CAWTHRON

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Review of biological data relating to the Waimea River Catchment

Prepared for

Waimea Water Augmentation Committee

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by

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Cover Photo: Lee River: Sally Marx, Tonkin & Taylor 2005

EXECUTIVE SUMMARY

Water in the Waimea River Catchment has come under increasing demand for out of stream uses, particularly irrigation, to the extent that in the lower catchment water currently is over allocated. Augmentation of flow in the river during periods of low flow, from a water storage reservoir, currently is being considered as a way to alleviate this problem. This report reviews existing biological data from the catchment, to make a preliminary assessment of what instream values, including the stream biota and habitat values, could be affected, and to identify gaps in existing knowledge that may need to be addressed in order to allow informed decision making.

Biological and water quality data from a range of sources indicate that the rivers of the Waimea Catchment generally are characterised by good water quality, although there are some concerns with nutrient enrichment and faecal contamination in the Wai-iti River. There also seem to be issues with elevated water temperatures, especially during prolonged periods of low flow in summer.

The Wairoa River's macroinvertebrate community does not appear to contain any rare or endangered species, however, the Wairoa River's fish community is considered to be of regional importance due to its diversity and includes dwarf galaxias and longfin eel, which are both classified as chronically threatened by DoC. Algal and macroinvertebrate communities are strongly influenced by flow conditions. Unsightly accumulations of algae are common in the Waimea River and in the lower reaches of the Roding, Wairoa and Wai-iti rivers. These algal growths presumably are responsible for the change from a mayfly dominated community to a worm dominated community that has been documented in the Waimea River and lower reaches of the Wairoa River during periods of low flow.

In general, there is a relatively large amount of information on the Waimea River, Roding River, and on the lower reaches of the Wairoa and Wai-iti rivers. Other areas of the catchment have been studied as part of the Tasman District Council's SoE monitoring programme, but little is known about the water quality, macroinvertebrates, or algae present in the Left and Right branches of the Wairoa River, the upper Lee River, or the tributaries of the Wai-iti River. Records of fish distribution within the catchment are reasonably well spread. Recent surveys in the middle and upper reaches of the Wairoa and Lee rivers have provided useful information on the fish communities present in these parts of the catchment. The most obvious knowledge gap is the paucity of information about the distribution of blue duck. There are anecdotal reports of blue duck in the Left Branch of the Wairoa River and in the lower reaches of the Lee River. It is not known if blue duck are found in the upper reaches of the Lee River or in the Right Branch of the Wairoa River, although these areas would be expected to provide good habitat. If the proposed dam site is chosen in these areas, further information on blue duck distribution and abundance would be required.

There is a range of potential water storage options being considered as part of the Waimea Water Augmentation Project. Based on existing information, storage systems on the Western tributaries of the Wai-iti River would have the least potential ecological impacts. The ecological effects of storage systems on the Lee River, and Right and Left branches of the Wairoa River are likely to be similar, although the perceived high value of the trout fishery in the branches of the Wairoa River probably means more potential impacts there. The confirmed presence of blue duck in the Left branch of the Wairoa River means that an assessment of the impacts of a storage system on blue duck would definitely be required in that part of the catchment. A storage system in the mid reaches of the Wairoa River would be expected to have the greatest ecological impacts of any storage option due to the large proportion of flow potentially retained there and the substantial change to the hydrological regime downstream.

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Report reviewed by:	Approved for release by:
Dr John Stark, Principal Scientist	Rowan Strickland, Freshwater Group Manager

1. INTRODUCTION

This report reviews the current state of knowledge of the aquatic biology and water quality of the Waimea River Catchment, Tasman District, New Zealand.

Water in this catchment has come under increasing demand for out of stream uses, particularly irrigation, to the extent that in the lower catchment water currently is over allocated. Augmentation of flow in the river during periods of low flow, from a water storage reservoir, currently is being considered. It is hoped that this development would make it feasible to alleviate some of the pressure on instream values, including recharging groundwater resources, while still meeting the needs of out of stream water users.

Part of the feasibility study for this potential development is to assess the likely impacts of the project on instream values, including the stream biota and habitat values. This report forms the first stage of such an assessment by reviewing the existing water quality and freshwater biological data from the catchment, to make a preliminary assessment of what could be affected, and to identify gaps in existing knowledge that may need to be addressed in order to allow informed decision making. The report does not address aspects related to terrestrial ecology in the catchment, or any potential impacts on riparian or terrestrial ecosystems that may occur as a result of inundation behind a water storage reservoir.

Most existing information relates to the lower reaches of the catchment, downstream of the Wairoa Gorge. This is understandable given that this is the area where the majority of abstraction occurs and land use intensity is highest. Therefore, it is also where any existing impacts are most likely to be apparent. There has also been a reasonable amount of investigation in the area associated with Nelson City Council's municipal water supply abstraction from the Roding River. More recently, Tasman District Council's (TDC) regular State of the Environment (SoE) monitoring has provided macroinvertebrate and water quality data for a number of sites throughout the catchment.

This report has been divided into sections focusing on water quality, algae, macroinvertebrates, fish, the trout fishery and blue ducks. These sections are then followed by a section on the effect of low flow in the catchment and an overall summary of the existing data and an indication of the gaps evident in the existing knowledge. The ecological advantages and disadvantages associated with the potential water storage sites are summarised.

2. EXISTING DATA

Information and data on the biology of the Waimea Catchment have been collected from a range of sources (Table 1).

Table 1 Sources of information used in this report

Information Source	Information	Sites sampled	Other details
Bruce 1986	Water quality, plus a broad description of macroinvertebrates and fish from the catchment	16 sites in the Waimea, Wai-iti, lower Wairoa, Lee and Roding rivers	Water quality information was based on samples collected at irregular intervals throughout the 1970’s and early 1980’s
Stark 1988	Macroinvertebrates, water quality, algae, fish	5 sites in the Waimea, lower Wai-iti and lower Wairoa rivers	
Stark 1992	Macroinvertebrates, algae and fish	Same 5 sites as for Stark 1988	Samples collected during a period of 1-in-20 year low flows in April 1992
Stark unpublished data	Macroinvertebrates	1 Site – Wairoa River at Gorge	Samples collected at least twice per month for one year, June 1993 - June 1994
Hayes & Stark 1995	Macroinvertebrates and fish	17 sites on the Roding River and 3 sites on Hackett Creek	
Strickland & Stark 1996	Macroinvertebrates and fish	4 sites re-sampled on the Roding River	
Stark 2004	Macroinvertebrates	2 sites on the Roding River	
Tasman District Council SoE and bathing waters data	Water quality, macroinvertebrates and algae	8 sites spread throughout the catchment	Bacteriological water quality is measured weekly/fortnightly over the summer season at 4 other sites
New Zealand Freshwater Fisheries Database	Fish	60 records submitted to the database	Database accessed 18 January 2005
Fish & Game drift dive data	Trout	5 sites – Waimea, Lee and 3 sites in the Wairoa	
DoC BioWeb	Blue duck	9 records submitted to the database	Database accessed 14 February 2005

2.1 Water quality

The water quality data reviewed indicated that water in rivers of the Waimea Catchment generally has been of good quality. However, there have been some exceptions. The Wai-iti River, in particular, has a history of elevated levels of nitrate and phosphate compared with the Waimea and Wairoa Rivers (Stark 1988; Bruce 1986). Peaks in faecal indicators, generally associated with flood flows, were also reported to be higher in the Wai-iti River (Bruce 1986). These data are based on sampling mainly concentrated in the lower catchment (Figure 1), and therefore conclusions on the upper catchment can only be based on the condition of water quality at the most upstream of sites sampled.

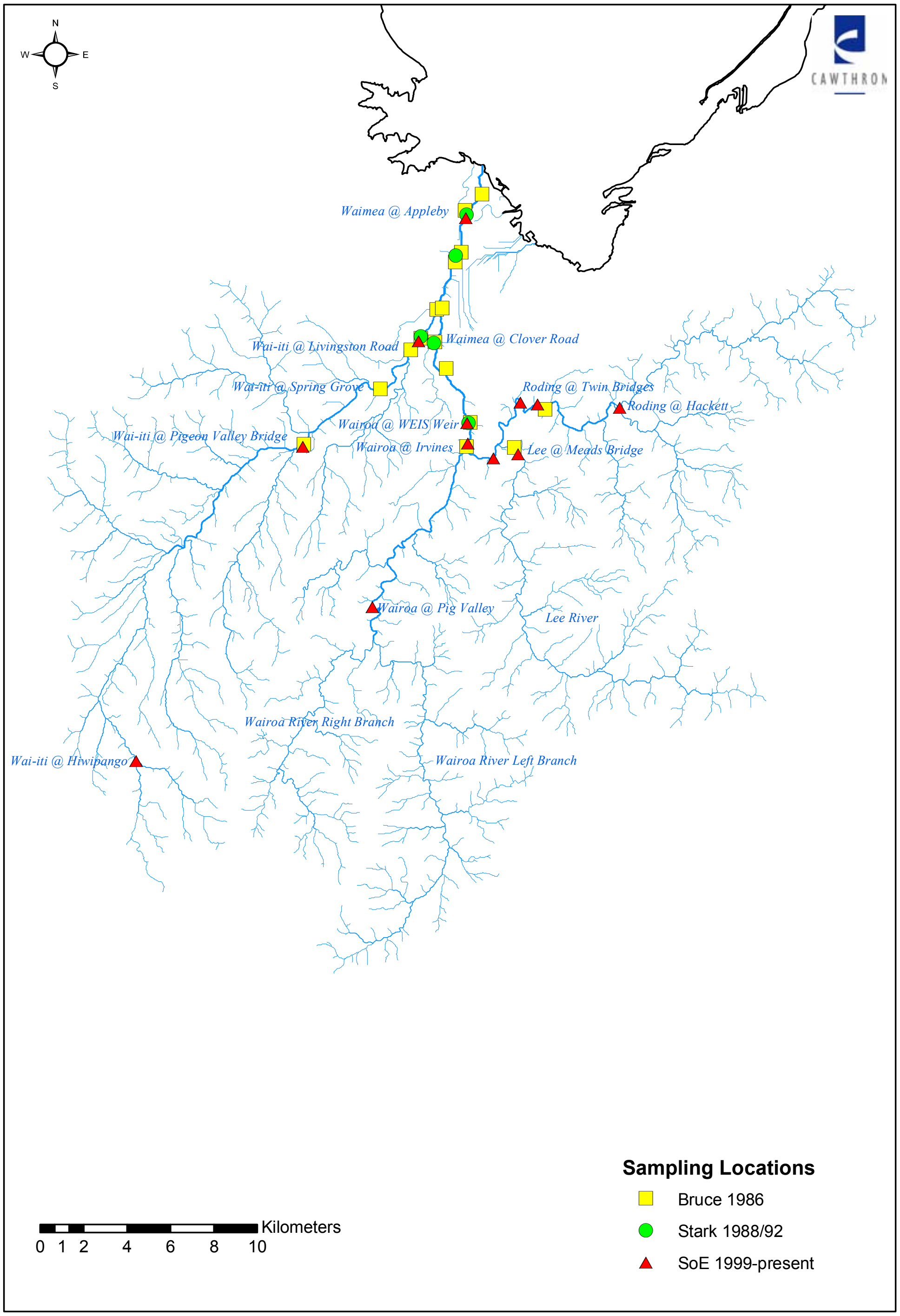

Figure 1 Sites in the Waimea Catchment where the water quality data reviewed in this report were recorded (coded by data source).

More recent water quality data are available from TDC's regular SoE and bathing water monitoring. Young *et al*. (2005) provides a good summary of these data. Most sites in the SoE program have been sampled quarterly since late 1999 and thus have been sampled 15-20 times to date. Sites sampled as part of bathing water surveys have been monitored weekly to fortnightly each year over the swimming season (November-March). Bathing water surveys involved only spot measurements of faecal indicator bacteria, whereas sampling at the SoE sites was undertaken using the following protocols. Spot field measurements of temperature, dissolved oxygen, pH, specific conductivity and turbidity were measured using standard meters (YSI 85, YSI 650, Orion 210A, Hach 2100P), while visual water clarity was measured using a black disc (Davies-Colley 1988). River flow was determined using either; velocity and depth measurements across the river cross-section, or from permanent stage-height recorders at the sites. Samples were collected for laboratory analysis of nitrate nitrogen (NO_3-N), ammonium nitrogen (NH_4-N), total nitrogen (TN), dissolved reactive phosphorus (DRP), total phosphorus (TP), total suspended solids (TSS), fixed (inorganic) suspended solids (FSS), volatile (organic) suspended solids (VSS) and faecal indicator bacteria (*Escherichia coli*). The quarterly sampling generally has been carried out under stable flow conditions.

These data also show water quality to be largely of a good standard, generally complying with appropriate standards (Table 2), but there are a few exceptions. Total nitrate and dissolved inorganic nitrogen exceeded guideline levels (Table 2) on approximately 25 % of sampling occasions in the Waimea River at Appleby, and on 77 % and 57 % of sampling occasions in the Wai-iti River at the Livingstone Road and Pigeon Valley sites respectively (Figure 2).

Table 2 Guideline water quality values for protection of river ecosystem and human health.

Parameter	Guideline value		Reference
Dissolved oxygen	>80% Saturation or >6.5 mg/L		ANZECC (1992)
pH	5 - 9		CCREM (1987)
Clarity	>1.6 m		ANZECC & ARMCANZ(2000)
Turbidity	<5.6		ANZECC & ARMCANZ(2000)
Total nitrogen	<0.614 mg/L		ANZECC & ARMCANZ(2000)
Dissolved inorganic nitrogen	<0.444 mg/L		ANZECC & ARMCANZ(2000)
Dissolved reactive phosphorus	<0.01 mg/L		ANZECC & ARMCANZ(2000)
Total phosphorus	<0.033 mg/L		ANZECC & ARMCANZ(2000)
E. coli	<260 cfu/100 mL	Acceptable	MfE & MoH (2002)
	260-550 cfu/100 mL	Alert	
	>550 cfu/100 mL	Action	

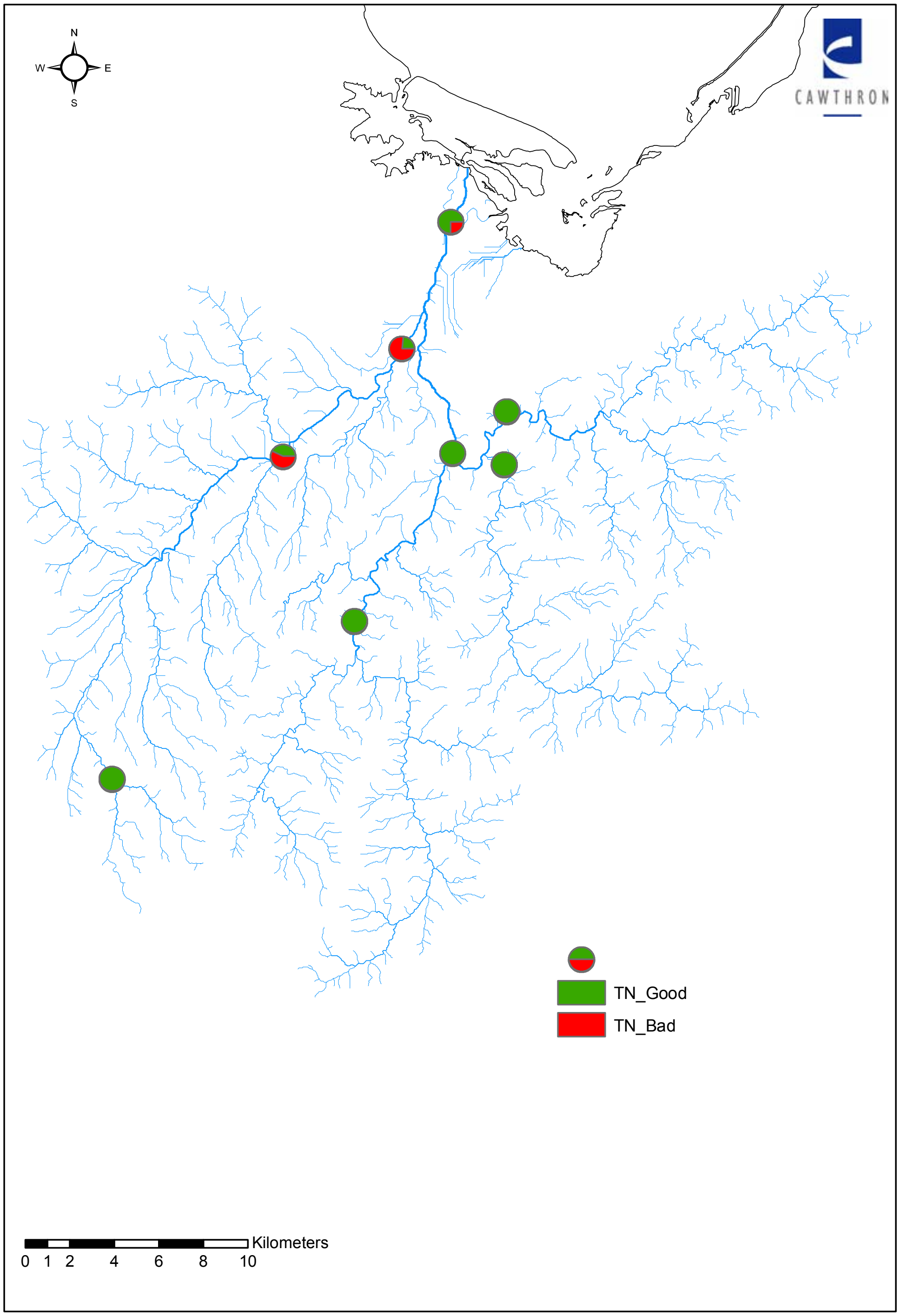

Figure 2 Proportion of sampling occasions on which levels of Total Nitrogen (TN) were within, or exceeded, guideline levels at SoE monitoring sites. (See Table 2 for guideline levels and Figure 1 for site names).

Similar patterns of guideline exceedances were evident for Dissolved Inorganic Nitrogen (Figure 3). However, there have also been a small number of exceedances of this guideline in the Wairoa River @ Irvines.

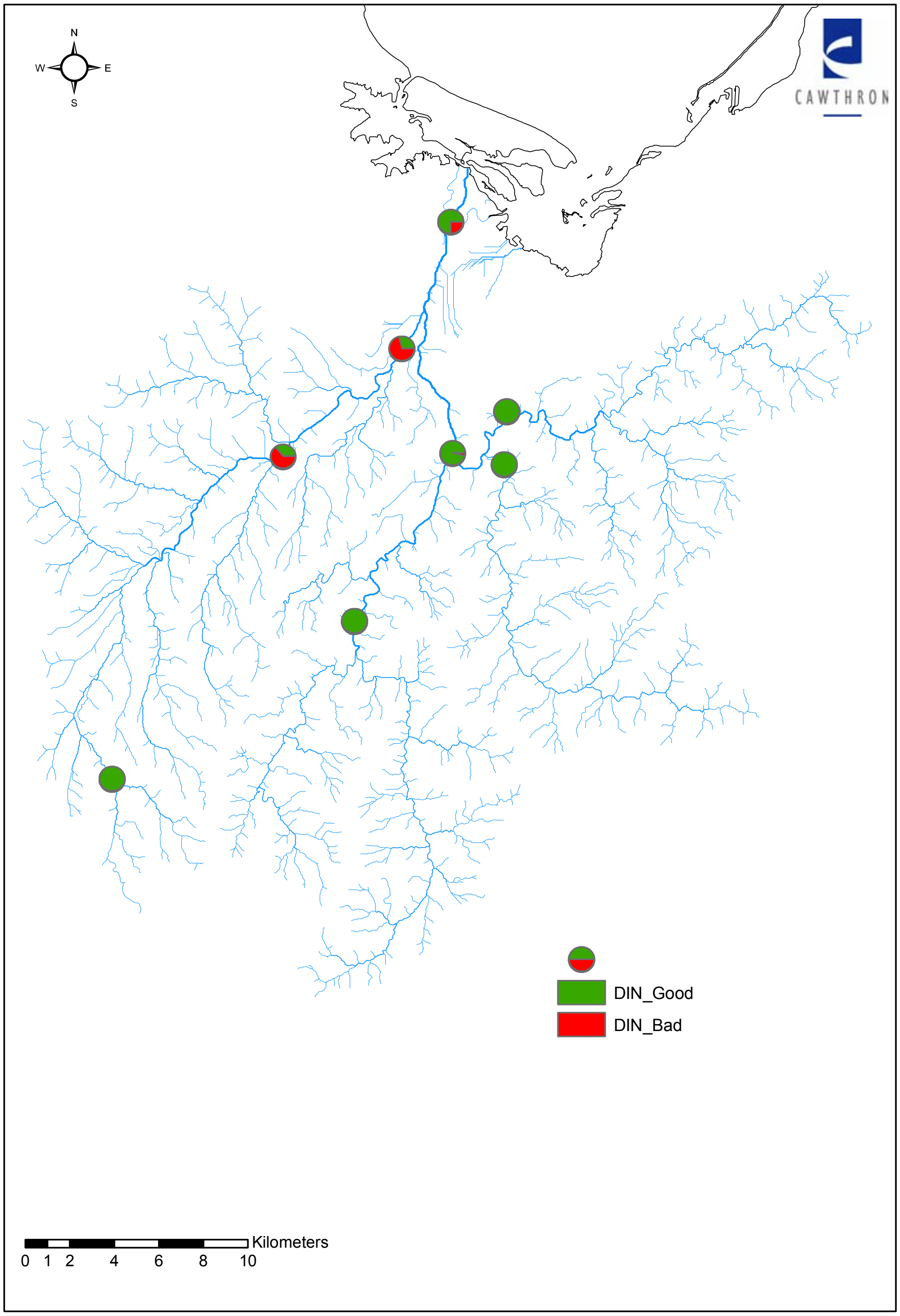

Figure 3 Proportion of sampling occasions on which levels of Dissolved Inorganic Nitrogen (DIN) were within, or exceeded, guideline levels at SoE monitoring sites. (See Table 2 for guideline levels and Figure 1 for site names).

Total phosphorus exceeded guidelines in less than 10 % of samples in the lower Waimea and to a lesser extent in the Wai-iti (Figure 4), with a similar trend evident in dissolved reactive phosphorus (DRP, Figure 5). However, the Wai-iti site above Hiwipango exceeded guideline levels for DRP on 75 % of sampling occasions (Figure 5).

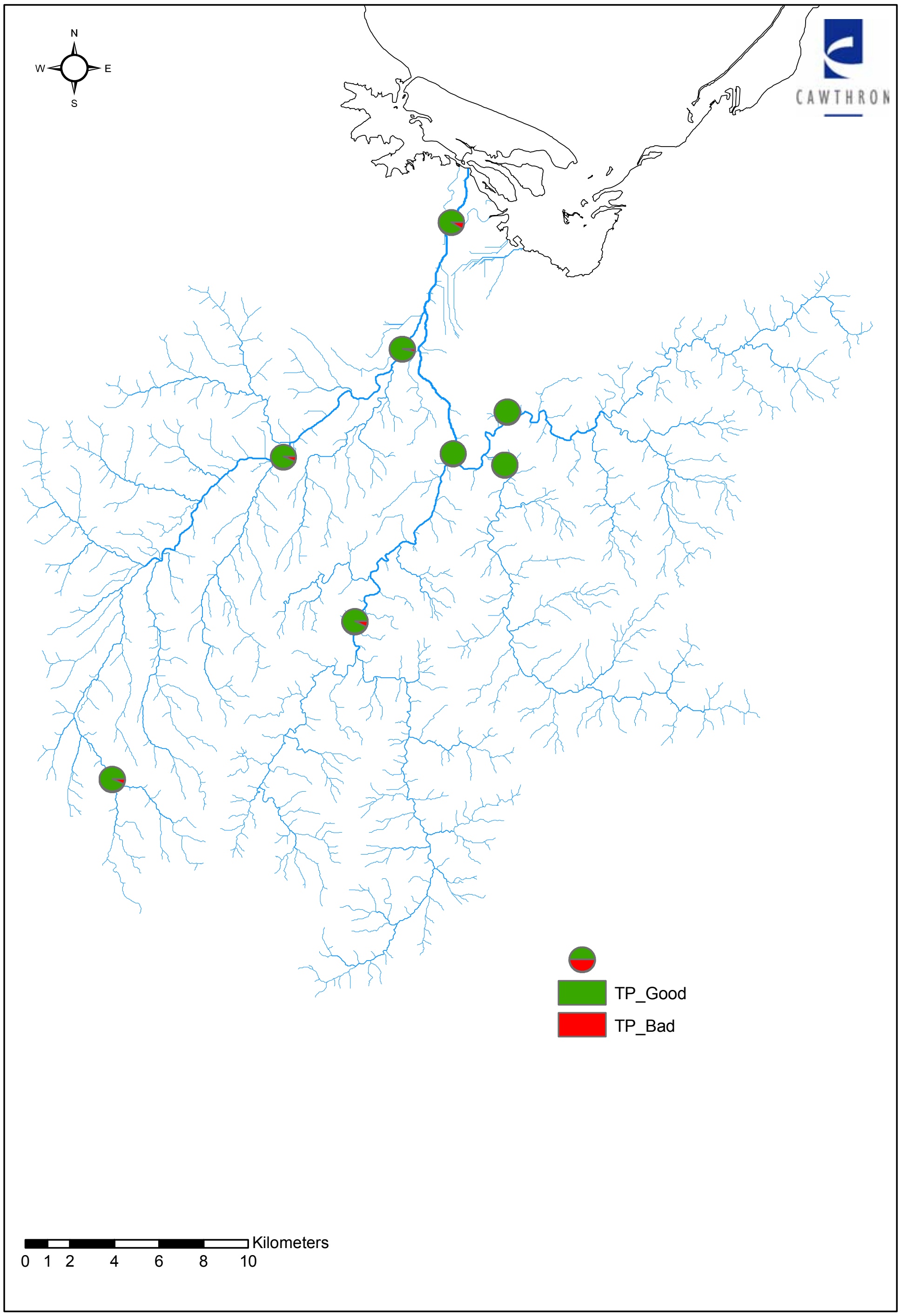

Figure 4 Proportion of sampling occasions on which levels of Total Phosphorus (TP) were within, or exceeded, guideline levels at SoE monitoring sites. (See Table 2 for guideline levels and Figure 1 for site names).

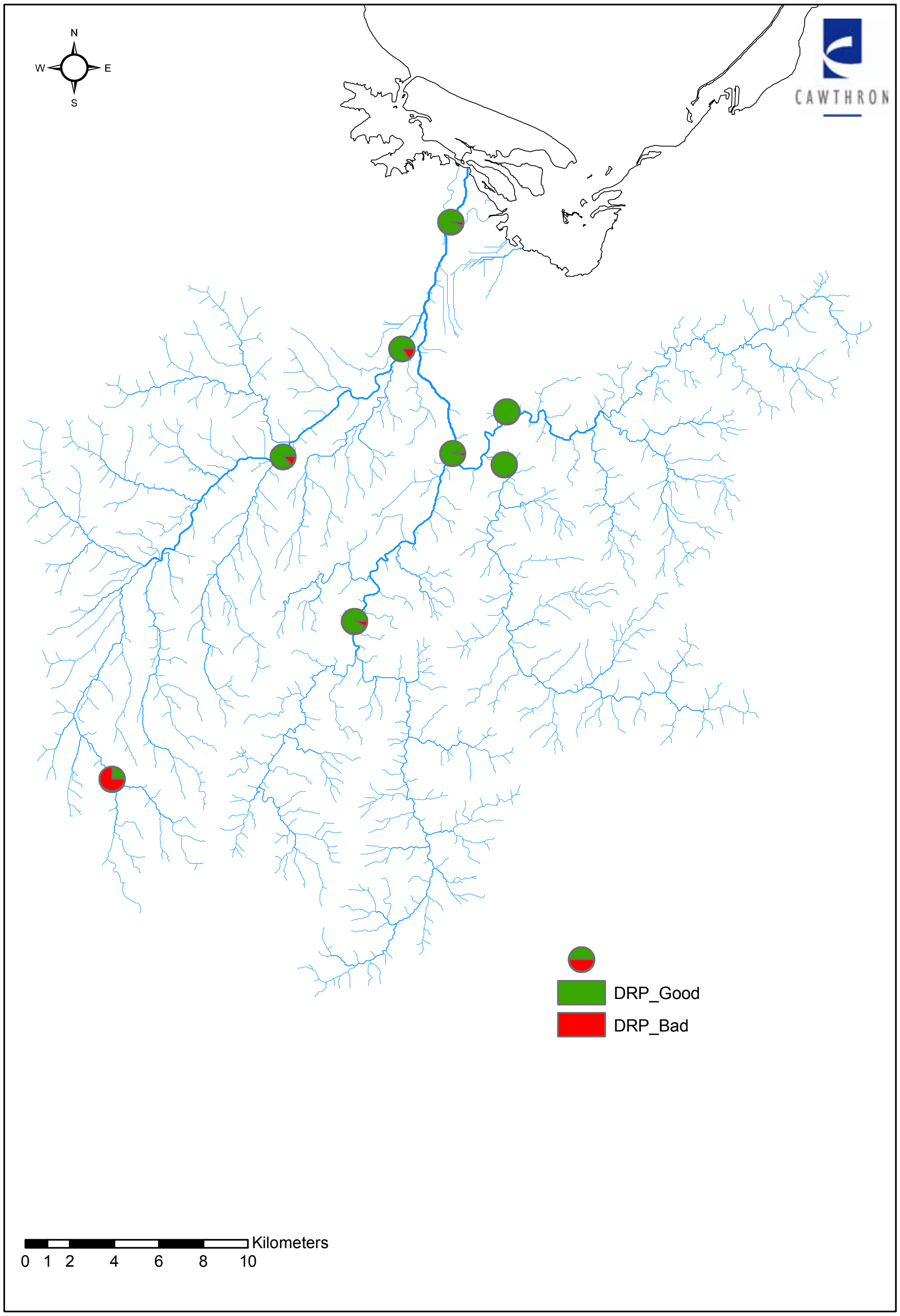

Figure 5 Proportion of sampling occasions on which levels of Dissolved Reactive Phosphorus (DRP) were within, or exceeded, guideline levels at SoE monitoring sites. (See Table 2 for guideline levels and Figure 1 for site names).

The Wai-iti River at Livingston Road also exceeded water clarity and turbidity guidelines on approximately 15 - 20 % of sampling occasions (Figures 6 & 7), with guidelines also being exceeded very occasionally in the Wairoa @ Irvines site. Turbidity guidelines also were exceeded occasionally at the Wai-iti @ Pigeon Valley and Lee @ Meads sites (Figure 7).

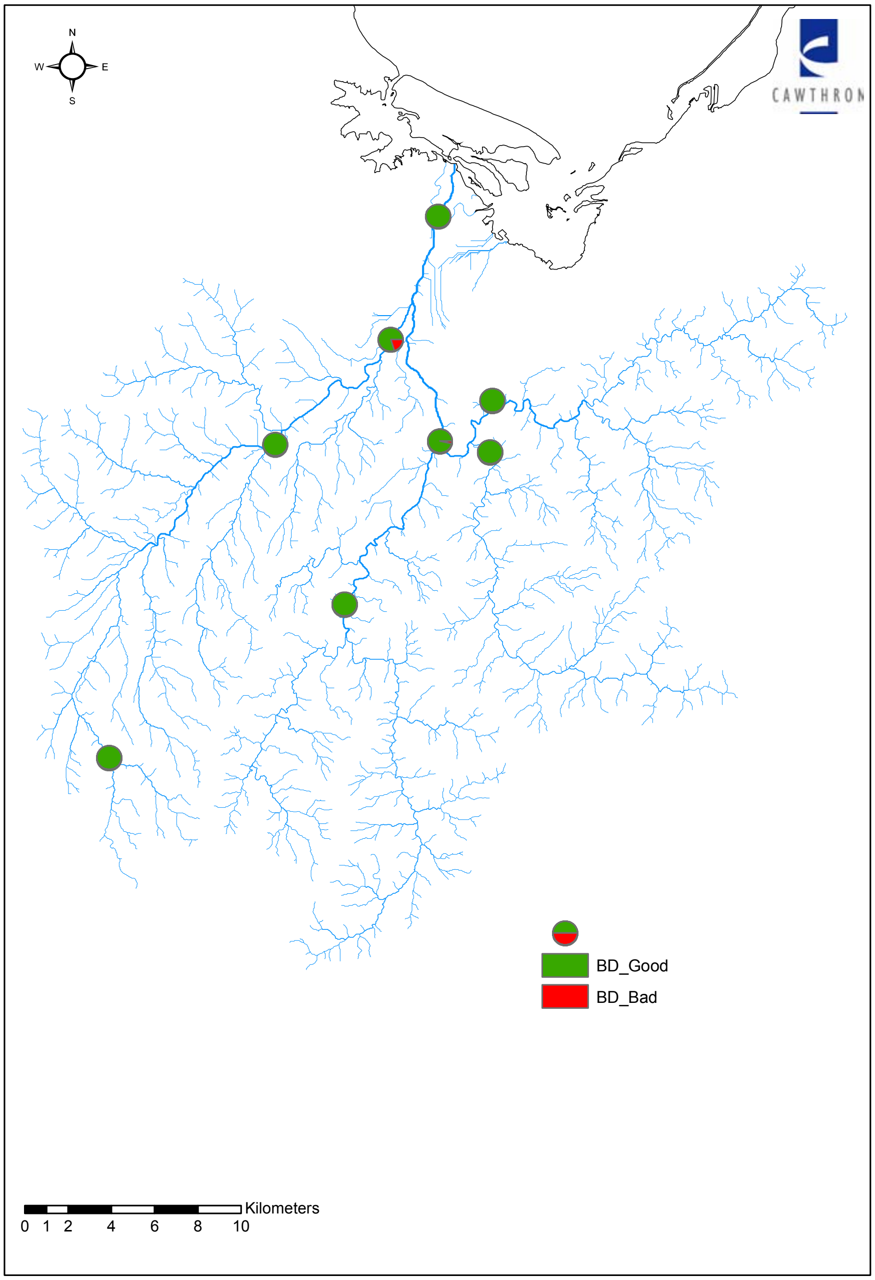

Figure 6 Proportion of sampling occasions on which 'Black Disc' (BD) measurements of water clarity were within, or exceeded, guideline levels at SoE monitoring sites. (See Table 2 for guideline levels and Figure 1 for site names).

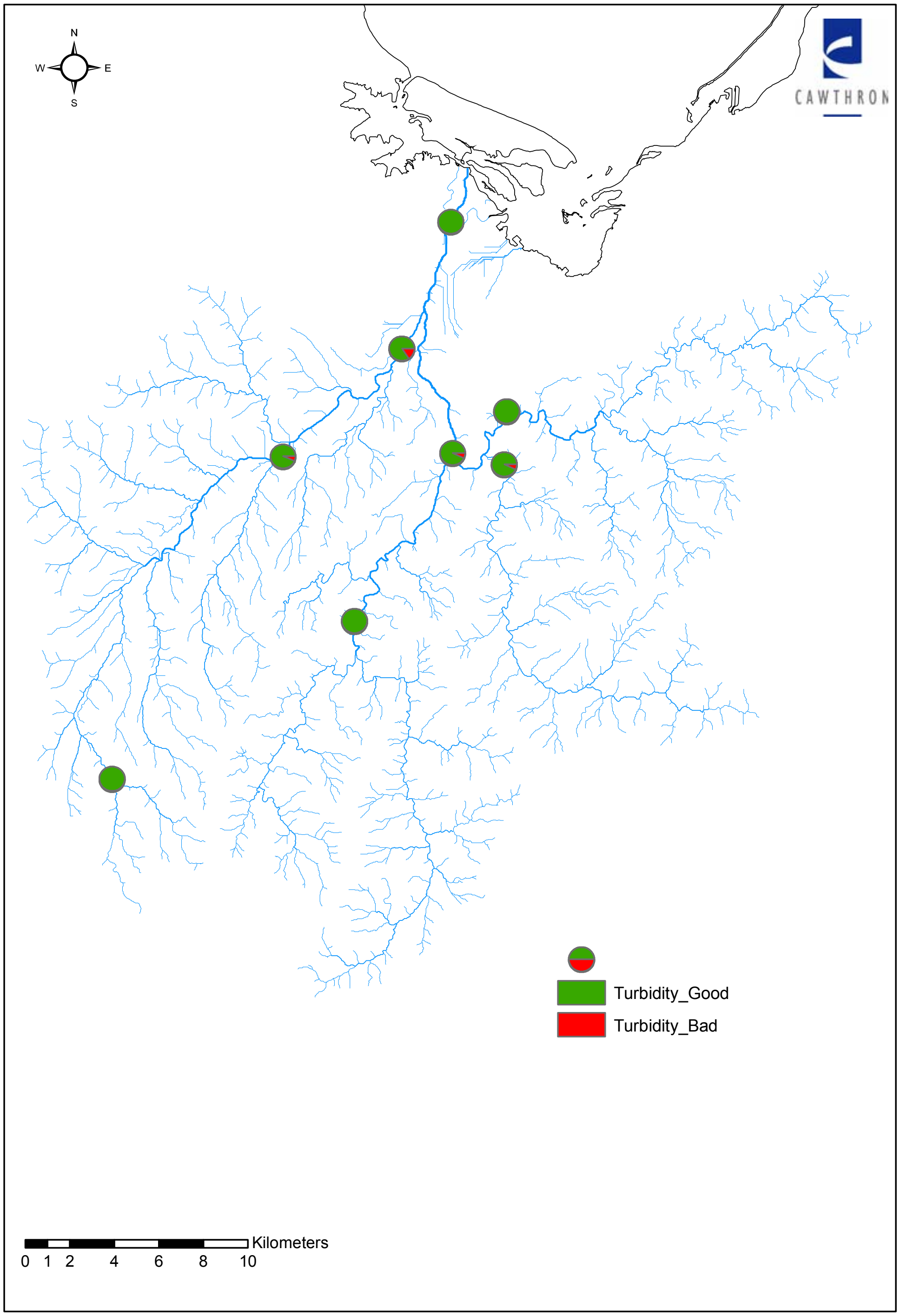

Figure 7 Proportion of sampling occasions on which levels of turbidity were within, or exceeded, guideline levels at SoE monitoring sites. (See Table 2 for guideline levels and Figure 1 for site names).

Concentrations of the faecal indicator bacteria exceeded the high 'Action' level on approximately 4 % of sampling occasions at the Wai-iti @ Livingston Road site (Figure 8). The more moderate 'Alert' level was exceeded at other times at the Wai-iti @ Livingston Road site and occasionally at the Wai-iti @ Pigeon Valley, Roding @ White Gates and Wairoa @ Irvines sites (Figure 8). Samples collected at the remaining sites indicated that faecal bacteria numbers were sufficiently low to allow safe contact recreation (Figure 8).

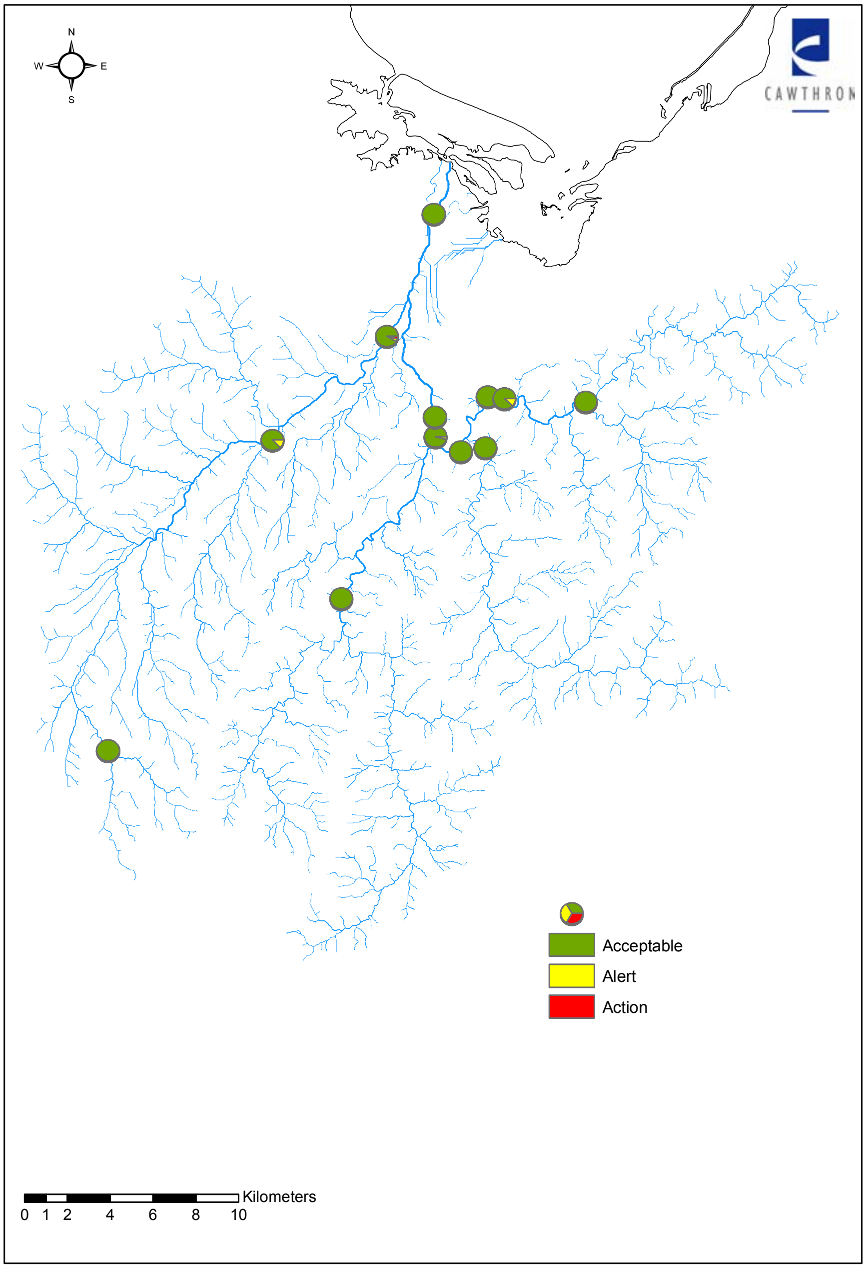

Figure 8 Proportion of sampling occasions on which levels of the faecal indicator bacteria *E. coli* were within, or exceeded, guideline levels at SoE and bathing water monitoring sites. (See Table 2 for guideline levels and Figure 1 for site names).

Notwithstanding these exceedances, the generally good water quality measurements at most of the sites in the Waimea Catchment caused these sites to be grouped with other clean water sites in the wider Tasman District in a cluster analysis (Young *et al*. 2005). The only exceptions were the Wai-iti @ Pigeon Valley and Wai-iti @ Livingston Road sites, which clustered with sites of intermediate water quality (Young e*t al.* 2005). These sites have a larger proportion of agricultural land in their catchment upstream than the other sites.

High temperatures, particularly associated with low summer flows are common, especially in the lower reaches of the catchment (Hayes 1998; Hayes & Stark 1995; Bruce 1986; Rob Merrilees, NIWA, unpublished data). The main concerns with water temperature are the effects of high temperatures on aquatic life. Some species prefer relatively cool water and may become stressed or die if temperatures become too high. For example, laboratory studies indicate that brown trout growth is optimal at 13°C (Elliott 1994). Trout will cease feeding once temperatures climb above 19°C and begin to die once temperatures exceed 25°C for a sustained period (Elliott 1994; Jowett 1997). Trout cannot tolerate temperatures above 30°C for even a short period. Similarly, Quinn et al. (1994) examined the temperature tolerances of 12 types of freshwater invertebrates and found that LT_{50} values (*i.e.*, the temperature at which 50% of animals died after 96 hours) ranged from 22.6°C to 32.4°C.

Spot water temperature measurements taken at a range of sites around the catchment in early February 2005 were extremely high (Rob Merrilees, NIWA, unpublished data). Temperatures ranged between 21.9 – 27.6 °C (mean 25.1 °C), with these very high temperatures being recorded relatively high in the catchment. The maximum temperature reported was recorded in the Roding River upstream of its confluence with the Lee, with other sites in the Lee and the Wairoa also exhibiting very high water temperatures. Interestingly, the lowest temperatures recorded in this survey were from the Wai-iti River.

2.2 Algae

Algae (or periphyton) are an important component of most river ecosystems, since they provide the base of the food chain in a similar way that grass provides food for the animals on a farm. However, too much of a good thing can be a problem. If abundant nutrients are available in the water, filamentous green algae will dominate and form unsightly mats covering the riverbed under stable flow conditions. This filamentous green algae is a poor quality food for macroinvertebrates compared to the thin layer of brown algae (diatoms) that is normally present in streams with low nutrient concentrations. In addition to being unsightly, the thick mats of green algae can cause problems with water quality reducing dissolved oxygen concentrations and causing high pH levels.

An early review of biological data from the Waimea Catchment (Bruce 1986) concluded that little was known about algal community composition in the catchment, other than that *Melosira* was reported to be common in the Wairoa Gorge during late summer.

Subsequent surveys by Stark (1988; 1992), of the same 5 sites from which water quality data were reported in his 1988 report (Figure 9), recorded 17 algal taxa (Appendix 1). Stark (1988; 1992) reported that the algal community composition was reasonably variable, both spatially and temporally. Although eight taxa were found at all five sites in the surveys on which his 1992 report was based, none were found at all sites on all three sampling occasions. Stark (1988) stated that 'the degree of algal proliferation is related not only to the nutrient status of the waterbody but also to the hydrological regime and the season'. He went on to conclude that given the relatively low conductivity of waters in the Waimea Catchment (indicating low nutrient enrichment), that development of algal communities to nuisance levels was unlikely, except under conditions of prolonged summer low flows or in localised areas of nutrient enrichment.

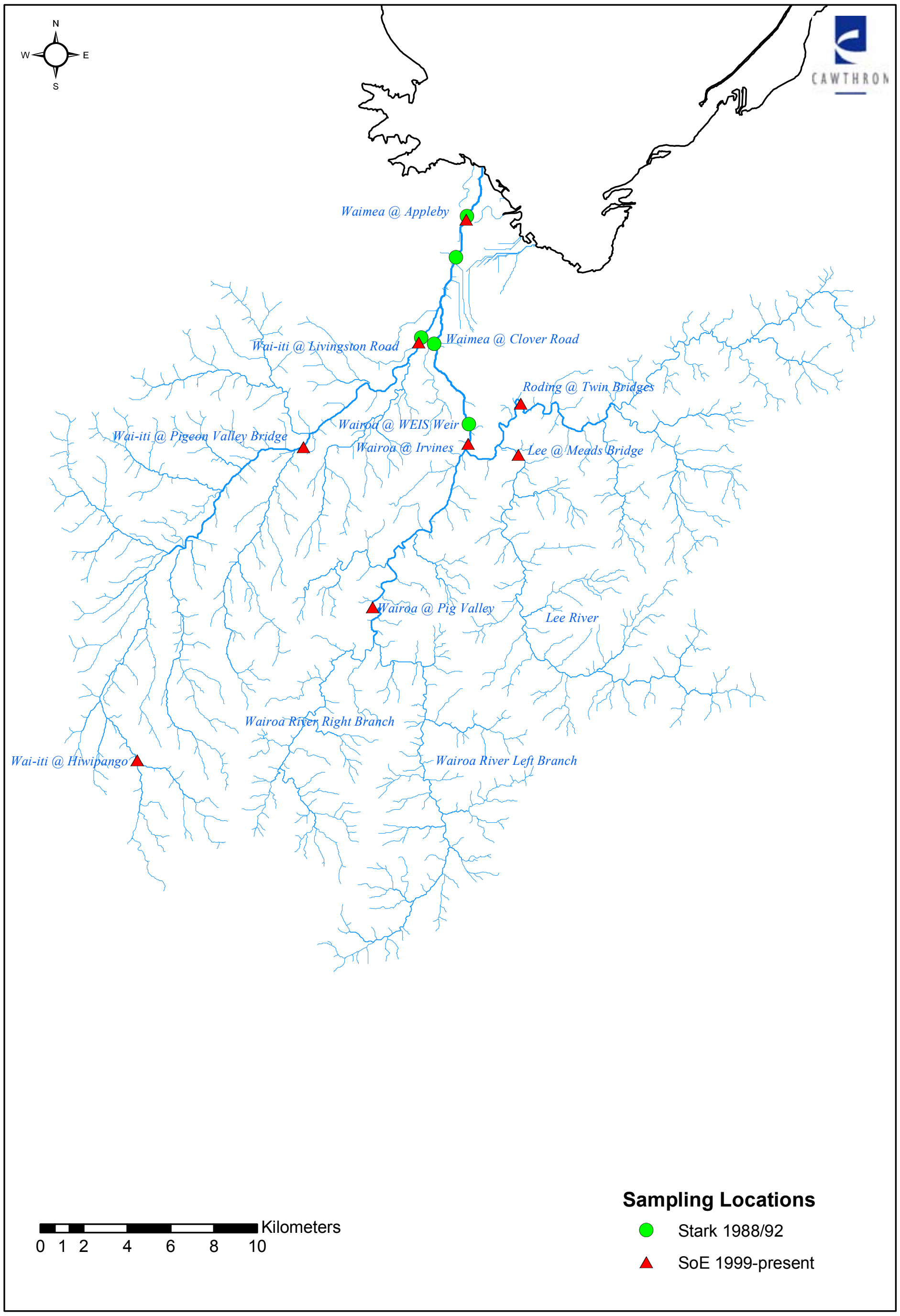

Figure 9 Sites in the Waimea Catchment where the algal data reviewed in this report were recorded (coded by data source).

As part of regular SoE monitoring TDC records observations of periphyton using the 'Rapid Assessment Method 2' protocol (Biggs & Kilroy 2000) at its monitoring sites (Figure 9). This involves estimating the percentage cover of all algae present, classified according to their appearance (*e.g.* growth-form and colour), at a number of regularly spaced points across 5 separate transects. The percentage cover values are weighted according to the pollution tolerance of each algal classification, and are then combined to give an overall score for the site ranging between 1 and 10 (1 indicating a site with highly degraded water quality and a score of 10 indicating a healthy site with good water quality). The TDC's methodology varies from that outlined by Biggs & Kilroy (2000) in that clean substrate is given a score of 10 (along with pollution intolerant classes of algae), rather than scoring 0.

In general, these data also showed the rivers of the Waimea Catchment to be healthy. All sites sampled have achieved the highest possible score of 10 during at least one sampling episode. The median scores of all sites were 8.5 or above. However, low scores have been recorded at many of the sites during periods of low flow. For example, scores from the Roding @ Twin Bridges, Wai-iti @ Pigeon Valley and Waimea @ Appleby sites were below 5 during the extremely low flows in late summer in 2001. Scores at the Wairoa at Irvines site were also relatively low during this period (<7), whereas scores at the Wai-iti @ Hiwipango, Wairoa @ Pig Valley and Lee @ Meads Bridge sites were still relatively high (>8.5). A separate set of 'one-off' periphyton assessments were carried out at other sites in the lower Wairoa and Waimea rivers during this low flow period. The lowest score (3.6) was recorded at the Wairoa @ WEIS Weir site, while scores at Clover Road, Wai-iti confluence, Nursery and Challies Island sites ranged between 4.7 and 6.7.

2.3 Invertebrates

The initial surveys of benthic macroinvertebrates in the Waimea Catchment focussed on 5 sites – 2 in the Wairoa River, 2 in the Waimea River, and 1 in the Wai-iti River (Stark 1988, 1992, Figure 10). The 1988 survey recorded 38 different types of macroinvertebrates, whereas the 1992 survey conducted during low flows recorded 65 macroinvertebrate taxa (Appendix 2). As well as this significant increase in species richness, the densities of the 6 most abundant taxa (*Deleatidium* mayflies; Elmidae beetles, Orthocladiiinae midges, *Aoteapsyche* caddisfly, *Pycnocentrodes* caddisfly, and Annelida worms) were higher in 1992 than in 1988 (Stark 1992). In both reports (Stark 1988; 1992), these numerically abundant species accounted for 86 – 96 % of the communities at each site.

There were also differences in macroinvertebrate community composition over this period, especially at the Waimea downstream of Appleby Bridge and Wairoa @ Clover Road sites where mayflies had been the dominant macroinvertebrates in 1988, but worms dominated the community at these sites in 1992. Stark (1992) suggested that this difference in community composition could have been due to an accumulation of fine organic-rich sediment within the streambed following the prolonged period of low flows prior to sampling in 1992. It should be noted that all these macroinvertebrate samples were collected from shallow riffles which provide similar physical conditions at high and low flow. Larger differences in community composition resulting from low flow periods would be expected in pools and runs where changes in water velocity and algal accumulation are likely to be substantial.

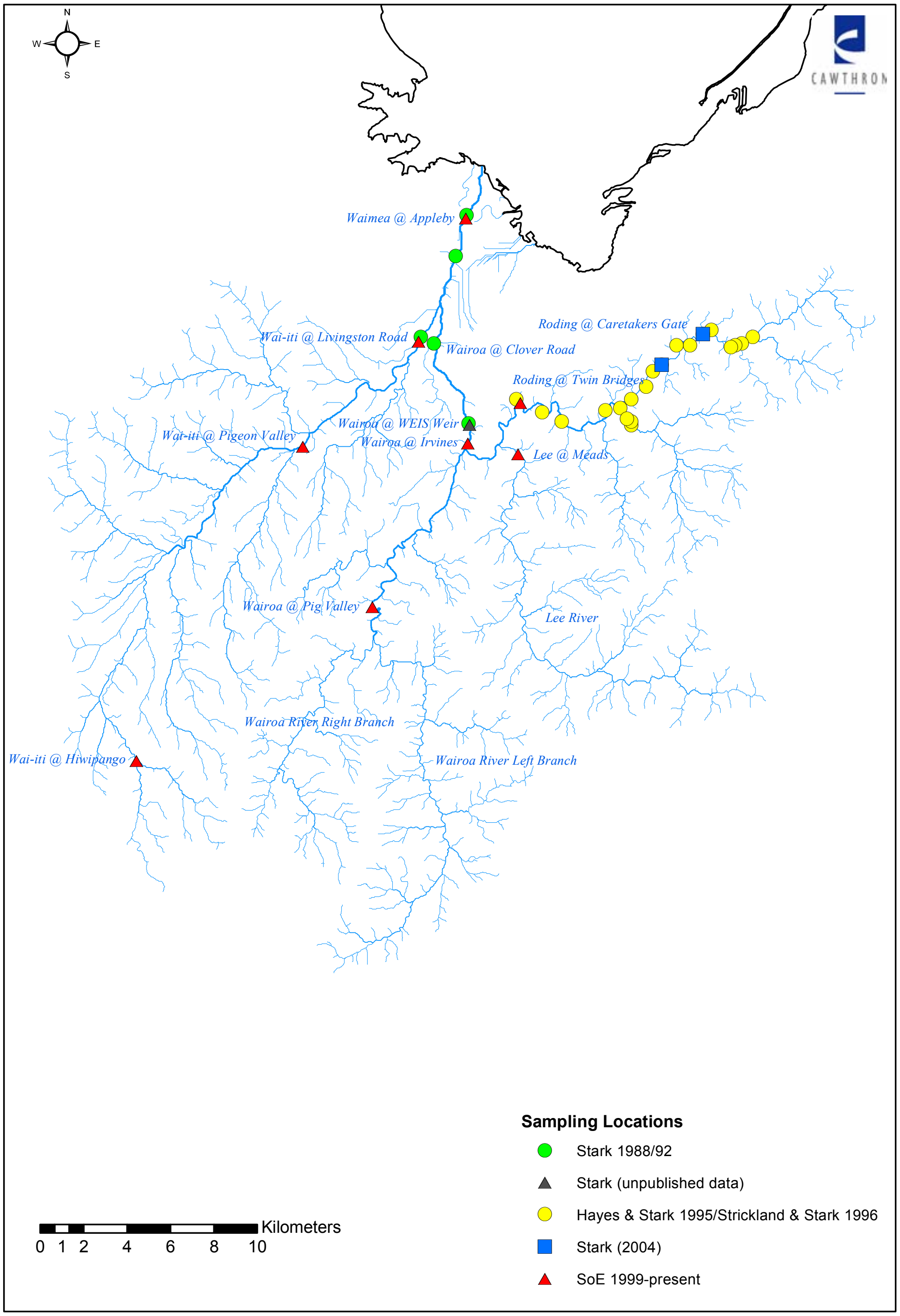

Figure 10 Sites in the Waimea Catchment where the benthic macroinvertebrate data reviewed in this report were recorded (coded by data source).

Despite the variability in the underlying richness and densities of invertebrate communities sampled in the catchment there is a reasonable degree of consistency in community indices calculated for these communities. Community indices provide a way of summarising large macroinvertebrate community datasets to give an indication of the type of community found at a given site, and the relative level of pollution tolerance of the given community. One advantage that this type of index has over spot measurements of water quality is that, since benthic invertebrates are reliant on the quality of the water in which they must dwell for most of their lives, indices based on their tolerance to pollution tend to give an indication of water quality over a longer period of time. A range of these indices show that the invertebrate communities through much of the Waimea Catchment are generally indicative of reasonably high water quality over time.

Intensively repeated sampling at one site in the Wairoa Gorge (Figure 10) (sampling at least twice per month for one year, June 1993 – June 1994) indicated consistently good water quality (Stark, unpublished data). Macroinvertebrate Community Index (MCI) scores were consistently >120, indicating an invertebrate community typical of clean water. Only on one occasion after a prolonged period of low flow did the MCI drop below this threshold (to 114, *i.e.* a community indicative of possible mild pollution). Two weeks later, after a large flood had occurred, it had recovered to its previous higher value.

Hayes & Stark (1995) found 44 taxa (Appendix 2) in a survey of the Roding River (Figure 10), although at reasonably low density relative to the nearby Maitai River. The communities sampled were dominated mainly by mayflies and caddisflies, with the pollution intolerant stonefly *Zelandoperla decorata* also being well represented in samples. In general, these communities returned good scores for the MCI and the quantitative version of this index (the QMCI), although scores decreased for communities downstream of Stratford Creek with increasing dominance of dipterans (true flies). Strickland & Stark (1996) also reported MCI and QMCI scores indicative of generally high water quality in the Roding River. More recently, Stark (2004) reported that the % EPT (percentage of the community comprised by Ephemeroptera [mayflies] Plecoptera [stoneflies] and Trichoptera [caddisflies]), MCI and QMCI all 'suggest that the Roding River is a moderately enriched stony stream at the Caretaker's site' (Figure 10), although 'following significant freshes, …flushing of periphyton and associated macroinvertebrate communities can produce conditions where mayflies and caddisflies are dominant and biological indices tend to be indicative of slight enrichment verging on pristine conditions'.

The taxa that were found to dominate invertebrate communities in samples from the Roding River were also known to be widespread or abundant in other rivers of the Nelson region (Hayes & Stark 1995; Strickland & Stark 1996). Although there were a few taxa recorded during this sampling that had not been recorded in other rivers in the Nelson region at that point in time, there were no rare or endangered species (on a national basis) found (Hayes & Stark 1995; Strickland & Stark 1996). However, in terms of the variety of macroinvertebrates found, the Roding Catchment would rank very highly on a national basis (Hayes & Stark 1995).

The most recent information available covering the wider Waimea Catchment comes from TDC's SoE monitoring, summarised by Young et al. (2005). These data showed low species richness in the lower Waimea River, but average levels elsewhere in the catchment, low % EPT in the Roding, but moderate elsewhere, and satisfactory to good MCI scores throughout the catchment. Scores for the SQMCI (the semi quantitative version of the MCI) indicated very good stream health in the upper parts of the catchment (Wairoa @ Pig Valley, Wairoa @ Irvines, Wai-iti @ Hiwipango), and good stream health in the rest of the catchment (Figure 11). The only exception was the lower reaches of the Wai-iti River at the Livingston Road site which had only satisfactory stream health (average SQMCI = 5.9, Figure 11), and reflects the relatively fair water quality at this site.

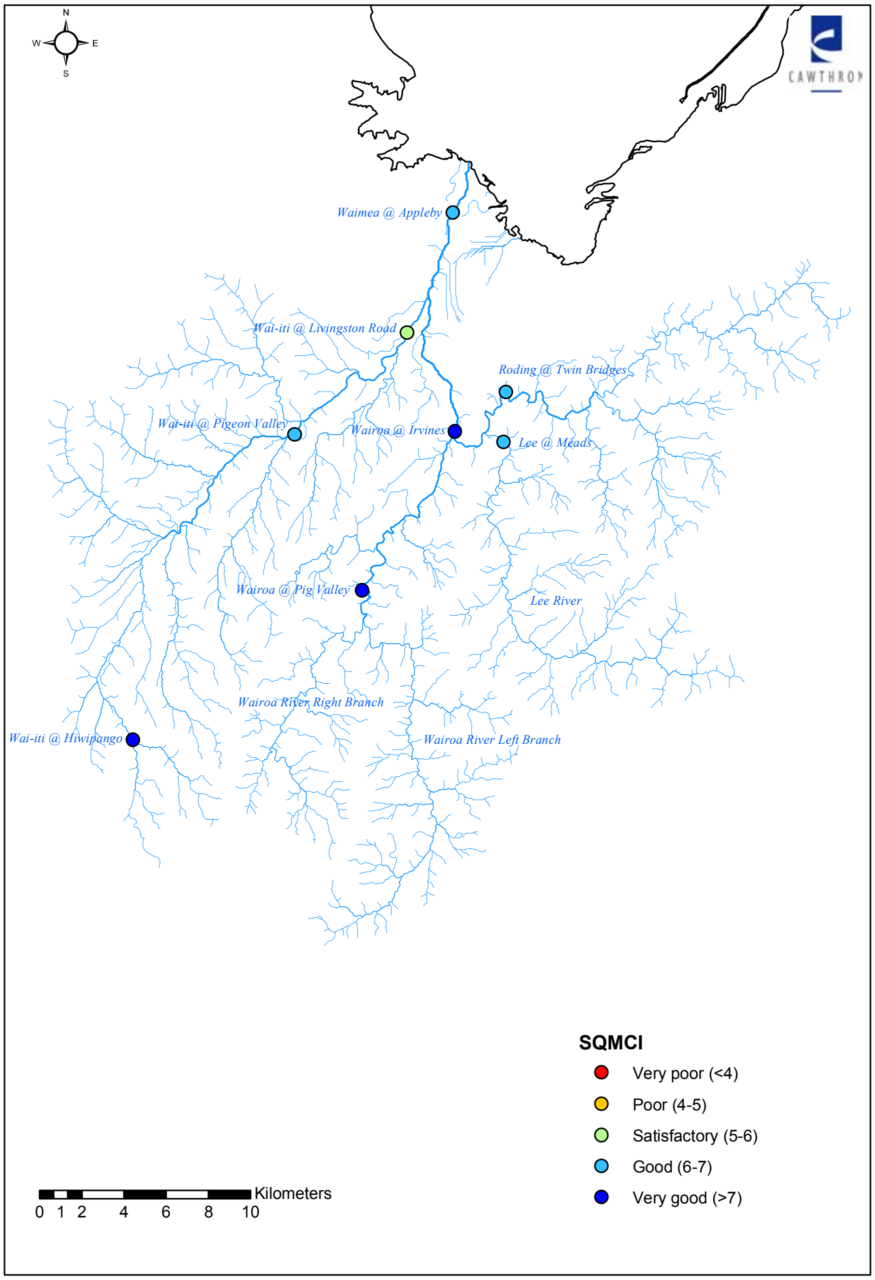

Figure 11 Average semi-quantitative macroinvertebrate community index (SQMCI) scores from the SoE monitoring sites. This index is based on the presence/absence and abundance of particular types of macroinvertebrates found at each site.

Hayes (1998) investigated habitat availability for benthic macroinvertebrates in relation to flow in the Waimea, Wairoa and Wai-iti rivers. This study employed habitat modelling within an Instream Flow Incremental Methodology (IFIM; see Bovee *et al.*

1998 for a description of this methodology), focusing on habitat in runs and riffles. The results of this modelling predicted that macroinvertebrate habitat availability will decline sharply below about 1 m^3/s in the Wairoa/Waimea mainstem. Therefore, Hayes (1998) suggested that a large improvement in habitat availability for benthic macroinvertebrates could result from relatively small increases to the minimum flow.

Koura (freshwater crayfish) have also been recorded during fish surveys in the Waimea Catchment (Figure 12; Appendix 3), and are listed by DoC as one of the aquatic values of the upper Lee River (BioWeb 2005).

2.4 Fish

There have been 15 different species of fish recorded from the Waimea Catchment (NZFFD 2005) (Appendix 3; Figures 12 - 15). Thirteen of these species are native fish, with brown trout and a single record of a chinook salmon in the Waimea River (Figure 12) being the 2 exotic species recorded from the catchment. Two additional native fish species (giant kokopu, *Galaxias argenteus*; lamprey, *Geotria australis*) have been recorded in Pearl Creek, a spring fed stream that drains into the Waimea Inlet. This creek depends on groundwater from the Waimea River system and therefore could be considered part of the larger Waimea River catchment.

Brown trout are found throughout most of the catchment (Figure 12). Torrentfish have primarily been recorded from the lower parts of the catchment, although they were recently found in the middle reaches of the Lee River (Figure 12).

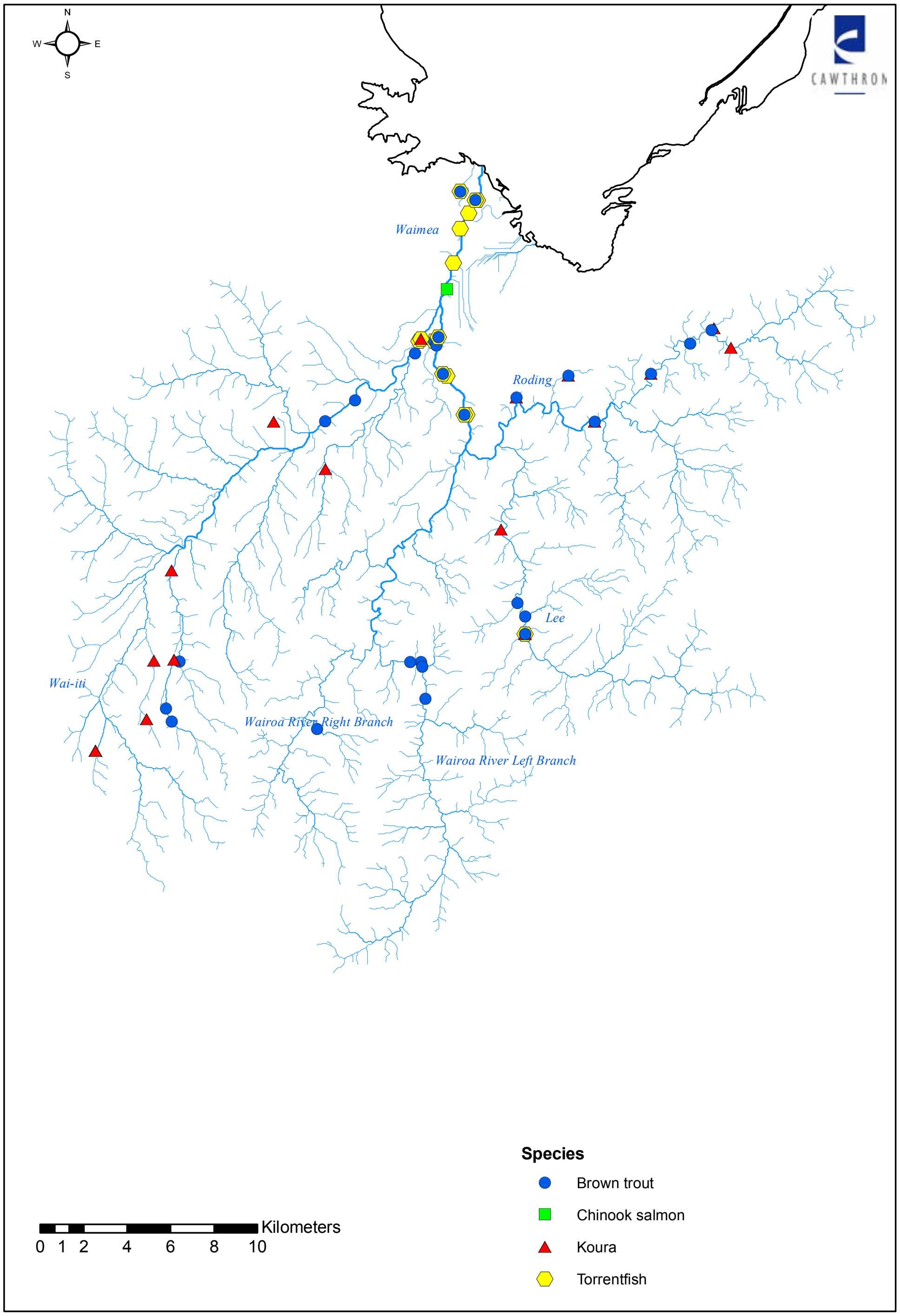

Figure 12 Locations of brown trout, chinook salmon, torrentfish and koura recorded from the Waimea Catchment.

Inanga are common in the lower reaches of the Waimea River and also have been recorded from the lower Wai-iti River (Figure 13). In contrast, koaro have only been recorded from the upper parts of the Wairoa, Lee and Roding rivers (or their tributaries). Koaro generally are found only in streams draining areas of native forest. Two native galaxiids, *G. divergens* (dwarf galaxias) and *G. fasciatus* (banded kokopu) have been recorded only once each in the catchment (Appendix 3). The dwarf galaxiid was recorded from the Wairoa and the banded kokopu from a tributary of the Roding (Figure 13). Dwarf galaxias are classified as 'chronically threatened' by DoC.

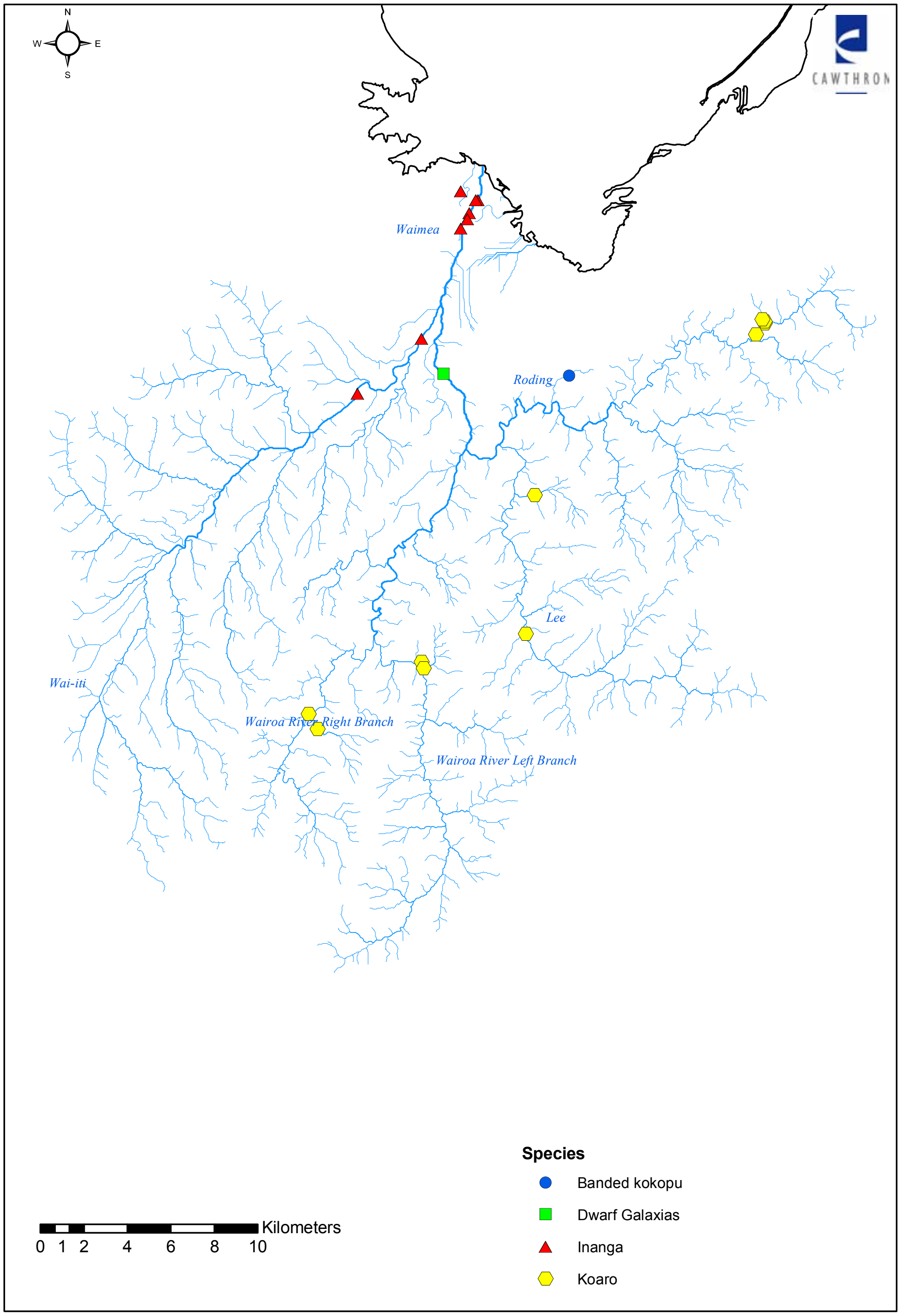

Figure 13 Locations of galaxiid species recorded from the Waimea Catchment.

Four species of bully (*Gobiomorphus*) have been recorded from the Waimea catchment. Upland bully appear to be common throughout the catchment (Figure 14). Redfin bully may also be widespread, but have not been recorded in the Wai-iti River and its tributaries or the Wairoa River and tributaries upstream of the Lee confluence (Figure 14). Common bully have only been recorded in the lower part of the catchment (Figure 14). Up until recently there have been no records of bluegill bully from the Waimea Catchment in the NZFFD. However, bluegill bully have been reported previously from the Waimea River downstream of the Appleby Bridge (Stark 1988), and have also been recently recorded from the Lee River (Figure 14). It is likely that they are also present in other parts of the wider catchment.

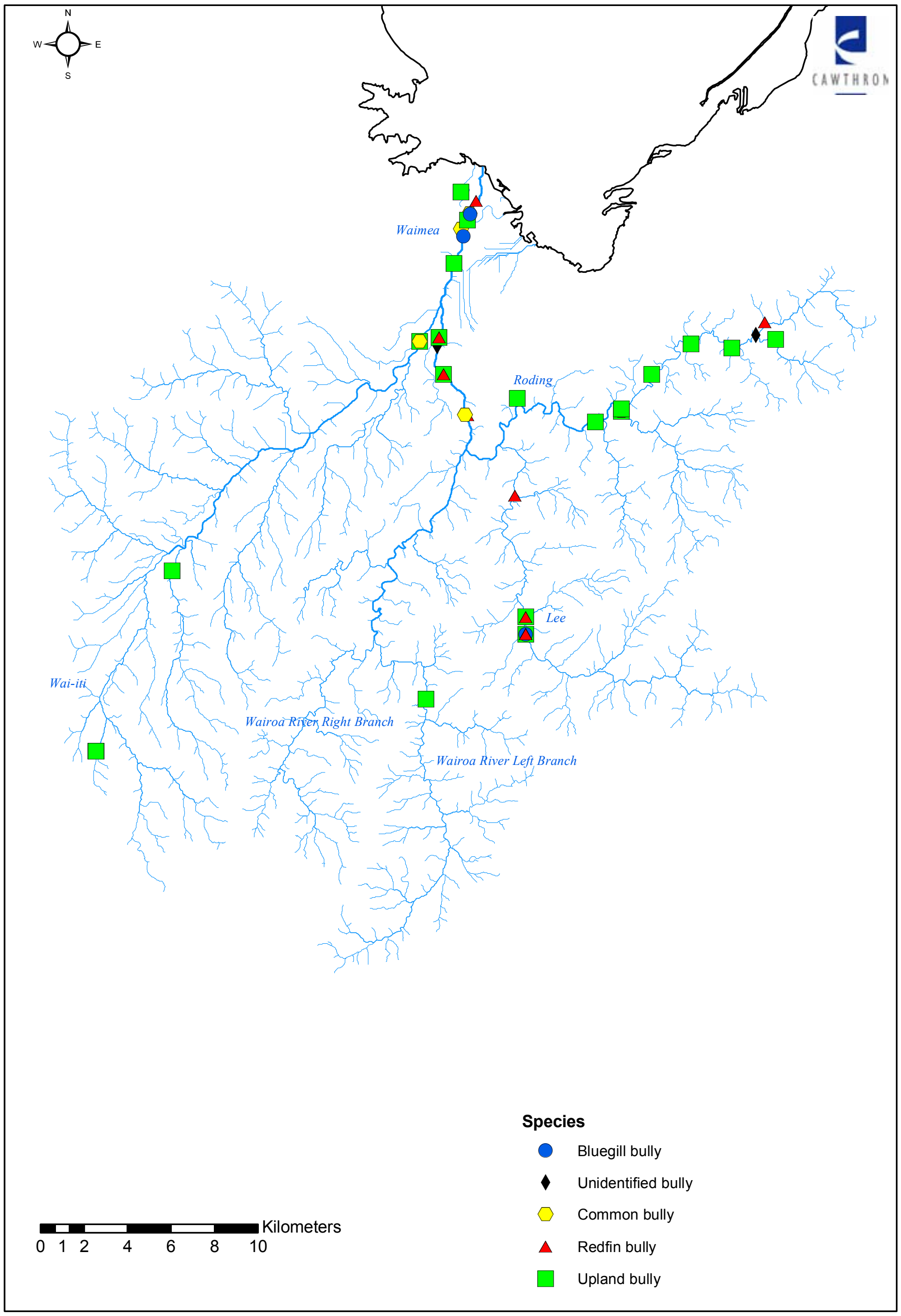

Figure 14 Locations of *Gobiomorphus* species recorded from the Waimea Catchment.

Common smelt normally are found only in the lower reaches of river systems, but have been recorded in the Roding and mid reaches of the Wairoa River (Figure 15) suggesting that they are relatively widespread in the Waimea Catchment. Longfin eels have been recorded throughout the catchment (Figure 15) and would be expected to occur in most locations where there is enough flow to maintain habitat. Longfin eels populations appear to be declining throughout New Zealand and DoC has recently listed them as a chronically threatened species. Shortfin eels have been recorded less regularly in the Waimea Catchment than longfins (Figure 15), but are expected to be widespread throughout the catchment. Yelloweye mullet have also been seen in the lower reaches of the catchment (Figure 15).

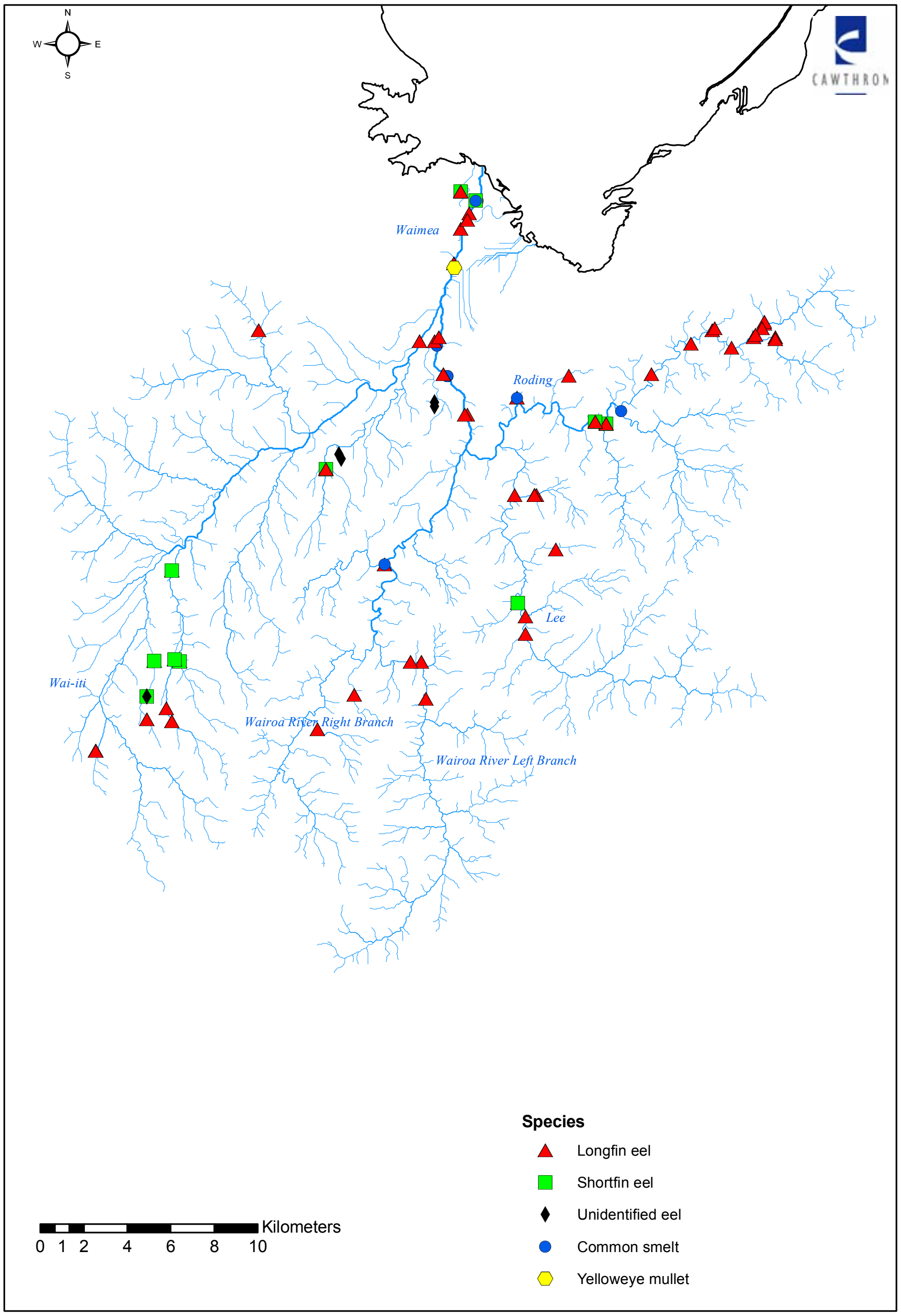

Figure 15 Locations of eels, common smelt and yelloweye mullet recorded from the Waimea Catchment.

The richness of fish communities varies through the Waimea Catchment. The fish community of the Wairoa River is described by DoC as a 'diverse fish fauna of regional importance' (M. Rutledge, DoC, pers. comm.). In surveys of the Waimea, Wairoa and Wai-iti Rivers, Stark (1988) reported that the Wai-iti had the poorest fish communities, and suggested that this might be due to summer drying of this river.

All of the native fish recorded, except upland bully and dwarf galaxias, are diadromous (*i.e.* they spend part of their life cycle in the sea and part in freshwater). They, therefore, require access to the sea at some stage in their life cycle, and, conversely, they must be able to negotiate any obstacle to their upstream passage if they are to reach habitat higher in the catchment. In this regard it is notable that at least three species of diadromous native fish have been recorded from above the Roding River water abstraction weir (koaro, longfin eel and redfin bully; Strickland & Stark 1996).

Stark (1992) found that torrentfish and upland bully seemed to be more abundant during lower flows in 1992 than during his 1988 survey. However, this was likely due to these fish being concentrated in the reduced wetted area available at lower flows, thus increasing the ease of capture.

Low flows can restrict the distribution and abundance of fish species in a catchment. Trout in particular have relatively high flow requirements. Flow related habitat modelling within the IFIM suggests that in the Roding River trout abundance is limited by low flows (Hayes & Stark 1995). However, in the Roding River this would still be the case under the natural flow regime, in the absence of abstraction.

Fish passage may also be restricted at low flows. Again this is pertinent mainly to trout, generally requiring greater water depth to allow movement through shallow riffle areas. Based on IFIM habitat modelling, Hayes (1998) suggested that a minimum flow of 0.65 m^3/s (as measured at Challies Island) was necessary to provide for trout passage at least as far as Clover Road, on the lower Wairoa (the upstream extent of this modelling). It has also been suggested that low flows may cause trout passage issues further upstream, in the Roding River Catchment (Hayes & Stark 1995).

High water temperatures, which often are associated with low flows, can have an impact on fish. High temperatures are likely to impact trout before native fish, since they have lower maximum temperature tolerance levels than most of New Zealand's native fish (Richardson *et al.* 1994; Raleigh *et al.* 1986). However, there are anecdotal reports of native fish kills associated with low flows and high water temperatures in the Roding River (Hayes & Stark 1995). The high temperatures recorded in rivers throughout the catchment in February 2005 (up to 27.6°C, Rob Merrilees, NIWA, unpublished data) were at, or exceeded, the upper end of thermal preference limits of most New Zealand fish, and approached lethal limits for many species (Richardson *et al.* 1994).

2.5 The trout fishery

Fish and Game New Zealand conducts drift dives to assess brown trout abundance in several reaches in the Waimea Catchment (Figure 16). Some of these sites have been dived regularly (*e.g.* Wairoa @ Lee confluence and Lower Waimea), whereas others have only been surveyed on one or two occasions (Figure 17). The abundance of adult trout (large and medium) has varied widely over time within the same reach (see Wairoa at Lee Confluence, Figure 17), and there is no evidence to suggest any consistent differences in trout abundance among the drift dive reaches. Highly variable numbers of small and fingerling brown trout have also been recorded from these reaches.

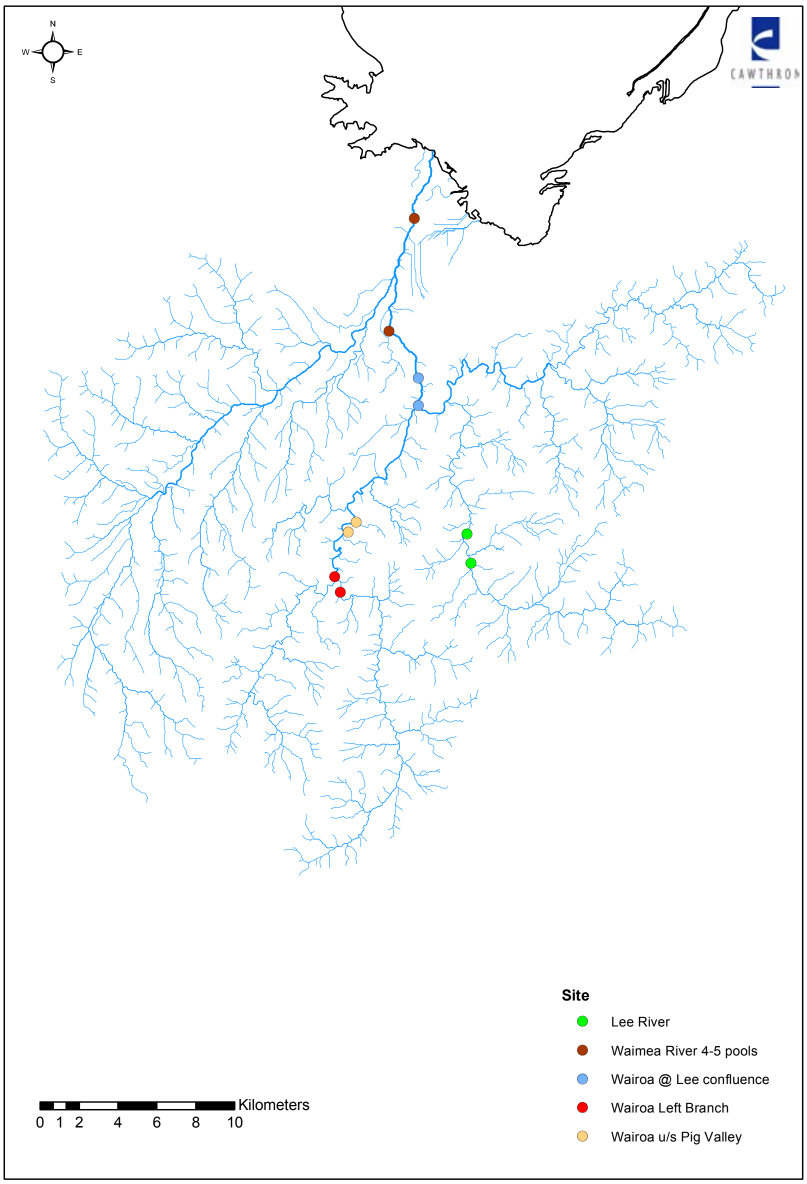

Figure 16 Fish and Game drift dive sites in the Waimea Catchment, showing start and finish points of drift dives. (N.B. between 4 and 5 pools are dived in the Waimea River reach, *i.e.* not the entire reach).

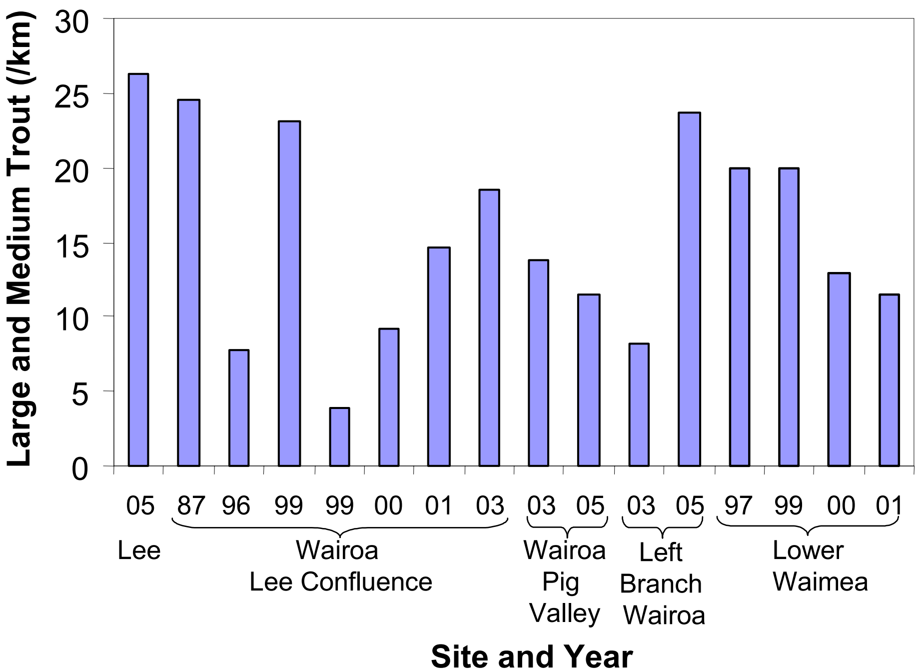

Figure 17 A summary of Fish and Game drift dive results at sites in the Waimea Catchment

These observed trout numbers can be compared with the numbers of brown trout observed in 158 drift dive reaches through out New Zealand that form the basis of Jowett's "100 Rivers Model" (Jowett 1992; Teirney & Jowett 1990). The numbers observed in the Waimea Catchment place these rivers around the middle of this data set. The median number of trout observed per km in the "100 Rivers" data set was 17 (large and medium trout combined). So an average count per km of 14.5 from the Wairoa ranks this river among rivers like the Rangitikei River, in its middle reaches, and Mohaka River, in its upper reaches. The higher numbers recorded in the Lee and Wairoa Left Branch in recent surveys see these rivers rank slightly higher (about 65th of 158 reaches, with similar counts to the Hurunui River at Lake Taylor), but still below the average count of 39.1 large and medium brown trout per km.

The Waimea Catchment is not known for the size of its trout, although the odd large sea-run trout can be caught in the lower catchment (Richardson *et al.* 1984). However, the proximity of rivers in the Waimea Catchment to centres of population have seen them frequented by relatively large numbers of anglers. Although angler surveys in 1984 showed that the trout fishery in the Waimea Catchment generally was not held in high regard, the Waimea and Wairoa attracted quite high use (Richardson *et al.* 1984), having the fourth highest number of angler visits of rivers in the wider Nelson region. This was the case despite a notable decline in the fishery between the late 1940s and the early 1960s (Graynoth & Skrzynski 1974). Over this period the annual catch rate was estimated to have declined from about 125 fish per year, down to about 30 fish per year at end of the period. More recent angler surveys in 1996 and 2001 also showed that the Waimea Catchment attracts a considerable number of anglers (1996, 2290 angler days per year, Unwin & Brown 1998; 2001 980 angler days per year, Unwin & Image 2003). This places it only behind the Motueka, Wairau, Buller, Takaka and Pelorus river systems in terms of angling use in the Nelson/Marlborough region. These surveys also split the results for different parts of river catchments. Within the Waimea Catchment, the Waimea River was the most heavily used by anglers in 1996 (1780 angler days per year versus 240 angler days per year in 2001), while the Wairoa River was the most heavily used in 2001 (550 angler days per year versus 280 angler days per year in 1996). Other parts of the catchment were used to a lesser extent -- Lee (1996, 130 angler days per year; 2001 80 angler days per year), Wai-iti (1996, 100 angler days per year; 2001, 30 angler days per year), Roding (2001, 70 angler days per year). The relatively low angling use values that were reported from the 2001 season have been attributed to the severe drought that occurred in the Nelson region during that season.

A keen local angler (Grant Irvine – ph 03 544 4023) was interviewed about the characteristics of the Waimea River to get some further impressions of the catchment as a fishery. Grant was raised on a farm in the Wairoa Valley and has fished the Wairoa River for most of his life. Grant rates the Wairoa River highly and lists its proximity to Richmond and Nelson as a major attraction. Despite the proximity of the river to these urban centres Grant believes that the river is not fished heavily and therefore the trout present are relatively easy to catch. Grant also enjoys the aesthetic values of the river and valley. Grant considers that the trout in the Wairoa River are relatively large compared with some other rivers in the district, with an average weight of 1.6 – 1.8 kg and with occasional fish up to 3.23 kg. Grant has heard of trout up to 5.4 kg being caught in the Wairoa. Grant reported that trout densities are not particularly high in the Wairoa River generally, although he remembered a sudden boost in trout numbers for a few years in the late 1970's. Grant also reported that he occasionally catches 'silver' trout that he presumes are sea-run fish, suggesting that fish can swim past the Waimea East Irrigation Scheme weir.

Grant has also fished in the Lee, Wai-iti and lower Waimea, but rates them less highly. He considers that the Lee River is smaller than the Wairoa and tends to hold fewer fish, although the fish there are of good size. Access through private property tends to restrict angling opportunities in the Lee. The Wai-iti River and its tributary (88 Valley Stream) hold some trout early in the fishing season but angling opportunities are reduced once flows decline. The lower Waimea River is known locally for occasional large trout, especially in the lower reaches when the whitebait are running.

2.6 Blue duck

Blue duck (or whio) have been reported from the Roding, Lee and Wairoa Catchments (Hayes & Stark 1995; BioWeb 2005; Gavin Udy, pers. comm.). The sightings recorded in the BioWeb database are shown in Figure 18 (See also Appendix 4). The majority of sightings have been from the lower reaches of the Lee River and the Left Branch of the Wairoa River (Figure 18). It is not clear if the lack of whio records in the Right Branch of the Wairoa, and other potentially suitable areas of habitat, reflect a lack of whio in these areas or a lack of survey effort. There is a public walking track up the Right Branch of the Wairoa River, so if any whio were present you would expect some records. In contrast, public access to the upper reaches of the Lee River is difficult and therefore there probably has been little survey effort in that part of the catchment.

Whio usually feed on macroinvertebrates that they glean off submerged stones in fast flowing rivers, generally in forested catchments (Veltman *et al.* 1995). Although they have been seen occasionally on ponds and small lakes in hill country areas, they are not known to use such stationary water habitat for feeding and consequently are reliant on fast flowing water habitat, in steep rocky streams.

Both the Lee and Wairoa catchments appear to contain good habitat for whio and could potentially maintain breeding populations if predators were controlled (Martin Rutledge, DoC, pers. comm.).

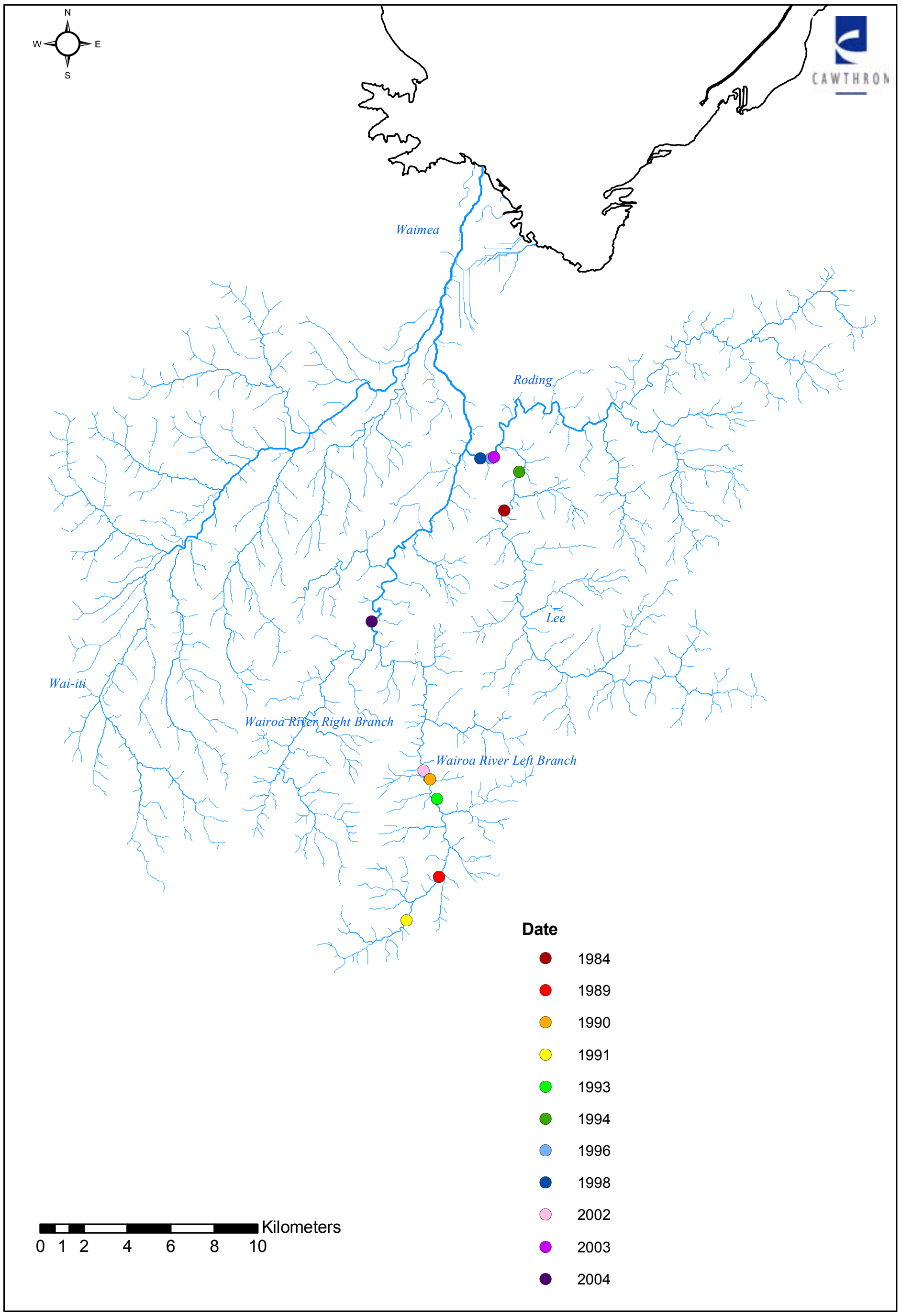

Figure 18 Sightings of blue duck in the Waimea Catchment recorded on the BioWeb database, coded by date of sighting.

The Wairoa/Wai-iti Catchment is listed as a Type I water body in the recently released DoC discussion document 'Identifying freshwater ecosystems of national importance for biodiversity' (Chadderton *et al.* 2004). This classification means that the majority of the catchment is considered nationally important for biodiversity. Threatened birds, along with a nationally important estuary, were cited as special features contributing to this classification being conferred on the catchment, although whio were not mentioned specifically.

3. IMPACTS OF LOW FLOW

The typical effects of low flows are reductions in the water depth, water velocity and the wetted area of the riverbed, along with accumulation of thick algal mats and changes to the composition of macroinvertebrate communities. In extreme circumstances, low flows also will result in high water temperatures, low dissolved oxygen concentrations, high pH values, and dead fish.

The data reviewed in this report indicate that many of the typical impacts of low flow have been recorded in the Waimea River catchment. For example, Hayes (1998) has shown how water depth, velocity and the area of suitable habitat will change with flow in the Waimea and lower Wairoa rivers. Periphyton assessments undertaken during the prolonged low flow period in 2001 indicated that there was substantial accumulation of algal mats in the Roding, lower Wai-iti, lower Wairoa, and Waimea rivers. These accumulations were not evident during the same period in the upper reaches of the Wai-iti, Wairoa or Lee rivers, suggesting that the algal accumulations were due to both the long period of low flows and the elevated nutrient concentrations in the lower parts of the catchment.

As mentioned earlier, Stark (1992) compared results from macroinvertebrate samples collected from riffles during normal flows in 1988 with samples collected from riffles during a 1-in-20 year drought in 1992. Coarse measures of ecosystem health such as species richness and invertebrate density were higher in 1992 than in 1988. However, more sensitive analyses looking at the composition of the macroinvertebrate communities showed a significant deterioration in the macroinvertebrate community in the Waimea and lower Wairoa rivers with a change from a community dominated by mayflies to a community dominated by worms. Accumulation of algae and organic-rich sediment was presumably responsible for this change in the macroinvertebrate community. Even larger changes in macroinvertebrate community composition would be expected in pools and runs.

Stark (1992) recorded abundant torrentfish and upland bully at some sites during the low flow period. It is possible that these fish were concentrated in the few remaining areas of suitable habitat. Electric fishing is probably also more efficient during low flows periods therefore it is difficult to make conclusions on the likely changes to the fish community resulting from low flows.

During the low flow period in late summer 2001, one of the authors of this report (Roger Young) conducted a dive in the lower Wairoa River near Clover Road. Very large numbers of torrentfish were seen in a riffle and run at the head of a long pool, perhaps suggesting that these fish had been concentrated in this area by the low flows. Some of the torrentfish were occupying surprisingly deep and slow water amongst coarse cobbles and boulders. No adult or juvenile trout were seen during the dive, which was surprising and perhaps suggested that trout had either perished or had moved out of the system. An extremely thick (up to 60 cm) accumulation of green algae completely covered the bottom of the pools. Water clarity was very good during the dive.

4. SUMMARY

4.1 Current condition of the Waimea Catchment

Biological and water quality data from a range of sources indicate that the rivers of the Waimea Catchment generally are characterised by good water quality. They are inhabited by relatively diverse fish and invertebrate communities, both of which vary spatially and temporally. The known invertebrate community does not appear to contain any rare or endangered species, although detection of rare species was not a specific aim of any of the surveys. However, the Wairoa River's fish community is considered to be of regional importance due to its diversity (M. Rutledge, DoC, pers. comm.).

As well as the obvious issues involving water quantity in the catchment, there are some issues with nutrient enrichment and faecal contamination, particularly in the Wai-iti River, and lower in the catchment. There also seem to be issues with elevated water temperatures, especially during prolonged periods of low flow over summer.

There is relatively little information recorded regarding algal communities in the catchment. Existing information on the taxonomic make up of these communities is restricted to surveys in two reports, focusing on 5 sites in the lower catchment in the late 1980's and early 1990's. However, more recent monitoring focusing on the general characteristics of algal communities as an indication of pollution, shows that algal communities generally are indicative of healthy, unpolluted water quality. Nevertheless, excessive algal accumulations do occur in the Waimea River and in the lower reaches of the Wairoa, Roding and Wai-iti rivers after prolonged periods of stable low flow. Lower nutrient concentrations in the upper reaches of the Wai-iti, Wairoa and Lee rivers appears to limit excessive algal accumulation in these parts of the catchment.

4.2 Knowledge gaps

In general, there is a relatively large amount of information on the Waimea River and the lower reaches of the Wairoa and Wai-iti rivers. There has also been a substantial amount of work conducted in the Roding River in relation to the Nelson City Council's water supply weir. Other areas of the catchment have been studied to a lesser extent, although the Tasman District Council's SoE monitoring programme covers the entire mainstem of the Wai-iti River, the middle reaches of the Wairoa River and the lower part of the Lee River. Little is known about the water quality, macroinvertebrates, or algae present in the Left and Right branches of the Wairoa River, the upper Lee River, or the tributaries of the Wai-iti River.

Records of fish distribution within the catchment are reasonably well spread. Recent surveys in the middle and upper reaches of the Wairoa and Lee rivers have provided useful information on the fish communities present in these parts of the catchment.

Perhaps the most obvious knowledge gap, with regard to rare or endangered species that may be affected by any development, is the paucity of information about the distribution of blue duck. The only reports of blue duck in the catchment are anecdotal It is not known if blue duck are found in the upper reaches of the Lee River or in the Right Branch of the Wairoa River, although these areas would be expected to provide good habitat. A focused investigation of blue duck habitat availability and habitat use would assist greatly in making robust decisions regarding the impact of any development in the upper catchment.

4.3 Potential impacts of water augmentation options

Several ecological issues are related to water augmentation and include potential positive effects such as the ability to maintain higher minimum flows in the lower river during dry periods, and potential negative effects such as obstruction to fish passage, changes to the flow regime, changes to water quality and temperature regime, and submersion of river and river margin habitats behind the water storage dam. Many of these effects have been observed in the neighbouring Maitai River catchment as a result of Nelson City Council's water storage reservoir in the upper reaches of the catchment. Ecological and water quality issues in the Maitai Catchment and related to this reservoir have been reviewed by Crowe et al. (2004).

At this stage there are several potential water storage options being considered as part of the Water Augmentation Project. These include sites on the Lee, Wairoa, and western tributaries of the Wai-iti. The advantages and disadvantages associated with storage options that affect various reaches of the river are set out below to give an indication of the relative ecological sensitivity of these catchments. An indicative ranking is also provided, with Rank 1 having the least ecological effect (based on information to date).

4.3.1 Western tributaries of the Wai-iti River

- There is no water quality information available from these streams. However, given the modified condition of the catchments (primarily farming and exotic forestry), water quality is expected to be equivalent to the lower reaches of the Wai-iti River (*i.e.,* some concerns with nutrient and faecal bacteria contamination).
- Storage of water in this part of the catchment is expected to have a minimal effect on the hydrological regime of the river downstream, although there may be implications of water abstraction from the Wai-iti River.
- There are no macroinvertebrate data available from these streams. However, given the modified condition of the catchments (primarily farming and exotic forestry), macroinvertebrates would probably indicate satisfactory stream health.
- There is a small amount of fish data from some of the streams. For example, the fish fauna of Pigeon Creek includes longfin eel, common bully and upland bully (Neil Deans, pers. comm.). Koura have also been recorded from this stream. Other species, such as koaro, banded kokopu may also be present. Giant kokopu, shortjaw kokopu, banded kokopu and koaro are found in a section of native forest in the neighbouring Eves Valley Stream.
- Trout have not been recorded from the streams, but they probably use some of them as a spawning and nursery areas.
- Blue duck are not expected to occur in these streams.
- Storage systems on these tributaries would be ranked 1st for least ecological effects. However, this assessment is based on limited data and would need to be checked for a specific stream.

4.3.2 *Lee River*

- Water quality is good in the Lee River and nutrient concentrations appear to be sufficiently low to restrict algal growth, even after a prolonged period of low flows. This could be an advantage downstream of a reservoir since there may be fewer moderate sized 'freshes' to remove algae from the river bed.
- Macroinvertebrate communities in the Lee River are also indicative of good ecosystem health.
- The fish fauna in the Lee consists of (at least) brown trout, koaro, bluegill bully, torrentfish, redfin bully, upland bully, shortfin eel, and longfin eel. Most of these species require access to and from the sea to complete their lifecycle, therefore obstruction to fish passage is a concern.
- Adult trout densities in the Lee River appear to be similar to those in other parts of the Waimea River catchment, but difficulties with access to the river, and perhaps perceptions of low fish numbers, means that angling pressure is relatively light.
- Blue duck have been recorded in the lower part of the Lee River and would be expected to occur further upstream. However, their presence and abundance in the upper reaches is unknown. The impacts of a water storage reservoir on blue duck habitat would need to be considered on this river.
- Given the existing information a storage system on this river would be ranked 2nd for least ecological effects, although the perceived lower value of the trout fishery in the Lee River is the only reason why a dam on this river might have less effect than a dam on either branch of the Wairoa River.

4.3.3 *Right Branch Wairoa River*

- There is no water quality information from this river, but presumably water quality is high. This branch of the Wairoa has a smaller catchment than the Left Branch and presumably contributes less flow. If this branch was dammed then some degree of natural flow fluctuation would still be maintained in the Wairoa River as a result of natural flows from the Left Branch.
- There are no macroinvertebrate data from this part of the river, but presumably the macroinvertebrates would be indicative of very good ecosystem health.
- The fish fauna consists of at least brown trout, koaro, upland bully, and longfin eel. Koaro and longfin eel require access to and from the sea to complete their life cycle, therefore fish passage is a concern.
- There are no data on adult trout abundance in this part of the catchment, but the large size of the trout, scenic surroundings and proximity to Nelson and Richmond means that this river is highly valued as a fishery by some anglers.
- Blue duck would be expected to occur in this river, but there are no recorded sightings. Their presence and abundance are unknown. The impacts of a water storage reservoir on blue duck habitat would need to be considered on this river.
- Given the existing information, a storage system influencing this part of the Wairoa River would be ranked 3rd for least ecological effects, although the difference in potential effects of storage in this part of the Wairoa River and storage in the Lee River is relatively minor.

4.3.4 Left Branch Wairoa River

- There is no water quality information from this river, but presumably water quality is high. This branch of the Wairoa has a larger catchment than the Right Branch and presumably contributes more flow. Nevertheless, if this branch was dammed some degree of natural flow fluctuation would be maintained in the Wairoa River as a result of natural flows from the Right Branch.
- There are no macroinvertebrate data from this part of the river, but presumably the macroinvertebrates would be indicative of very good ecosystem health.
- The fish fauna consists of at least brown trout, koaro, upland bully, and longfin eel. Koaro and longfin eel require access to and from the sea to complete their life cycle, therefore fish passage is a concern.
- Adult trout abundance is equivalent to other parts of the catchment. The large size of the trout, scenic surroundings and proximity to Nelson and Richmond means that this area of the river is highly valued as a fishery by some anglers. Trout may need to migrate to other parts of the catchment in order to maximise feeding opportunities and to spawn. Fish passage for trout may be a concern.
- Blue duck are known to occur in the Left Branch of the Wairoa River. However, their current abundance is unknown. The impacts of a water storage reservoir on blue duck habitat would need to be considered at this site.
- Given the existing information this site would be ranked 4^{th} for least ecological effects

4.3.5 Mid Wairoa River

- Water quality is also good in the mid Wairoa River, although a relatively large proportion of the catchment (and thus flow) could potentially be retained behind a dam located in this part of the river. This would have a substantial effect on the hydrological regime downstream of the dam, and the subsequent loss of moderate sized 'freshes' could exacerbate problems with algal proliferation in the lower river.
- Macroinvertebrate communities in the mid Wairoa River are indicative of very good ecosystem health.
- The fish fauna of the mid Wairoa consists of brown trout, koaro, upland bully, common smelt, and longfin eel. Shortfin eel, bluegill bully and redfin bully are also likely to be found. Most of these species require access to and from the sea to complete their lifecycle, therefore obstruction to fish passage is a concern.
- The large size of the trout, scenic surroundings and proximity to Nelson and Richmond means that this area of the river is highly valued as a fishery by some anglers. Trout may need to migrate to other parts of the catchment in order to maximise feeding opportunities and to spawn. Fish passage for trout may be a concern.
- Blue duck have been sighted further upstream in the catchment. It is not known if blue duck currently use the mid reaches of the Wairoa. The impacts of a water storage reservoir on blue duck habitat would need to be considered on this river.
- Given the existing information, any scheme that affected the mid reaches of the Wairoa would be ranked 5^{th} for least ecological effects

5. REFERENCES

ANZECC 1992: *Australian water quality guidelines for fresh and marine waters*. Australian & New Zealand Environment & Conservation Council.

ANZECC & ARMCANZ 2000: *Australian and New Zealand guidelines for fresh and marine water quality*. Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Biggs, B.J.F.; Kilroy, C. 2000: *Stream periphyton monitoring manual*. NIWA, Christchurch. 226p.

BIOWEB 2005: An internal Department of Conservation database of flora and fauna and archaeological sites of interest to the Department on a national basis. Department of Conservation, Crown Copyright New Zealand, (accessed on 14 February 2005)

Bovee, K.D.; Lamb, B.L.; Bartholow, J.M.; Stalnaker, C.B.; Taylor, J.; Henriksen, J. 1998: *Stream habitat analysis using the instream flow incremental methodology.* U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD_1998)0004. 131p.

Bruce, K.A. 1986: *Biological Data Review for the Waimea River Catchment*. Cawthron Report prepared for the Nelson Catchment and Regional Water Board. 55p + Appendices.

CCREM 1987. *Canadian water quality guidelines*. Canadian Council of Resource and Environment Ministers, Inland Water Directorate, Environment Canada, Ottawa.

Chadderton, W.L.; Brown, D.J.; Stephens, R.T. 2004: *Identifying freshwater ecosystems of national importance for biodiversity: Criteria, methods, and candidate list of nationally important rivers.* Discussion document, Department of Conservation, Wellington. 112p.

Crowe, A.; Hayes, J.; Stark, J.; Strickland, R.; Hewitt, T.; Kemp, C. 2004: *The Current State of the Maitai River – a review of existing information*. Prepared for Nelson City Council. *Cawthron Report No. 857*. 166 p.

Davies-Colley R. J. 1988: Measuring water clarity with a black disk. *Limnology and Oceanography 33*: 616-623.

Elliott, J.M. 1994: *Quantitative ecology and the brown trout*. Oxford Series in Ecology and Evolution, Oxford. 286 p.

Graynoth, E.; Skrzynski, W. 1974: *The Nelson Trout Fishery.* MAF Fisheries Technical Report No. 119. 34p.

Hayes, J.W. 1998: *Instream Habitat Flow Analysis for the Wairoa/ Waimea and Wai-iti Rivers.* Prepared for Tasman District Council and Fish and Game New Zealand – Nelson/Marlborough. Cawthron Report No. 414. 21p + Appendices.

Hayes, J.W.; Stark, J.D. 1995: *Benthic macroinvertebrate and fish communities of the Roding River and their minimum flow requirements.* Prepared for Nelson City Council. Cawthron Report No. 288. 41p.

Jowett, I.G. 1992: Models of the abundance of large brown trout in New Zealand rivers. *North American Journal of Fisheries Management* 12:417-432.

Jowett, I.G. 1997: Environmental effects of extreme flows. In: Mosely, M.P.; Pearson, C.P. (Eds.) *Floods and droughts: the New Zealand Experience*. New Zealand Hydrological Society, Caxton Press, Christchurch. Pp. 103-116.

MfE & MoH 2003: *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas*. NZ Ministry for the Environment and Ministry of Health.

NZFFD 2005: New Zealand Freshwater Fisheries Database. http://fwdb.niwa.co.nz/, (accessed on 18 January 2005).

Quinn, J.M.; Steele, G.L.; Hickey, C.W.; Vickers, M.L. 1994: Upper thermal tolerances of twelve New Zealand stream invertebrate species. *New Zealand Journal of Marine and Freshwater Research* 28: 391-397.

Raleigh, R.F.; Zuckerman, L.D.; Nelson, P.C. 1986: *Habitat suitability index models and instream flow suitability curves: brown trout, revised*. U.S. Fish and Wildlife Service. Biological Report No. 82 (10.124). 65p.

Richardson, J., Boubee, J. A., and West, D. W. 1994. Thermal tolerance and preference of some native New Zealand freshwater fish. *New Zealand Journal of Marine and Freshwater Research* 28: 399-407.

Richardson, J.; Unwin, M.J.; Teirney, L.D. 1984: *The relative value of Nelson rivers to New Zealand anglers.* MAF Fisheries Research Division. Fisheries Environmental Report No. 45. 44p + Appendices.

Stark, J.D. 1988: *Aquatic Studies of the Waimea River Catchment*. Cawthron Report prepared for the Nelson Catchment and Regional Water Board. 43p.

Stark, J.D. 1992: *Low Flow Studies in the Waimea Catchment*. Cawthron Report prepared for the Nelson Marlborough Regional Council. 19p + Appendices.

Stark, J.D. 2004: *Roding River consent compliance (1 January 2003 – 30 June 2004)*. Prepared for Nelson City Council. Cawthon Report No. 953. 22p.

Strickland R.R.; Stark, J.D. 1996: *A comparison of Roding River macroinvertebrate and fish communities with other rivers, and fish passage over the weir.*. Prepared for Works Consultancy Services. Cawthron Report No. 356. 18p + Appendix.

Teirney, L.D.; Jowett, I.G. 1990: *Trout Abundance in New Zealand Rivers: An Assessment by Drift Diving.* MAF New Zealand Freshwater Fisheries Report No. 118. 25p + Appendices.

Unwin, M.; Brown, S. 1998: *The geography of freshwater angling in New Zealand*. NIWA Client Report No. CHC98/33. Prepared for Fish & Game New Zealand.

Unwin, M.; Image, K. 2003: *Angler use of lake and river fisheries managed by Fish & Game New Zealand: results from the 2001/02 National Angling Survey*. NIWA Client Report No. CHC2003/114. Prepared for Fish & Game New Zealand.

Veltman, C. J.; Collier, K.J.; Henderson, I.M.; Newton, L. 1995. Foraging ecology of blue ducks *Hymenolaimus malacorhynchos* on a New Zealand river: Implications for conservation. *Biological Conservation* 74: 187-194.

Young, R.G.; James, T.; Hay J. 2005: *The State of Surface Water Quality in the Tasman District.* Prepared for the Tasman District Council. Cawthron Report No.933. 69 p. plus appendices.

Appendix 1 List of Algal taxa recorded from the Waimea Catchment (from Stark 1988; 1992)

Blue green algae

Oscillatoria

Green algae

Ulothrix
Stigeoclonium
Oedogonium
Cladophora
Closterium
Cosmarium
Mougeotia
Spirogyra

Diatoms

Melosira
Cocconeis
Cymbella
Diatoma
Epithemia
Gomphonema
Navicula/ Nitzschia
Synedra

Appendix 2 List of invertebrate taxa recorded from the Waimea Catchment

Source / Taxon	Stark (1988)	Stark (1992)	Hayes & Stark (1995)	Strickland & Stark (1996)	Stark (In Prep.)	TDC's SoE monitoring 1999-present: Wai-iti R @ Pigeon Valley	Wai-iti R @ Hiwipango	Wai-iti R @ Livingstone Rd	Lee R @ Meads Bridge	Wairoa R u/s Pig Valley	Waimea R @ Applby	Roding R @ Twin Bridges	Waimea R @ Irvines	Wairoa R. @ Gorge
EPHEMEROPTERA														
Nesameletus sp.	x	x	x	x	x	x	x		x	x		x	x	x
Coloburiscus humeralis	x	x	x	x	x	x	x		x	x	x	x	x	x
Deleatidium spp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Austroclima jollyae		x	x							x		x		
Austroclima sepia					x									
Neozephlebia scita				x				x						
Mauiulus luma		x												
Rallidens macfarlanei			x											
PLECOPTERA														
Stenoperla prasina	x	x	x											
Stenoperla spp.							x		x	x			x	x
Austroperla cyrene			x	x			x							
Zelandoperla decorata	x	x	x	x			x		x	x				x
Zelandobius furcillatus		x		x							x			
Zelandobius confusus			x											
Zelandobius spp.				x										
Zelandobius unicolor		x												
Acroperla trivacuata	x	x										x		
Spaniocerca zelandica							x							
Megaleptoperla diminuta			x											
LEPIDOPTERA														
Nymphula nitens	x													
Hygraula nitens		x												
MEGALOPTERA														
Archichauliodes diversus	x	x	x	x	x	x	x	x	x	x	x	x	x	x
COLEOPTERA														
Hydrophilidae													x	
Hydrophiloidea														
Hydraenidae		x	x	x	x	x	x	x	x	x	x	x	x	x
Elmidae	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scirtidae		x												
Staphylinidae		x	x											
DIPTERA														
Aphrophila neozelandica	x	x	x	x	x	x	x		x	x	x	x	x	x
Eriopterini	x	x	x	x		x	x		x				x	x
Tanypodinae						x		x			x	x		
Parochlus sp.									x					
Maoridiamesa spp.	x	x	x	x	x	x		x	x	x	x	x	x	x
Orthocladiinae	x	x	x	x	x	x	x	x	x	x	x	x	x	
Tanytarsus vespertinus		x	x	x	x	x		x	x		x	x		
Tanytarsini	x													
Polypedilum sp.			x	x										
Chironomidae	x	x												
Austrosimulium spp.		x	x	x	x	x		x	x		x	x	x	x
Austrosimulium longicorne	x													
Empididae	x	x	x				x							
Anthomyiidae				x										
Tabanidae			x				x		x					
Tabanoidea														
Neocurupira hudsoni			x				x							x
Neocurupira campbelli			x											
Paralimnophila skusei								x						
Muscidae												x		
Psychodidae		x												
Neoscatella sp.		x												
Harrisius pallidus					x									

Source	Stark (1988)	Stark (1992)	Hayes & Stark (1995)	Strickland & Stark (1996)	Stark (In Prep.)	Wai-iti R @ Pigeon Valley	Wai-iti R @ Hiwipango	Wai-iti R @ Livingstone Rd	Lee R @ Meads Bridge	Wairoa R u/s Pig Valley	Waimea R @ Applby	Roding R @ Twin Bridges	Waimea R @ Irvines	Wairoa R. @ Gorge
TRICHOPTERA														
Aoteapsyche spp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Polyplectropus puerilis				x		x								
Hydrobiosella stenocerca							x			x				
Hydrobiosis clavigera	x	x	x	x	x	x	x	x	x	x			x	
Hydrobiosis parumbripennis	x	x	x	x	x				x				x	
Hydrobiosis soror				x										
Hydrobiosis umbripennis				x		x		x			x	x		
Hydrobiosis spp.				x	x	x	x	x			x	x	x	
Hydrobiosis copis				x		x		x			x	x	x	
Psilochorema bidens	x	x				x		x						
Psilochorema leptoharpax				x			x	x	x	x	x		x	
Psilochorema macroharpax	x	x	x	x										
Psilochorema sp.	x	x	x				x			x		x	x	x
Neurochorema armstrongi		x												
Neurochorema confusum		x	x	x	x								x	
Neurochorema forsteri					x									
Neurochorema sp.				x										
Costachorema callistum		x												
Costachorema psaropterum		x							x					
Costachorema xanthopterum		x	x	x	x	x			x			x	x	
Costachorema sp.	x	x	x	x	x			x	x			x	x	
Hydrochorema crassicaudatum							x							
Oxyethira albiceps	x	x			x									
Paroxyethira eatoni			x											
Paroxyethira hendersoni		x												
Pycnocentria evecta	x	x				x		x						
Pycnocentria gunni	x	x												
Pycnocentrodes sp.	x	x	x	x		x	x	x	x	x	x	x	x	x
Beraeoptera roria	x	x	x	x			x		x	x	x	x	x	x
Olinga feredayi	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Confluens olingoides		x	x	x	x				x	x			x	
Hudsonema amabile	x	x												
Helicopsyche sp.	x	x					x	x	x	x	x		x	x
Helicopsyche albescens			x	x										
Philorheithrus agilis			x											
Plectrocnemia maclachlani			x		x	x	x	x				x	x	
HEMIPTERA														
Saldidae							x							
Microvelia macgregori			x											
ANNELIDA	x	x	x											
OLIGOCHAETA (Worms)						x		x			x	x		
NEMATOMORPHA	x	x					x	x						
NEMERTEA	x	x						x						
PLATYHELMINTHES		x	x							x	x			
HIRUNDEA														
MOLLUSCA														
Potamopyrgus antipodarum	x	x				x		x			x	x		
Physa acuta											x			
Physa spp.		x												
Gyraulus corinna	x	x												
Potamopyrgus pupoides		x												
ACARINA									x			x		
Pionidae		x			x									
CRUSTACEA														
Amphipoda		x			x			x				x	x	
Ostracoda		x						x						
Herpetocrypris pasheri		x												
Paratya curvirostris	x	x												
COLLEMBOLA		x												
COLENTERATA														
Hydra spp.		x												

Appendix 3 List of fish taxa recorded from the Waimea Catchment (from the New Zealand Freshwater Fisheries Database http://fwdb.niwa.co.nz/, accessed 18 January 2005). ***Plus additional species recorded in the lower Waimea River (Stark 1988; Neil Deans, pers. comm.) and Lee River (DoC and Fish & Game survey, January 2005).

Species	Common name	Number of records
*Aldrichetta forsteri****	Yelloweye mullet	
Anguilla australis	Shortfin eel	5
Anguilla dieffenbachii	Longfin eel	40
Anguilla spp.	Unidentified eel	4
Cheimarrichthys fosteri	Torrentfish	14
Galaxias brevipinnis	Koaro	6
Galaxias divergens	Dwarf galaxias	1
Galaxias fasciatus	Banded kokopu	1
Galaxias maculatus	Inanga	7
Gobiomorphus breviceps	Upland bully	17
Gobiomorphus cotidianus	Common bully	5
Gobiomorphus huttoni	Redfin bully	7
Gobiomorphus spp.	Unidentified bully	2
Gobiomorphus hubbsi ***	Bluegill bully	
Retropinna retropinna	Common smelt	8
Salmo trutta	Brown trout	15
Oncorhynchus tshawytscha	Chinook salmon	1
Paranephrops planifrons	Koura	13

Appendix 4 Blue duck sightings in the Waimea Catchment recorded in the BIOWEB database. Searched on 14 February 2005. **Reported sighting in lower Lee River (Gavin Udy, DoC Motueka, pers. comm.). ***Recent sighting reported by Trevor James, TDC. Grid references are NZMG and relate to sheet N28 in the 260 map series.

River	Observer	Date	No. seen	N	E
Lee	N Kearns	1984	2	5975100	2522600
Lee	E Hawkins	1996	2	5977500	2522000
Lee	J Evans	1998	3	5977500	2521500
Lee	B Thorpe	1994	1	5976900	2523300
Lee	Not known**	2003	4 (2 pairs)	5977560	2522140
Wairoa	I Cox	2002	1	5963100	2518900
Wairoa	B Handwick	1993	2	5961800	2519500
Wairoa	J Perrin	1989	2	5958200	2519600
Wairoa	I Paterson	1990	2	5962700	2519200
Wairoa	M Hawes	1991	2	5956200	2518100
Wairoa	T James***	2004	1	5970000	2516500