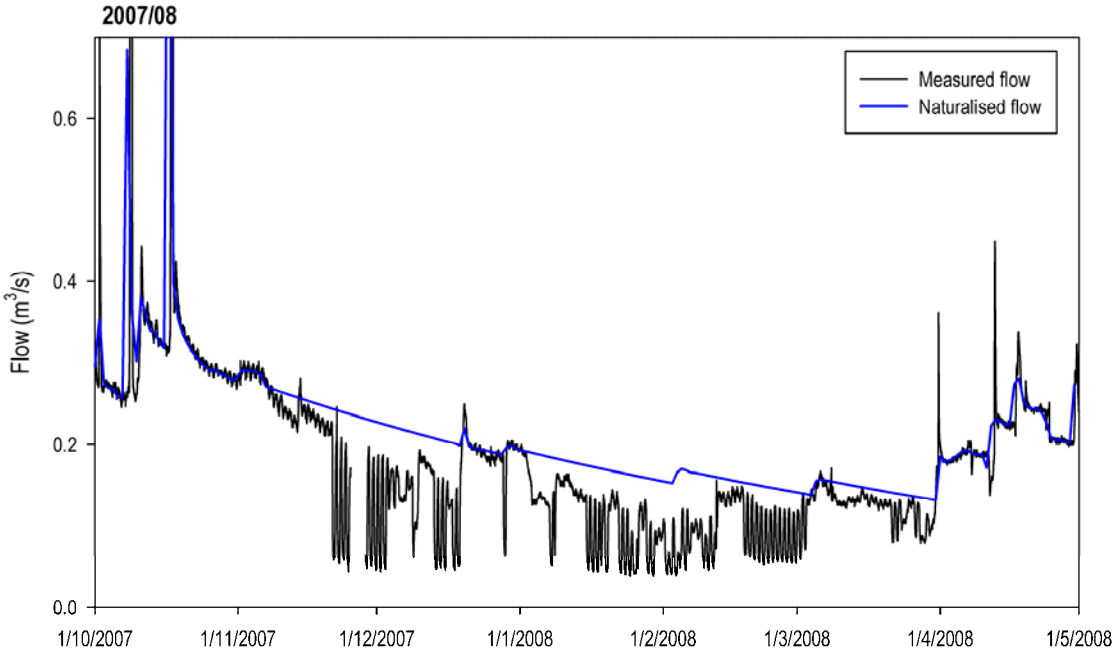
Thank you to the Papawai Community Trust for providing information on cultural values associated with the Papawai Stream, and to the Papawai Stream Community Group for welcoming our attendance at their meeting at Papawai Marae in November 2008. Thank you also to Peter Handford for advice relating to the Papawai Stream characteristics and giving a background to the restoration efforts.

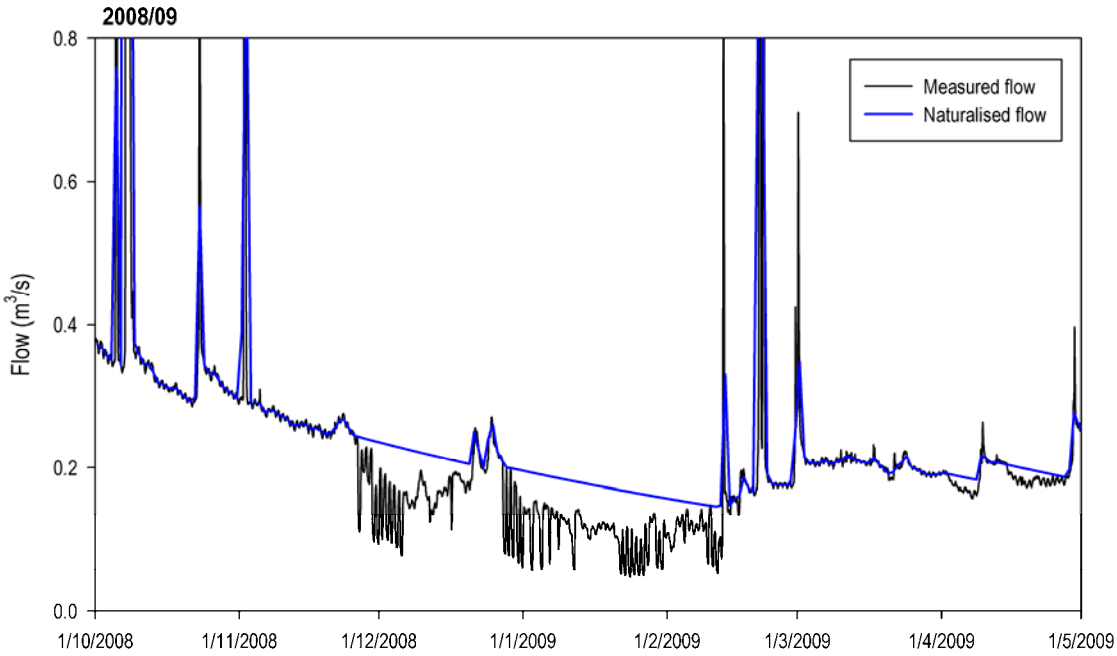
The analysis in this report is largely based on information collected by Greater Wellington's Environmental Monitoring and Investigations staff – notably Matt Rowland and Brett Cockeram who maintain the stream flow and continuous water quality monitoring sites, and Alton Perrie who carried out fish surveys of the stream. Thank you to Alton Perrie, Scott Ihaka and Juliet Milne for reviewing sections of this report.

Appendix 1: Naturalised flow records for Papawai Stream






2007/08
Measured flow
Naturalised flow
Flow (m3/s)
0.0
0.2
0.4
0.6
1/10/2007
1/11/2007
1/12/2007
1/1/2008
1/2/2008
1/3/2008
1/4/2008
1/5/2008


2008/09
Measured flow
Naturalised flow
Flow (m3/s)
0.0
0.2
0.4
0.6
0.8
1/10/2008
1/11/2008
1/12/2008
1/1/2009
1/2/2009
1/3/2009
1/4/2009
1/5/2009

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Papawai Stream looking downstream of Fabians Road

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