Management flows for aquatic ecosystems in the Tuapeka River

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Otago Regional Council
Private Bag 1954, Dunedin 9054
70 Stafford Street, Dunedin 9016
Phone 03 474 0827
Fax 03 479 0015
Freephone 0800 474 082
www.orc.govt.nz

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Report writer: Xiaofeng Lu, Hydrologist
Reviewed by: Matt Hickey, Manager of Resource Science

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Foreword

Otago has been at the forefront of water management practice and law in New Zealand as much of the region has long been recognised as a water-short area. The Regional Plan Water for Otago sets the framework for the management of water in Otago. It provides for better utilisation, protection and management of water so that the goals of the future development of Otago can be achieved.

The goal of management flows is to maintain the stream's aquatic ecosystem and natural characters during periods of low flow. Furthermore, setting appropriate allocation limits and improving water-use efficiency help ensure sustainable use of the water resource, which provides for the needs of the community.

Surface water supplies in Otago are heavily allocated. Over abstraction can degrade a stream's natural values. The best way to avoid over abstraction is to assess the instream values, set a minimum flow and allocation limit so degradation does not occur.

This report focuses on the hydrology and instream values of the Tuapeka River, and provides some management flow options for consideration in the minimum flow process.

Executive summary

The purpose of this report is to investigate the flows required to maintain the habitat of fish in the Tuapeka River.

The Tuapeka River has a catchment area of 249 km^2 and is located approximately 70 km west of Dunedin. Currently a total of 19 l/s is allocated from the catchment, which is used for the Tuapeka Rural Water Supply Scheme.

The 7-day Mean Annual Low Flow (MALF) and low-flow return periods have been calculated for the Tuapeka River to give an indication of low flow patterns in the catchment. Rainfall statistics have also been summarised to show general rainfall distributions and seasonal variations over the catchment.

Instream habitat surveys were carried out in 2005, and flow requirements for all of the resident species were assessed by examining the relationships between flow and available habitat using Instream Flow Incremental Methodology (IFIM).

The Tuapeka River and its tributaries contain koura and five native fish species, of which dusky galaxias and Clutha flathead galaxias have been identified as nationally endangered and nationally vulnerable, respectively (Allibone and David et al., 2010, pp. 271--287). The population of longfin eel species are considered to be declining (Allibone et al., 2010). The introduced fish species in the Tuapeka catchment – brown trout have a locally significant fishery value according to the 2007/2008 National Angling Survey carried out by Fish & Game New Zealand (FGNZ) and NIWA (Unwin, 2009).

The recommended flow for each fish species in the Tuapeka catchment has been estimated from the results of the habitat modelling. Flow distribution analysis was carried out to calculate the average number of days per season during which flows were below those recommended by habitat modelling. The analysis has found that the flow regime of the Tuapeka catchment supports the recommended habitat and has no impact on the existing fish species.

The range of flows required to maintain the aquatic values should be used as part of future policy discussions for determining a minimum flow in the Tuapeka River.

Contents

List of figures

List of tables

1. Introduction

The Regional Plan: Water for Otago 2004 (Water Plan) sets out as one of its objectives 'to retain flows in rivers sufficient to maintain their life-supporting capacity for aquatic ecosystems and their natural character'. As a means of achieving this objective, the Water Plan provides for the setting of minimum flows in Otago's rivers.

The purpose of this report is to provide information on the Tuapeka River that is relevant to determining the flows desirable for sustaining the river's aquatic habitat. Hydrological data have been analysed to determine low flow return periods for the Tuapeka River. Rainfall data are given to show the variation in rainfall over the catchment. A brief overview of the topography, vegetation, land use, and soil type within the catchment has been provided, along with a summary of the recreational and biodiversity values of the Tuapeka River. A physical habitat study (Instream Flow Incremental Methodology or IFIM) was conducted to determine the effects of low flows on the availability of habitat for both the native and introduced fish found within the catchment.

1.1. Focus of document

To better utilise, protect, and manage the existing water resource in the Tuapeka River (Figure 1.1), it is important to have technical information on aquatic ecosystems available to the public, to support discussions on the setting of a minimum flow in the future. This short report has summarised the available hydrological data to show the rainfall pattern and flow regime for the Tuapeka catchment. IFIM data have also been analysed with a focus on how the available habitat for each species responds to flow variations. Flows to maintain habitat for each fish species of the Tuapeka River have been recommended.

Figure 1.1 1 km north of Tuapeka Mouth along the Tuapeka River (taken on 25/7/2012)

2. The Tuapeka catchment

The Tuapeka River is one of the tributaries of the Clutha River, with its confluence at Tuapeka Mouth between Beaumont and Clydevale (Figure 2.1). The Tuapeka River has a total catchment area of 249 km^2 and is located approximately 70 km west of Dunedin.

2.1. Vegetation

As Figure 2.1 shows, high producing exotic grasslands make up to 60% of the catchment area, most located at lower catchment between Lawrence and Tuapeka Mouth. Almost a quarter of the catchment is exotic forest, which predominate the higher lands in the north of the catchment.

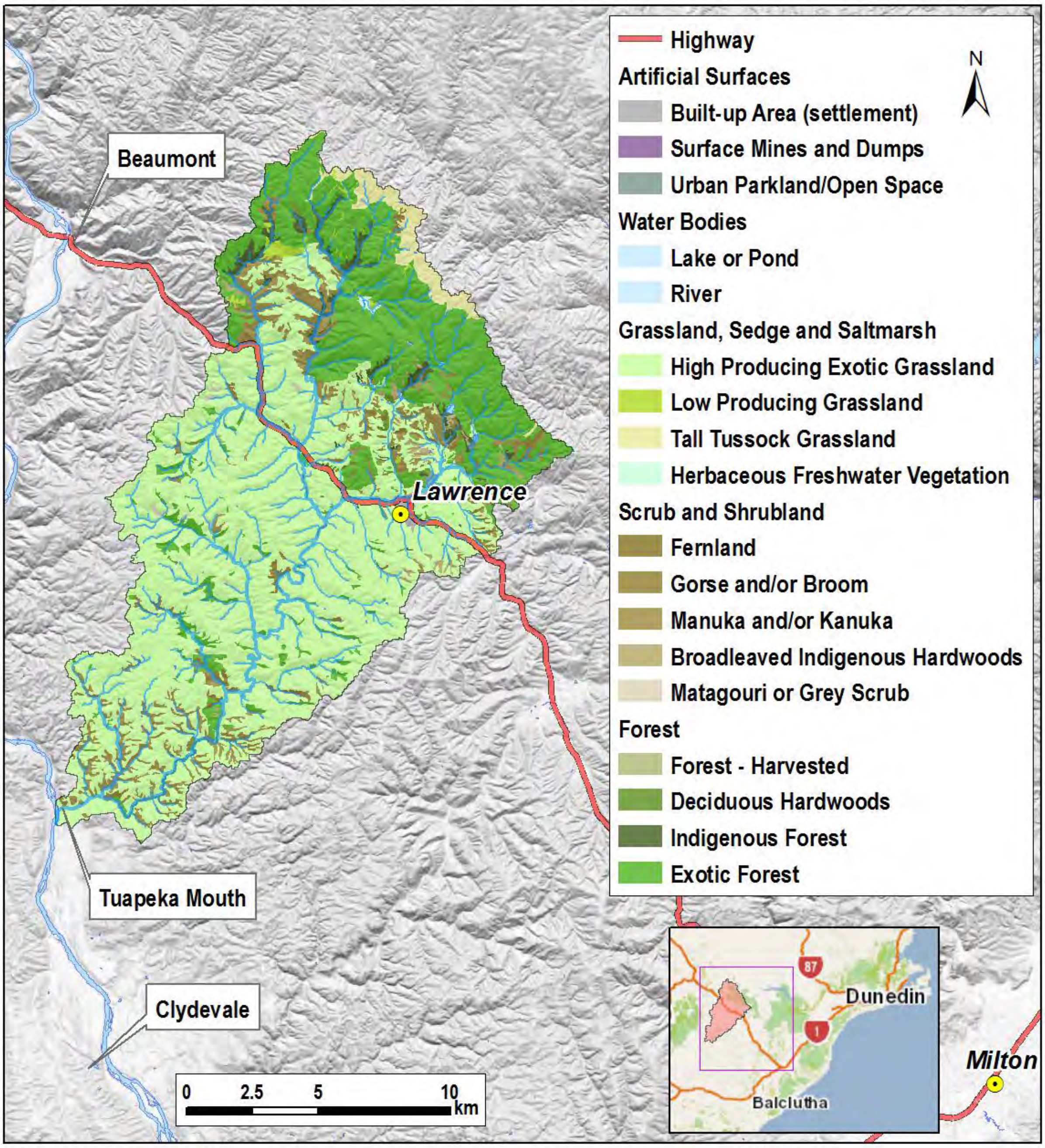

Figure 2.1 **Land cover for the Tuapeka catchment**

2.2. Land use and water allocation

Most land to the west of the Tuapeka River is mainly used for mixed sheep and beef farming, and almost one third of the catchment is currently sheep farms, most across the eastern part of the catchment (Figure 2.2).

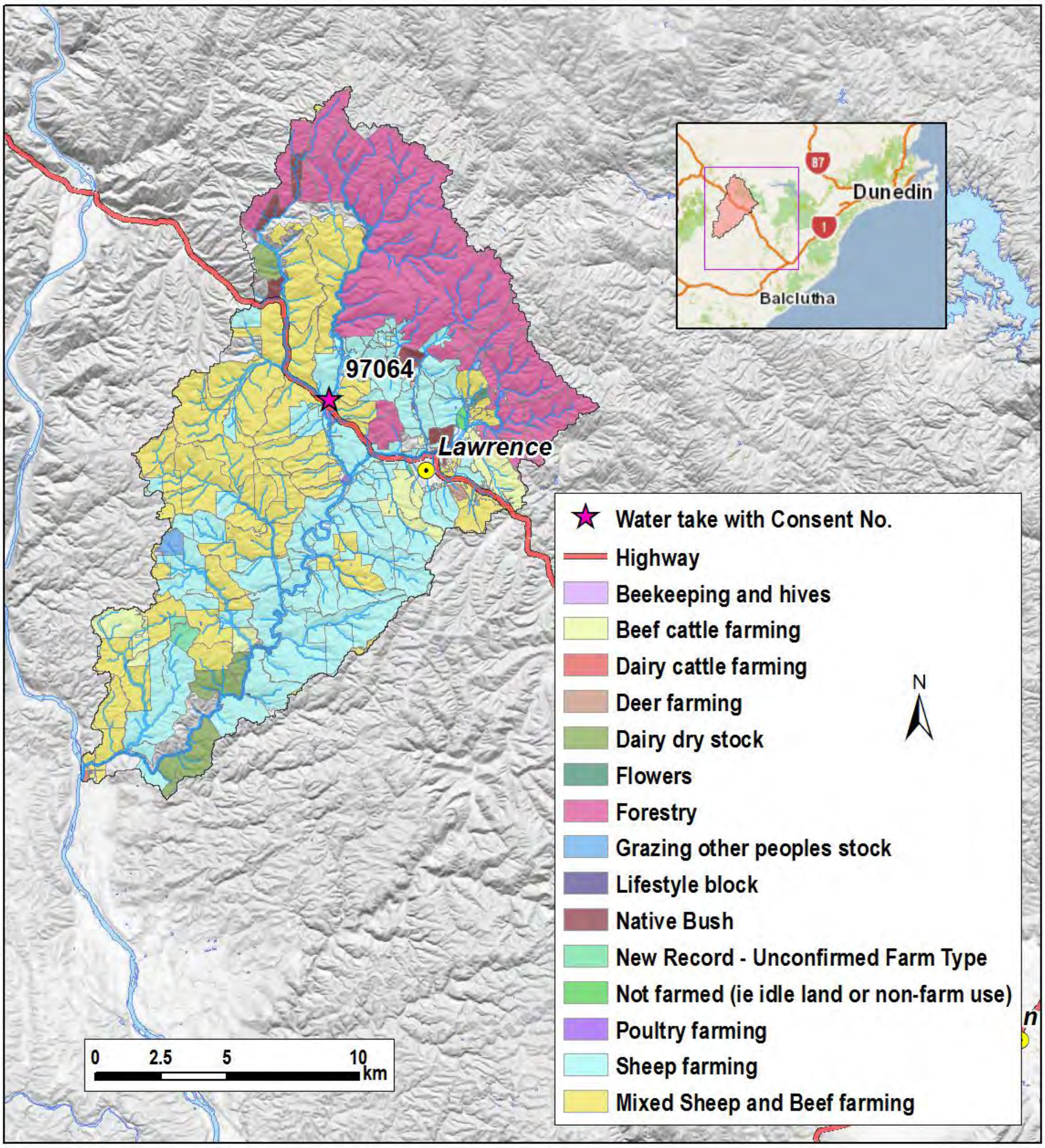

Figure 2.2 **Land use and water allocation for the Tuapeka catchment**

There is currently only one consented surface water take (Figure 2.2) in the Tuapeka catchment, owned by the Clutha District Council, with a maximum abstraction rate of 19 l/s. The take is located on the Tuapeka River at 200 m upstream of the State Highway 8 road bridge on Munro's Gully Road. The water is used for the Tuapeka Rural Water Supply Scheme, which supplies reticulated water to the Evans Flat, Lawrence and Tuapeka West

Area. The Scheme has been identified as water supply values in Schedule 1B of the Regional Plan Water (2013). The details of this take are listed in Table 2.1.

Table 2.1 The current water abstraction in the Tuapeka catchment

Consent No.	97064
Holder	Clutha District Council
Purpose	Water Supply Rural Scheme
Maxmum rate (l/s)	19
Daily volume (m^3)	1640
Monthly volume (m^3)	50000

2.3. Topography and soils

The north edge of the catchment has a relatively high elevation ranging from 600 to 750 m, while most of the catchment to the south has a relatively low elevation of below 300 m (Figure 2.3).

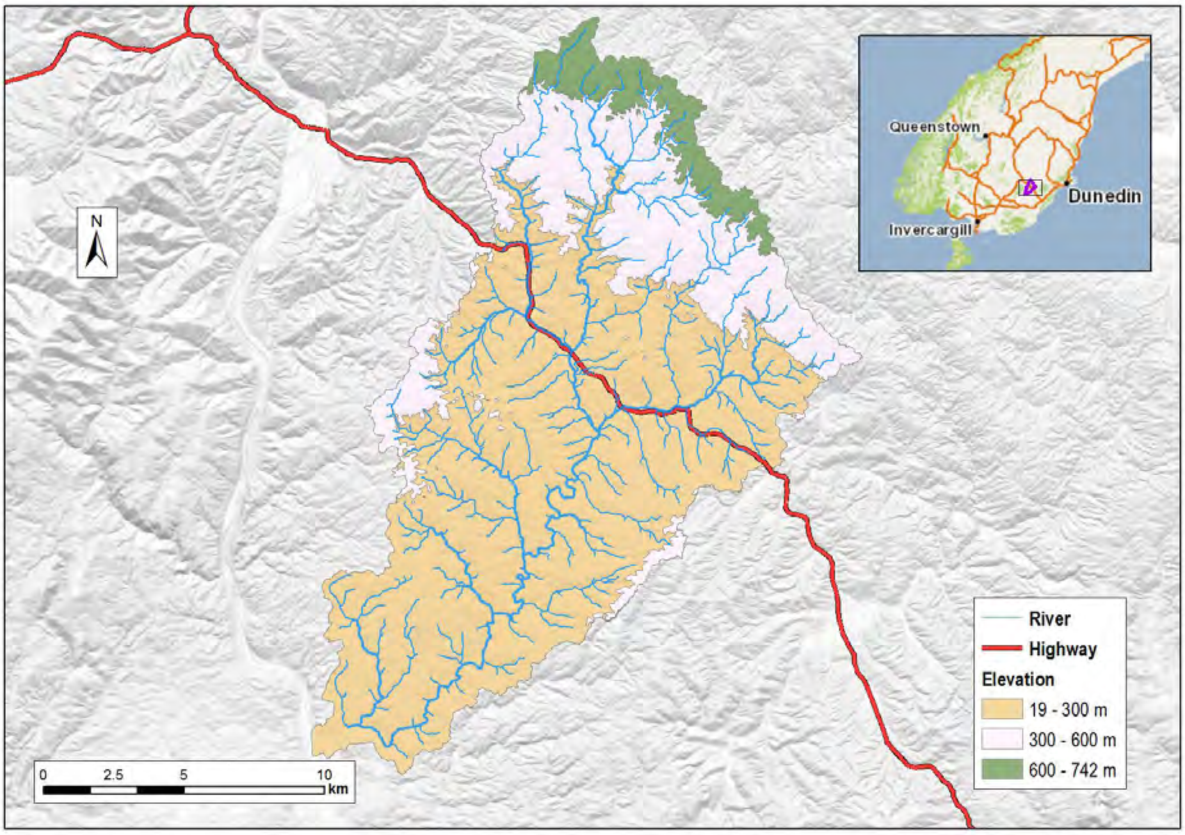

Figure 2.3 Topography of the Tuapeka catchment

Figure 2.4 shows the distribution of the soils over the Tuapeka catchment. The soils in the Tuapeka catchment fall in three categories by New Zealand Classification (NZ Soils, 2014).

- Acidic Orthic Brown Soil
- Mottled Fragic Pallic Soil
- Typic Orthic Gley Soil

Acidic Orthic Brown Soils take up to almost half the catchment area (49%) and are mainly distributed in the relatively high lands to the north and in the vicinity of the river banks in the lower catchment. This soil type is generally well drained, friable, weakly acid (NZ Soils, 2014).

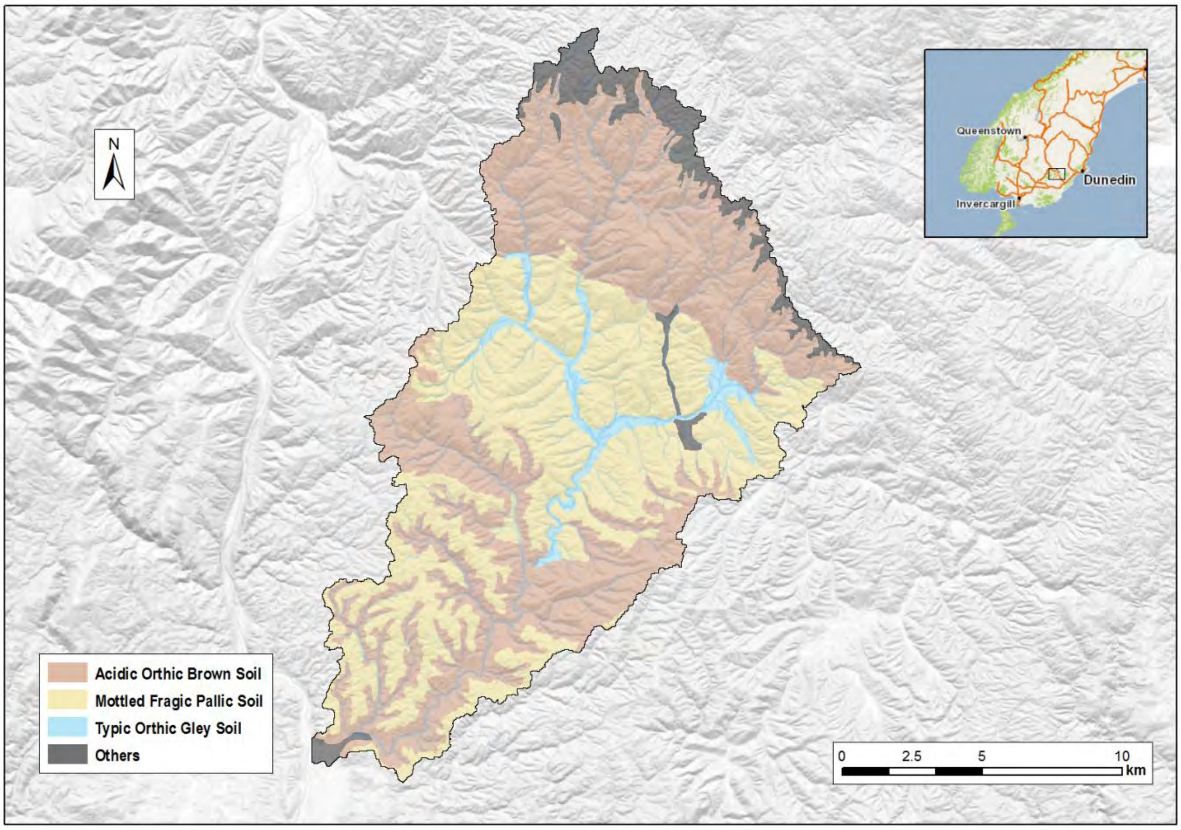

Figure 2.4 Soil distributions over the Tuapeka catchment

Mottled Fragic Pallic Soils are distributed in the middle and some part of the lower catchment. This type of soil is generally poorly drained with low natural fertility, and it usually becomes wet in winter and is easily pugged (NZ Soils, 2014).

Typic Orthic Gley Soils are spatially distributed in the vicinity of the main water bodies in the middle of the catchment. This type of soil is poorly drained with slow permeability when it is wet (NZ Soils, 2014).

3. Rainfall and flow patterns

The long-term median rainfall pattern over the Tuapeka catchment and the general flow regime of the Tuapeka River are described in the following section.

3.1. Rainfall patterns

Figure 3.1 shows the long-term median annual rainfall pattern based on the data from growOTAGO[1], and the nearby rain gauges and flow records around the Tuapeka catchment.

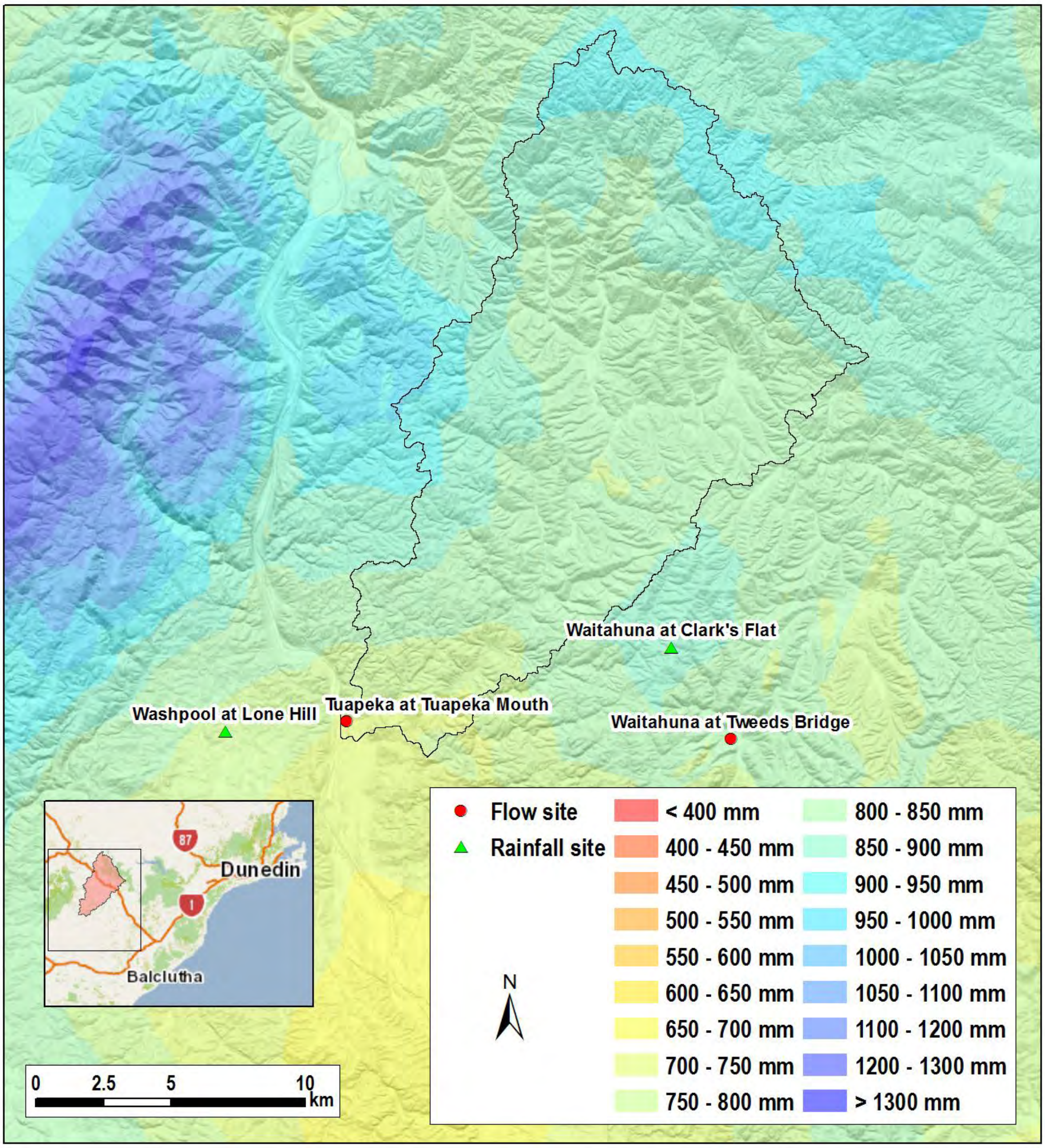

Figure 3.1 **Median annual rainfall patterns over the Tuapeka catchment (Sourced from growOTAGO)**

[1] growOTAGO was developed by the Otago Regional Council, using the scientific expertise of NIWA, AgResearch, Landcare, and the universities of Otago and Auckland.

The long-term median annual rainfall over the Tuapeka catchment ranges from over 900 mm along the north and east edges to approximately 700 mm down the lower south.

Figure 3.2 illustrates the long-term monthly rainfall totals for the nearby rain gauge at Clarks Flat. More rainfall is usually received during summer than other seasons, particularly in December and January (both around 80 mm at Clarks Flat), while the least amount below 50 mm is recorded in July and August.

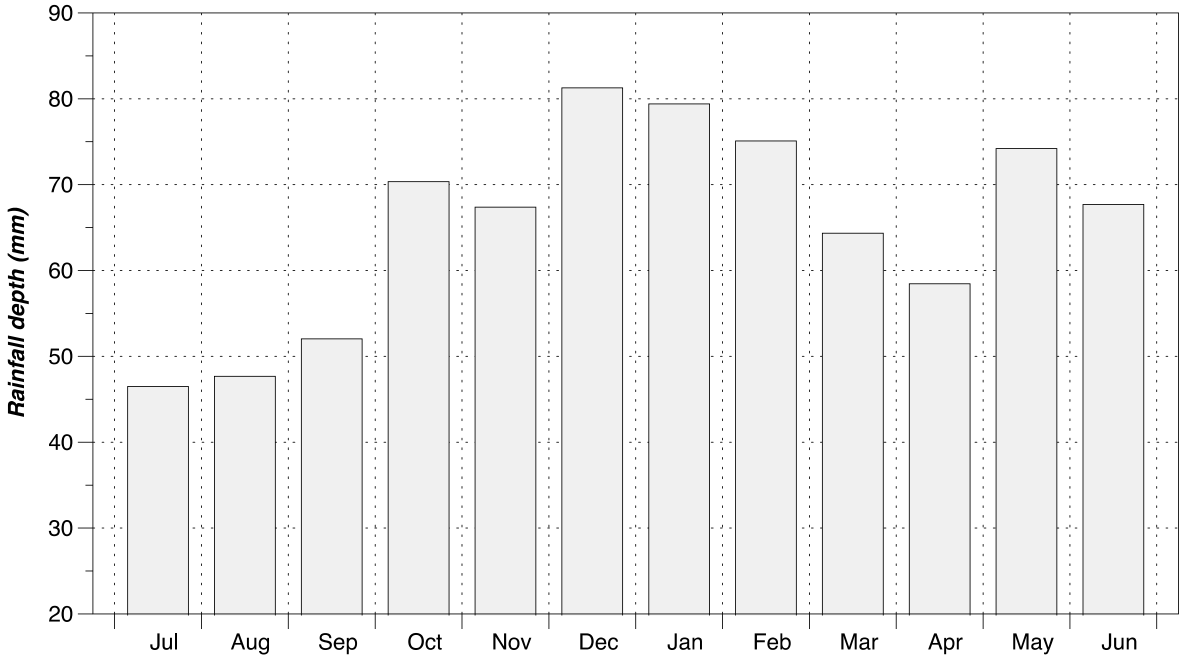

Figure 3.2 Long-term monthly rainfall totals at Clarks Flat

Table 3.1 summarises the annual rainfall statistics for the rain gauge at Waitahuna at Clarks Flat from 1985 to 2014.

Table 3.1 The annual rainfall statistics for Waitahuna at Clarks Flat

min (mm)	max (mm)	mean (mm)	median (mm)	years of record
614	986	802	798	29

Based on the available 29-year rainfall records from Clarks Flat, the least amount of annual rainfall received was 614 mm during the hydrological year[2] of 1998/99, while the most recorded rainfall was 986 mm in the hydrological year of 1995/96. The long-term median annual rainfall is 798 mm.

[2] From July to next June

3.2. Flow pattern

The flow recorder at Tuapeka Mouth is the only one located inside the catchment with a relatively short period of records; while the nearby flow site at the Waitahuna River at Tweeds Bridge has 22 years of record (Figure 3.1). Therefore, a synthetic flow for simulating the flow records at Tuapeka Mouth can be created from the nearby flow recorder at Tweeds Bridge. The correlation of this synthetic flow is illustrated in Figure 3.3.

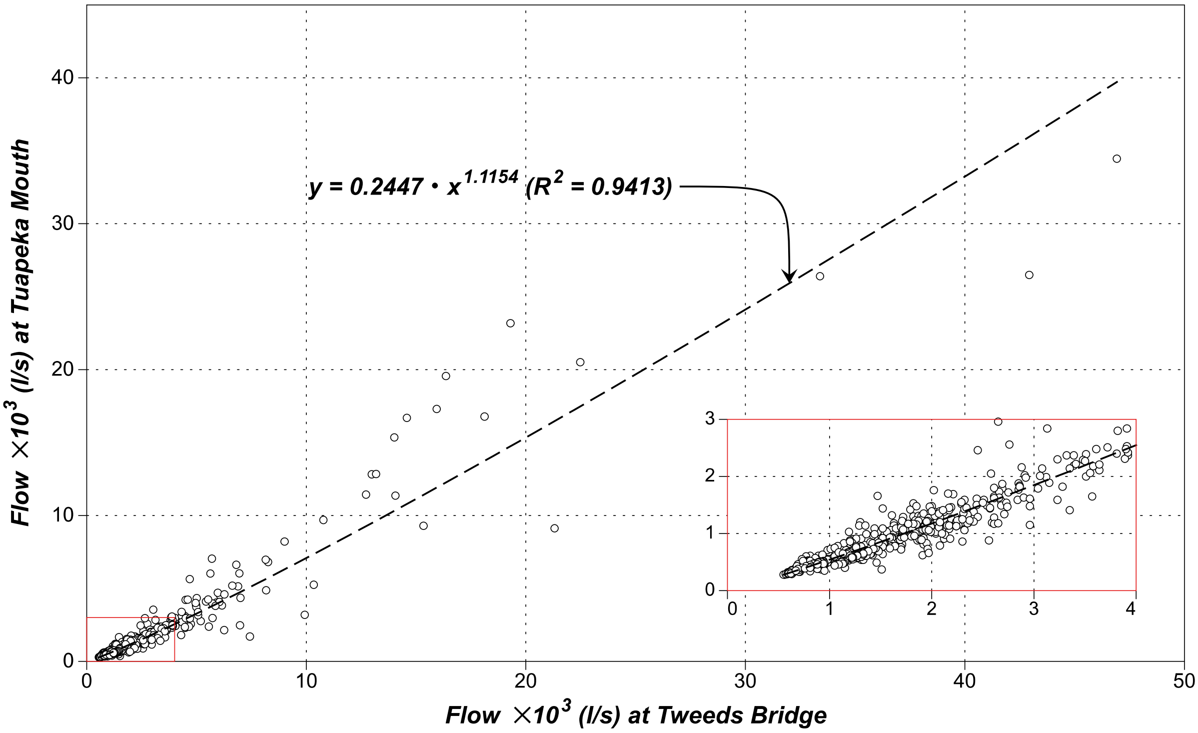

Figure 3.3 Correlation between the existing flow records from the two flow sites

As Figure 3.3 shows, the power correlation ($y = 0.2447\ x^{1.1154}$) was created from all the available flow records from Tuapeka Mouth and Tweeds Bridge on a daily basis. The correlation is particularly good when flows at Tuapeka Mouth were below 3,000 l/s. The simulated long-term flow statistics at Tuapeka Mouth are summarised in Table 3.2.

Table 3.2 The synthetic long-term flow statistics at Tuapeka Mouth

min (l/s)	Max (l/s)	Mean (l/s)	Median (l/s)	7-day MALF (l/s)	Lowest 7-day low flow (l/s)	Catchment area (km^2)	Catchment yield at 7-day MALF ($l/s/km^2$)
171	189,378	1,574	951	340	226	249	1.365

The lowest value summarised from the synthetic flows at Tuapeka Mouth was 171 l/s, which occurred near the end of February 1995. The simulated 7-day MALF and catchment yield at 7-day MALF at Tuapeka Mouth is 340 l/s and 1.365 $l/s/km^2$, respectively. The lowest 7-day low flow occurred in February 1999, with a simulated flow of 226 l/s.

Figure 3.4 shows the 7-day low flows at Tuapeka Mouth and the rainfall total during each irrigation season (October to April inclusive) at Clarks Flat summarised from all the available records.

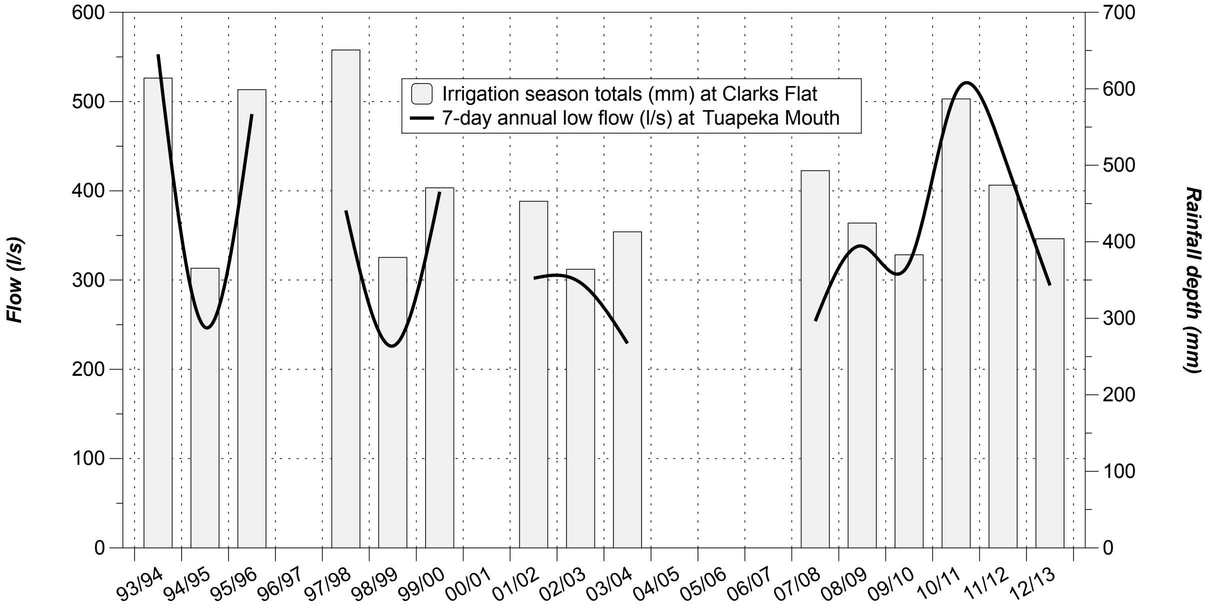

Figure 3.4 **The 7-day annual low flows at Tuapeka Mouth with the rainfall totals for the irrigation season (October to April, inclusive) at Clarks Flat**

As Figure 3.4 shows, five years of records were not included due to data availability. The trend of the 7-day annual low flows generally followed that of the rainfall totals during irrigation seasons apart from 03/04 and 07/08 irrigation seasons; this was due to the higher rainfall early in the irrigation season and followed by relatively low rainfall and flows later in summer.

Table 3.3 shows the 7-day and instantaneous low-flow return periods for the synthetic flows at Tuapeka Mouth.

Table 3.3 **Return period analysis of 7-day and instantaneous flows at Tuapeka Mouth**

Return period	7-day low flow (l/s)	Instantaneous flow (l/s)
1:50 year low flow	175	124
1:20 year low flow	205	162
1:10 year low flow	235	196
1:5 year low flow	275	237

As Table 3.3 shows, instantaneous flows in the Tuapeka catchment drops below 237 l/s and 7-day low flows drops below 275 l/s once in five years on average, respectively.

4. Ecosystem values of the Tuapeka River

The Tuapeka River is identified within Schedule 1A of the Water Plan (updated to 1 October 2013), which lists ecosystem values supported by Otago's lakes and rivers. In the Tuapeka River, these ecosystem values include significant habitat for trout and several threatened native species. The values considered to be significant are listed in Table 4.1.

Table 4.1 Ecosystem values of the Tuapeka River

Water body	Ecosystem values
Unnamed tributary of the Tuapeka River a.k.a. Kononi Creek	• Freedom from aquatic pest plants.
Tuapeka River	• Gravel bed composition of importance for resident biota. • Large water bodies supporting high number of particular species. • Access within the main stem of the river unimpeded by artificial means. • Significant trout and salmon[3] spawning areas. • Significant areas for development of juvenile trout and salmon[3]. • Freedom from aquatic pest plants • Significant presence of trout, eels, and a range of indigenous invertebrates threatened with extinction.
Unnamed tributaries of the Tuapeka River upstream of G45:472668	• Freedom from aquatic pest plants • Significant habitat for flathead galaxiid and dusky galaxiid.

Figure 4.1 shows the rough locations of the identified water bodies in Schedule 1A within the Tuapeka catchment.

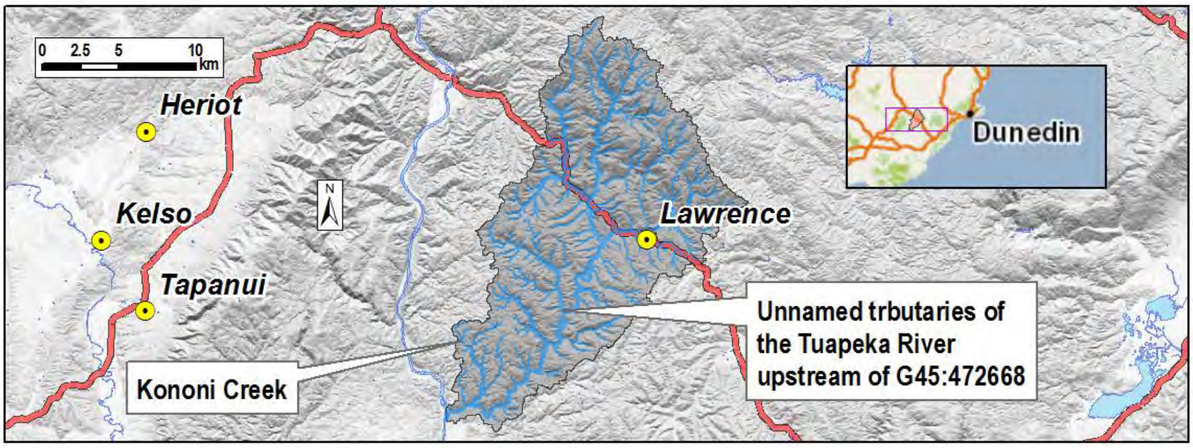

Figure 4.1 The identified water bodies in Schedule 1A

[3] Although 'significant areas for salmon spawning and juvenile salmon for the Tuapeka River' is mentioned in the Schedule 1A of the Water Plan (updated to 1 October 2013), there are no actual records of them being present from the fisheries data available.

4.1. The Tuapeka River's fish species

Based on NZ Freshwater Fish Database (NZFFD) maintained by NIWA, there are five native fish species and one crayfish species distributed along the Tuapeka River and its tributaries. Figure 4.2 shows the distributions of native fish and crayfish species in the Tuapeka catchment.

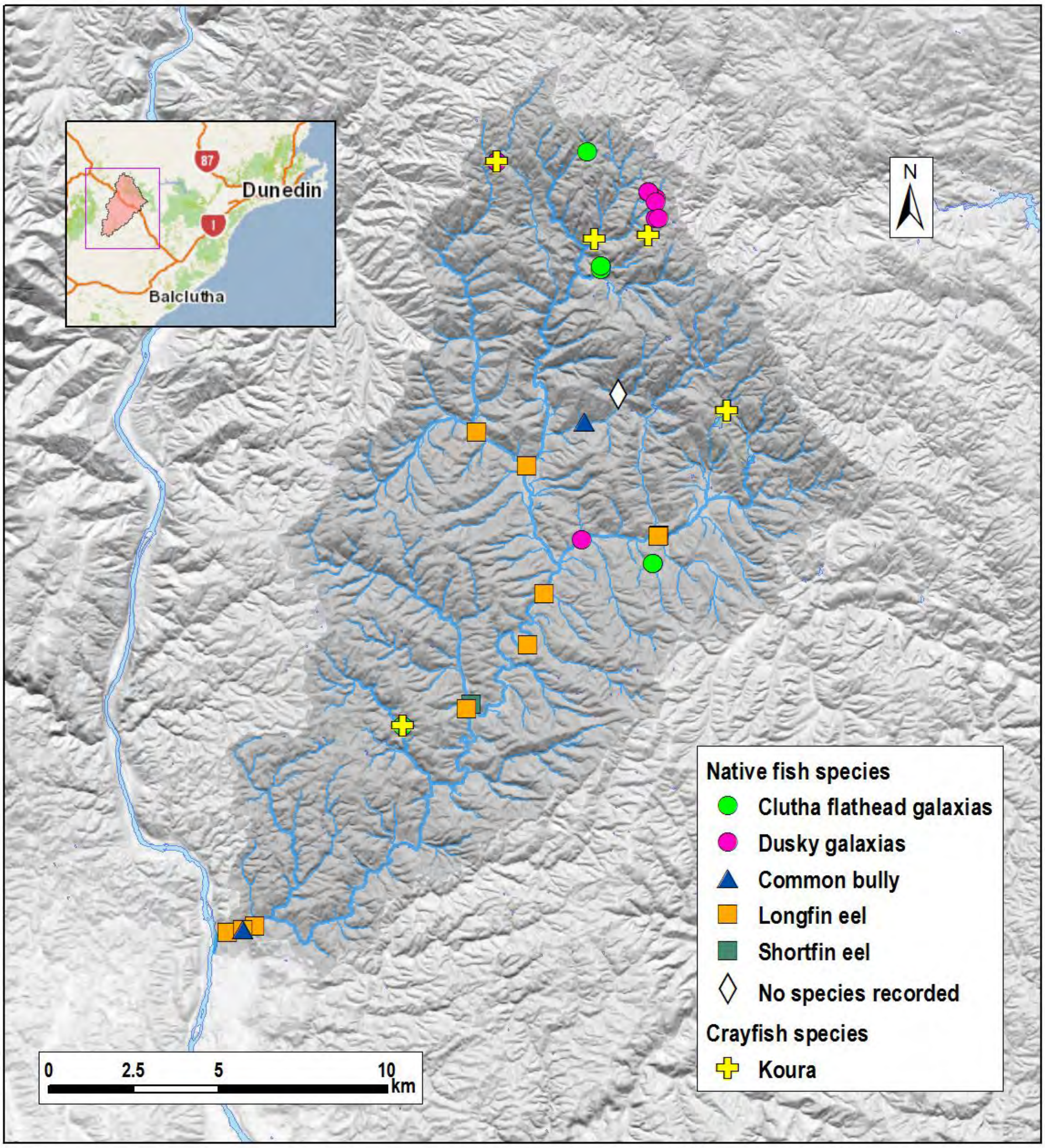

Figure 4.2 **Distributions of native fish and crayfish species in the Tuapeka catchment (Data Source: NZFFD)**

As Figure 4.2 shows, longfin eel species, considered to be declining (Allibone et al., 2010), are mainly distributed along the lower Tuapeka River. Dusky galaxias and Clutha flathead galaxias have been identified as nationally endangered and nationally vulnerable respectively (Allibone et al., 2010), most of them in the upper Tuapeka catchment.

Brown trout are evenly distributed over the areas above the Tuapeka Flat and confined around the Tuapeka Mouth (Figure 4.3). The fishery received 100 ± 80 angling days (between December and January) estimated by the 2007/2008 National Angling Survey carried out by Fish & Game New Zealand (FGNZ) and NIWA (Unwin, 2009), and the fishery value is considered locally significant.

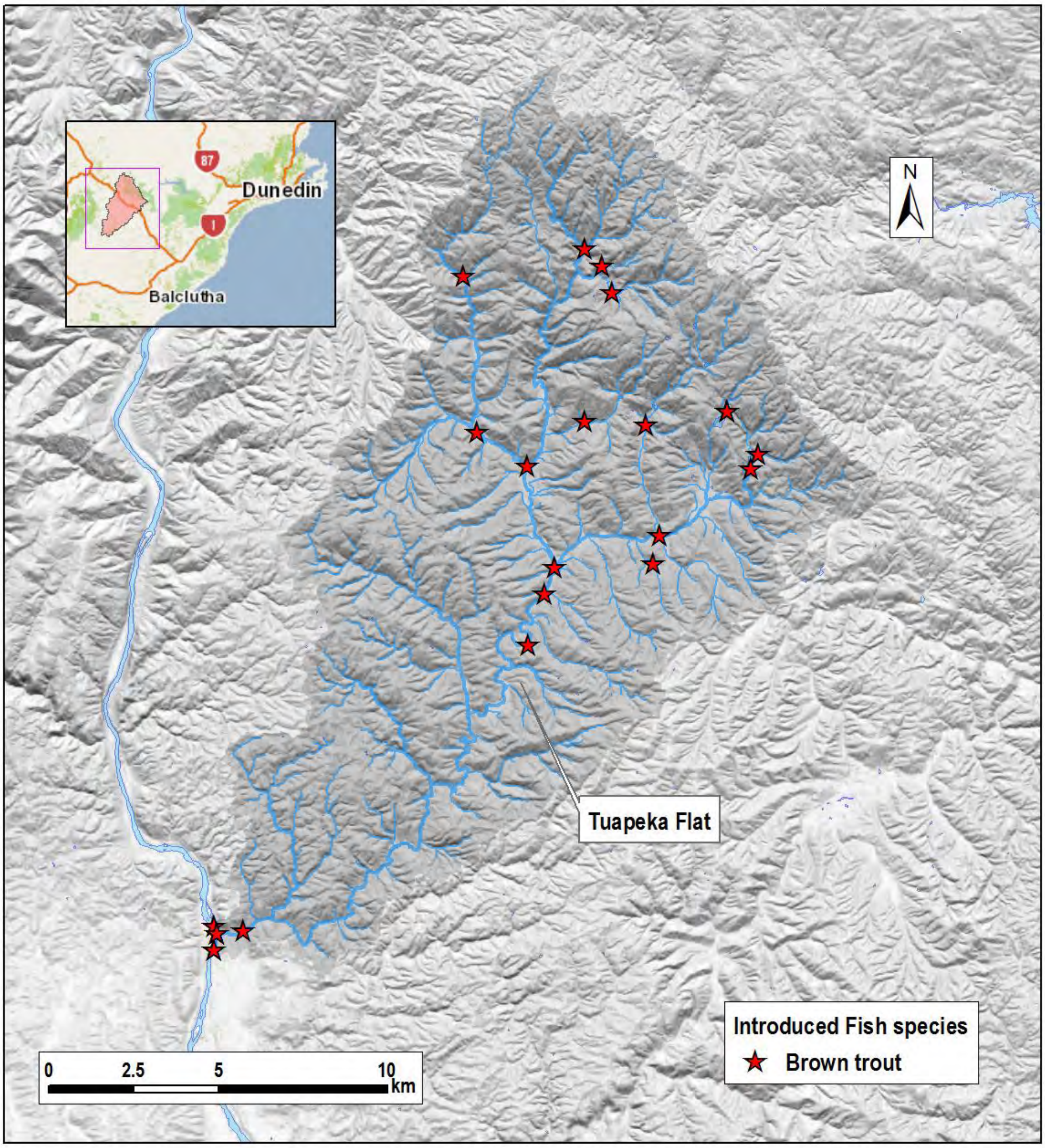

Figure 4.3 **Distributions of brown trout in the Tuapeka catchment (Data Source: NZFFD)**

5. Physical habitat survey

The Otago Regional Council requested NIWA carry out instream habitat surveys (2005) and determine flows required to maintain acceptable habitat for the fish species present in the Tuapeka River.

The main aims of the study were to:

- carry out instream habitat surveys in critical reaches of the Tuapeka River
- conduct a hydraulic analysis in these streams using RHYHABSIM (Jowett, 1989) to quantify how native fish and trout habitat varies with flows
- assess flow requirements for the Tuapeka River, based on the habitat requirements of the native and introduced fish species.

5.1. Instream Flow Incremental Methodology (IFIM) summary

Instream Flow Incremental Methodology (IFIM) is a decision-making tool that includes quantifying the incremental differences in instream habitat that result from alternative instream flow regimes. The purpose of physical habitat simulation is to relate changes in stream flow to changes in physical habitat for various life stages of a fish species or other organisms, for food production, for riparian vegetation or for a recreational activity. Changes in stream flow may be linked, through biological considerations, to environmental and social, political and economic outcomes (Stalnaker and Lamb et al., 1995). The goal of IFIM is to maintain, or even improve, the physical habitat for instream values, or to avoid limitations of physical habitat (Jowett, 2005).

5.2. Habitat preferences and suitability curves

The habitat-based methods (including IFIM) require detailed hydraulic data, as well as knowledge of the ecosystem and physical requirements of stream biota (Jowett, 2005). The basic assumption is that if there is no suitable physical habitat for a given species, then they cannot exist. However, if there is physical habitat available for a given species, then that species may or may not be present in a survey reach, depending on other factors not directly related to flow, or to flow related factors that have operated in the past (e.g., floods). In other words, habitat methods can be used to set the 'outer envelope' of suitable living conditions for the target biota (Jowett, 2005).

Biological information is needed to quantify how well a suitability value is suited a given depth, velocity or substrate for the particular species and life stage. The habitat criteria that are applied strongly influence over the result of an instream habitat analysis. For instance, maximum habitat will be provided by a relatively high flow if the criteria of deep water and high velocity are chosen (Jowett, 2005), and vice versa. The suitability curves were developed for New Zealand large, feeding adult brown trout (Hayes and Jowett, 1994) and specify higher depth and velocities than curves for adult brown trout developed in the US. (Raleigh Robert and Zuckerman Laurence et al., 1986). Whether this is due to differences in the sizes of fish has not been clarified. However, it is clear that it is important to use suitability curves that are appropriate to the river and were developed for the same size and life stage of fish, and behaviour, as those to which they are applied (Jowett, 2005).

The habitat analysis includes selecting appropriate habitat suitability curves or criteria, and modelling the effects of a range of flows on the selected habitat variables in relation to these criteria. The area of suitable habitat or weighted usable area (WUA[4]) can be calculated by a joint function of depth, velocity, and substrate type for different flows for each species of interest. The WUA at each cross-section is multiplied by the proportion of the total river length that each cross-section represents. The total WUA is then the sum WUA of all the cross-sections. Variations in the amount of suitable habitat with flow are then used to evaluate the effect of different flows for the target organisms. Flows can then be set to achieve a particular management goal (Jowett, 2005).

Generally, native fish are found in similar habitats over a wide range of rivers. The quantitative approach taken in New Zealand has been to develop general habitat suitability criteria for species of interest by using data collected from several rivers. To date, general habitat suitability curves have been developed for several native fish species, some of which has been published (e.g., Jowett and Richardson, 1995, pp. 13--23), while some remains unpublished.

5.3. IFIM for the Tuapeka River

An IFIM survey was carried out in both upper and lower reaches of the Tuapeka River by NIWA in 2005 (Figure 5.1). This short report only focuses on the lower reach.

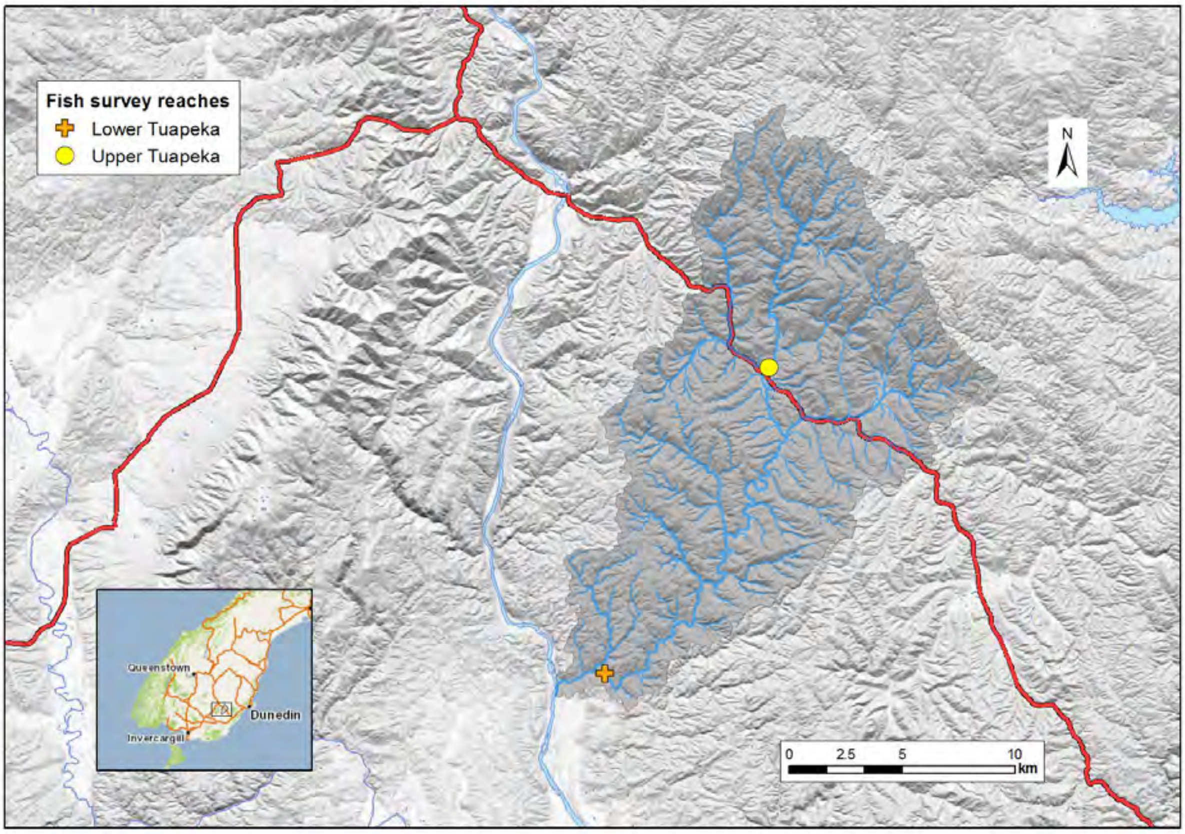

Figure 5.1 The fish survey carried out by NIWA (2005)

[4] Both *WUA (m^2/m)* and *WUA (%)* can be used to evaluate minimum flow requirements for fish.
WUA (m^2/m) – the measure of the total area of suitable habitat per metre of stream
WUA (%) – the percentage of suitable habitat within the wetted area

The lower Tuapeka River was surveyed in a short section (1 km) of river between the point where flows were influenced by the Clutha River and a 6 m concrete weir. The reach is lined with willows (Jowett, 2005).

Figure 5.2 shows how habitat of native fish varies in relation to flow in the lower reach (7-day MALF = 314 l/s). Dusky galaxias is not included as its suitability curve has not been published yet. This Figure shows that the habitat of both eel species in the lower reach of the Tuapeka catchment slightly increases as flows increase, and available habitat for common bully is almost stable as flows increase. The available habitat for flathead galaxias in the lower reach is more sensitive to variations of flows than the others, and decreases dramatically as flows increase.

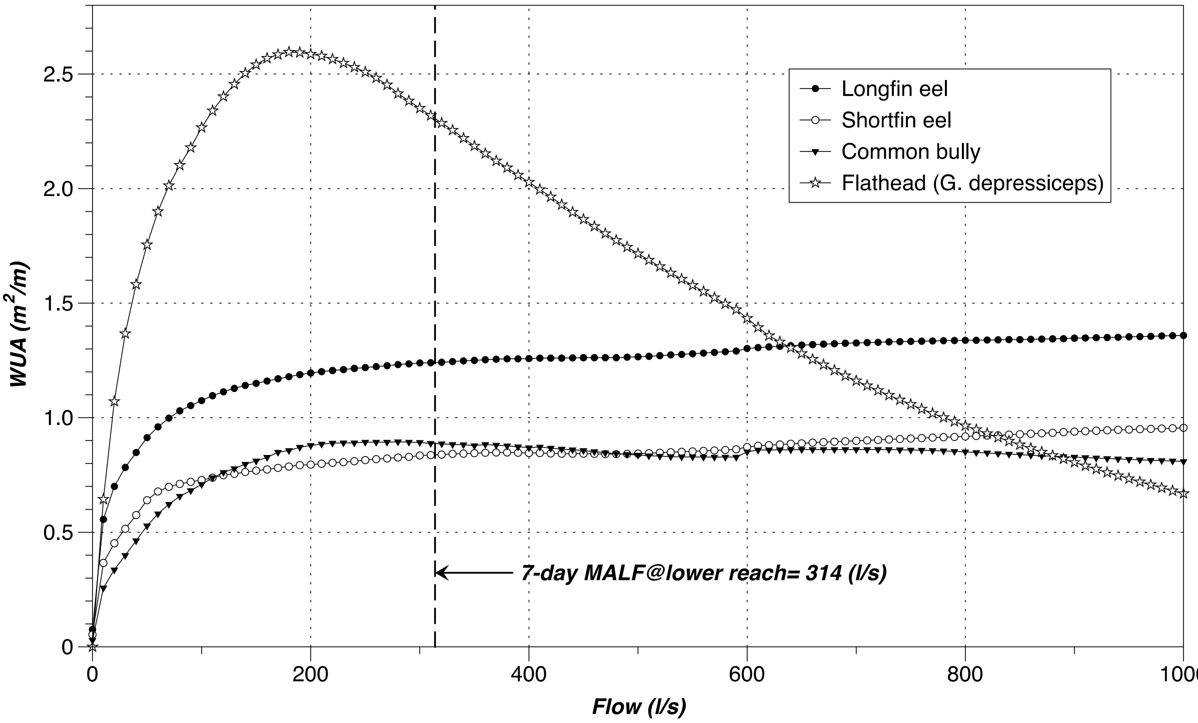

Figure 5.2 **Variation in instream habitat of native fish, in relation to flow, in the lower reach**

Figure 5.3 shows that available habitat for both adult and juvenile brown trout increase as flows increase. However, there is a gradual decrease in available brown trout spawning habitat with higher flows.

When the optimum flow at its maximum available habitat (peak WUA value) for a fish species (apart from brown trout spawning) is no less than the 7-day MALF or no clear optimum flow can be read from its habitat suitability curve, the method used for determining the optimum flow is then based on the concept of retaining a certain level of suitable habitat for critical instream values in the river of interest (Jowett and Hay, 2004). The level of habitat retention depends on the relative ecological/recreational values of the species, and Table 5.1 summarised these estimated percentage values. However, the estimation of the recommended flow for brown trout spawning is the only exception as the spawning season for brown trout usually occurs during winter months (May to September, inclusive), which means its recommended flow is not subject to the 7-day MALF. Figure 5.4 illustrates the procedure for estimating the recommended flow for each fish species in the Tuapeka catchment, and the IFIM-recommended flows for all fish species are summarised in Table 5.2.

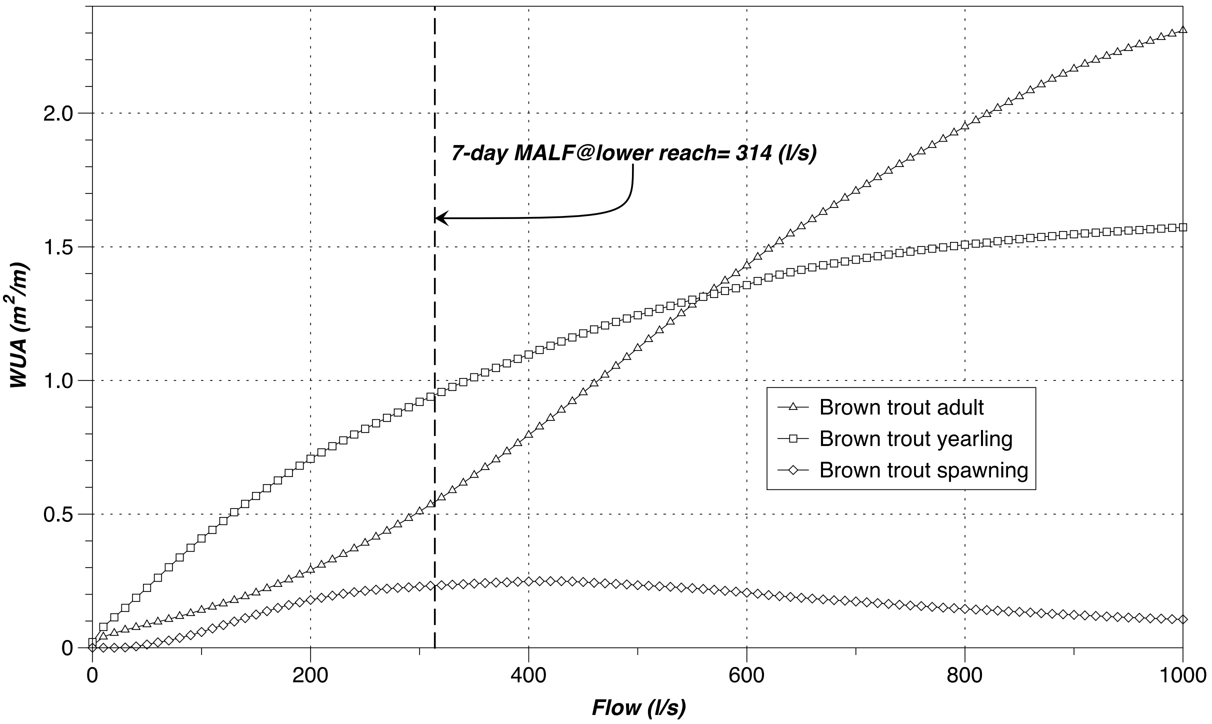

Figure 5.3 **Variation in instream habitat of brown trout, in relation to flow, in the lower reach**

Table 5.1 **Assessment of instream values for the Tuapeka River with recommended levels of habitat retention (based on the approach of Jowett & Hayes, 2004)**

Fish species	Fishery or conservation value	Recommended % habitat retention
Eel species	**Moderate (declining*)**	**70**
Common bully	**Low****	**60**
Flathead (G. depressiceps)	**High (nationally vulnerable*)**	**90**
Brown trout adult	**Low†**	**70**
Brown trout yearling	**Moderate‡**	**80**

* Based on the New Zealand threat classification of Allibone et al. (2010)
**Based on Review of methods for setting water quantity conditions in the Envronment Southland draft Regional Water Plan (Jowett and Hayes, 2004)
† Based on the results from 2007/08 National Angling Survey (NIWA, 2009)
‡ Based on the ecosystem values of the Tuapeka River (section 4)

Specifically, a flow of 60% of available habitat at MALF for common bully is preferred due to its nature of relatively low significance ranking and fishery quality (Jowett and Hayes, 2004). 90% of available habitat at MALF is used for Clutha flathead galaxias as this species has been identified as 'naturally vulnerable' by Allibone et al. (2010), which is supposed to be more sensitive to flow variations. The majority of eel species in the Tuapeka River are longfin eels, whose conservation value is considered as moderate. Therefore, 70% habitat retention level is applied for both eel species.

The introduced fish species – brown trout, which is given by 70% of available habitat at 7-day MALF, have a locally significant fishery value in the Tuapeka River, with 100 ± 80 angling days (between December and January) estimated by the 2007/2008 National Angling Survey carried out by Fish & Game New Zealand (FGNZ) and NIWA (Unwin, 2009). The recommended flow for juvenile brown trout is 220 l/s, which provides for 80% of the habitat available at 7-day MALF. The optimum flow of 420 l/s for maintaining the highest level of brown trout spawning habitat can be read directly from its suitability curve, and it is not subject to the 7-day MALF. Therefore, this optimum flow is considered as the recommended for brown trout spawning.

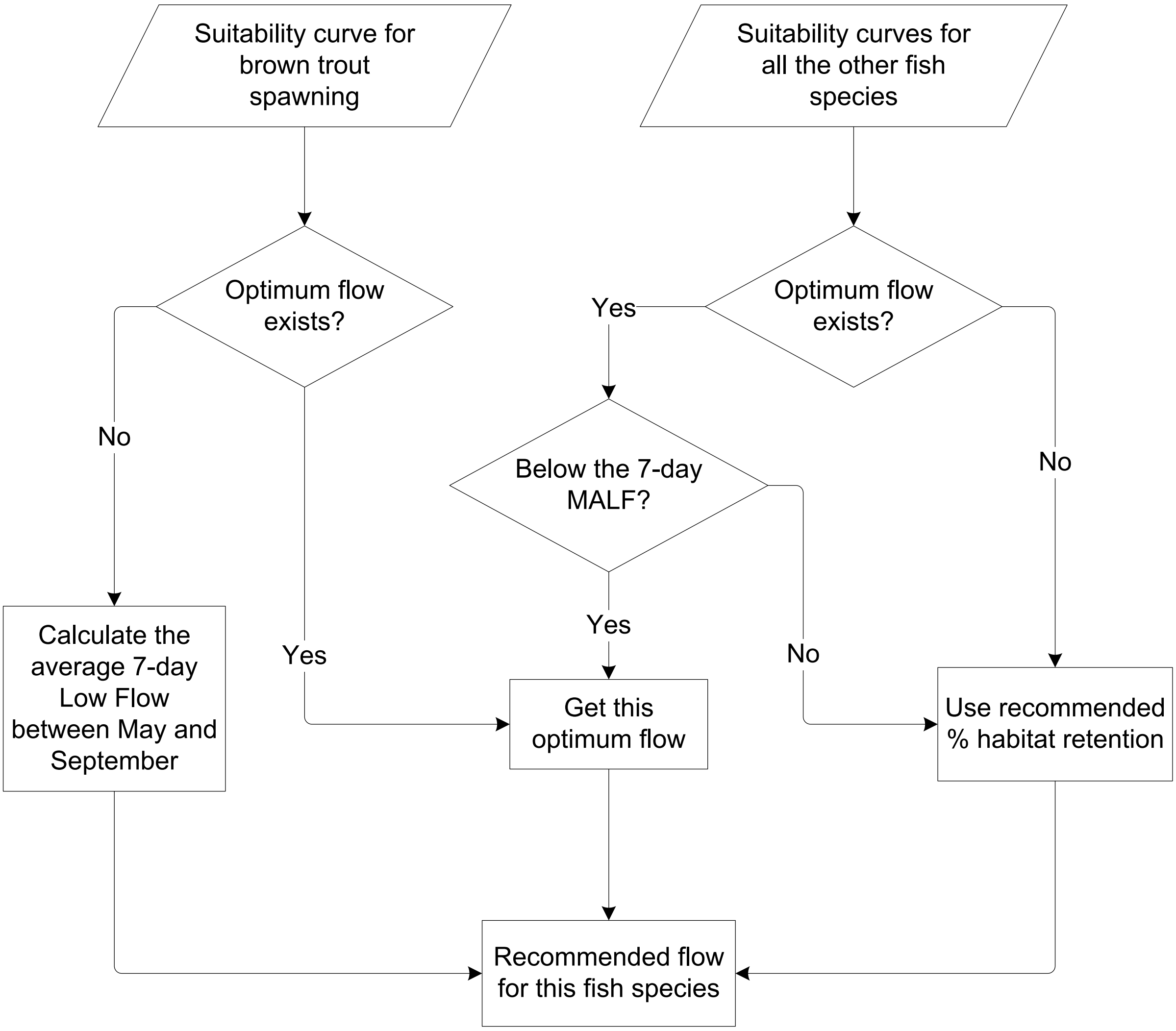

Figure 5.4 **Estimation of the recommended flows for the fish species in the Tuapeka catchment**

Table 5.2 summarises the recommended flows for all fish species in the lower Tuapeka River based on the methods illustrated in Figure 5.4.

Recommended flows for the existing fish species in the lower reach were estimated by assigning flows at which suggested levels (see Table 5.1) of available habitat at 7-day MALF of the lower reach occur. However, there are obvious optimum flows for common bully and Clutha flathead galaxias, which are both below the 7-day MALF of the lower reach. Therefore, recommended flows for common bully and Clutha flathead galaxias were directly read from their corresponding habitat suitability curves, which were 280 l/s and 180 l/s, respectively. The optimum flow for trout spawning is read directly from its suitability curve as it not subject to the 7-day MALF.

Table 5.2 Recommended flow requirements for fish species in the lower reach of the Tuapeka River

Fish species		Flow (l/s) at which recommended % of available habitat at 7-day MALF occurs	Recommended % habitat retention
Native	Shortfin eel	45	70
	Longfin eel	45	70
	Common bully	280 (optimum flow)	60
	Clutha flathead galaxias	180 (optimum flow)	90
Introduced	Brown trout adult	245	70
	Brown trout juvenile	220	80
	Brown trout spawning	420 (optimum flow)	NA

5.4. Flow distribution analysis

The recommended flows required to maintain fish habitat have been compared to the flow distributions[5] for the Tuapeka River. Flow distributions have been analysed for the irrigation season (October to April, inclusive) and the non-irrigation season (May to September, inclusive) due to the different flow patterns.

5.4.1. Irrigation season (October to April, inclusive)

Since the recommended flows have been estimated for the lower reach of the Tuapeka River, these flows are chosen for further analysis. Table 5.3 shows the percentage of time and average days that flows in the lower Tuapeka River are below the recommended for each instream value. Brown trout spawning is not included in the flow duration analysis during a normal irrigation season as its spawning season only occurs during winter months (May to September, inclusive).

Table 5.3 Comparison of the amount of time that flows are below those recommended to maintain habitat for fish species in the lower reach of the Tuapeka River during irrigation season

Species		Flow recommended by IFIM (l/s)	Percentage of time flow is reached (Oct - Apr)	Average No. days that flows are below recommended value
Native	Shortfin eel	45	0	0
	Longfin eel	45	0	0
	Common bully	280	3	6.4
	Clutha flathead galaxias	180	0.4	0.9
Introduced	Brown trout adult	245	1	2.1
	Brown trout yearling	220	1	2.1

Based on the flow distribution analysis over the simulated 22 years of records, flows at the lower reach are always above 160 l/s during a normal irrigation season. Flows in the lower reach are below the value recommended for juvenile and adult trout for an average of both 1% (2.1 days) during a normal irrigation season. About 3% (6.4 days) and 0.4% (0.9 days) of time during a normal irrigation season having flows drop below the recommended values for common bully and Clutha flathead galaxias, respectively.

[5] Simulated actual flows at both upper and lower reaches were used instead of naturalised flows for this analysis as getting naturalised flows is not possible due to the lack of needed information

5.4.2. Non-irrigation season (May to September, inclusive)

Similar to the analysis on the flow distributions during irrigation season, the recommended flows for the existing fish species have been assessed for the non-irrigation season (see Table 5.4).

Table 5.4 Comparison of the amount of time that flows are below those recommended to maintain habitat for fish species in the lower reach of the Tuapeka River during non-irrigation season

Species		Flow recommended by IFIM (l/s)	Percentage of time flow is reached (May - Sep)	Average No. days that flows are below recommended value
Native	Shortfin eel	45	0	0
	Longfin eel	45	0	0
	Common bully	280	0	0
	Clutha flathead galaxias	180	0	0
Introduced	Brown trout adult	245	0	0
	Brown trout yearling	220	0	0
	Brown trout spawning	420	3.5	5.4

Table 5.4 shows that no flows drop below the recommended values for all native fish species during the non-irrigation season for the lower reach. Brown trout spawning is the only one having flows below its recommended value during a normal non-irrigation season, estimated by 3.5% (5.4 days) in the lower reach.

6. Conclusions: Flow requirements for aquatic ecosystems in the Tuapeka River

A key concern when setting a minimum flow is to maintain flow variability to sustain instream values, as the total amount of water allocated has a significant effect on the flow variability in a given catchment. If the amount of water allocated has a relatively large proportion of the naturalised flow of the stream, the flow variability could be significantly reduced. The Draft Guidelines for the Selection of Methods to Determine Ecological Flows and Water Levels (MFE, 2008) state that a flushing flow between three and six times the median flow is required to flush fine sediment and algae. In the Tuapeka River, this equals to a flow of from 2,853 to 5,706 l/s. The current single water abstraction of maximum rate of 19 l/s in the Tuapeka River is unlikely to have any impact on flushing flows.

For the lower reach of the Tuapeka River, longfin and shortfin eel species, with optimum flows of both 45 l/s, are less sensitive to variation of flow changes. Clutha flathead galaxias and adult brown trout, the optimum flows of 180 l/s and 245 l/s, are more sensitive to flow changes.

The naturalised 7-day MALF for the lower reach of the Tuapeka River is around 360 l/s. Based on the flow distribution analysis over the 22 years of records, over 96% of time during a normal non-irrigation season, the flows are more than the optimum flow for brown trout spawning in the lower reach (420 l/s). This indicates that the flow regime of the Tuapeka catchment supports the recommended habitat and has no impact on the existing fish species.

Finally, this report does not aim to recommend a single management flow to maintain instream values in the Tuapeka catchment, but rather to inform on the potential effect of flows on specific instream values.

7. Acknowledgments

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8. Glossary

Catchment – The area drained by a river or body of water

Instream Flow Incremental Methodology (IFIM) – An instream habitat model used to assess the relationship between flow and available habitat for fish and invertebrates

7-day MALF (seven-day Mean Annual Low Flow) – The average of the lowest seven-day moving average flow for every year of record.

Mean flow – The average flow of a watercourse (i.e., the total volume of water measured divided by the number of sampling intervals).

Median flow – The ‘middle’ value of the whole flow records when they have been arranged in the order from the lowest to the highest.

Minimum flow – The flow below which the holder of any resource consent to take water must cease taking water from that river.

Primary allocation – The volume of water established under Policy 6.4.2 of the RPW that is able to be taken, subject to a primary allocation minimum flow.

Reach – A specific section of a stream or river.

7-day Low Flow – The lowest seven-day low flow in any year is determined by calculating the average flow over seven consecutive days for every consecutive seven day period in the year and then choosing the lowest.

Vegetation – Plant cover, including trees, shrubs, plants or grasses.

Water abstraction – The extraction of water from a water body (including aquifers).

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