The development of the 'Waterway Self Assessment Form' - a stream management tool for landowners

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GENERAL INTRODUCTION

General Introduction

Increasing environmental awareness amongst the general public and more specific user groups, such as land owners, has led to concern about the impacts of land use on specific environmental qualities such as water quality and stream biota. As a result, methods for reducing and or ameliorating these impacts have become a key area of research in freshwater ecology over the last decade (Fahey and Rowe, 1992; Hanchet, 1989; Hughes, et al., 1986; Osborne and Wiley, 1988; Quinn, et al., 1997; Watson, 1986; Wilcock, 1986; Winterbourn, 1986). The dominant focus of this research has been in riparian management (Large and Petts, 1992; Platts, et al., 1987; Quinn, et al., 1993).

As many streams and rivers in New Zealand flow at some stage through pastoral land, the responsibility of managing riparian zones is largely that of the landowners. Simple tools for managing waterways and their riparian zones, which take into account the requirements of individual landowners, and also facilitate education and awareness, are now needed (Quinn and Collier, in press).

The Waterway Self Assessment Form (Chapter Two) (Polglase and Death, in press) has been developed to meet these needs, for both the evaluation of, and education about riparian management. The aim of the form is to provide landowners with a means of assessing riparian requirements of their own land, and to provide a practical and direct way of introducing issues of riparian management and stream health. The primary function of the form is to pinpoint problem areas of waterways and provide a management tool for monitoring management progress.

Other self assessment forms with similar aims to the Waterway Self Assessment Form have also been developed such as, the Stream Habitat Monitoring and Assessment Kit (SHMAK) (Biggs and Kilroy, 1998) and AgResearchs' Waterway Self Assessment Scale (Parminter and Tarbotton, 1996b). The SHMAK has been designed for use with farming or community groups rather than individuals, this is largely because of the high cost involved in purchasing the kit (approximately $300). It involves detailed measurement, collection and observations of a vast amount of information, and is therefore relatively time consuming. The collection of some information requires a reasonable level of skill, such as relatively precise identification of macroinvertebrates. In comparison, the Waterway Self Assessment Form has no cost to the landowner. It takes only 10 minutes to complete, which is important as the length of time an assessment takes may influence interest in undertaking an assessment. The Waterway Self Assessment Form is also very simple to use and requires no expert knowledge or skill. The SHMAK is a very useful tool, but with a different target user group to the Waterway Self Assessment Form. AgResearchs' Waterway Self Assessment Scale takes a similar approach to the Waterway Self Assessment Form. However, subsequent testing of AgResearchs' Scale (Parminter, et al., 1997) found several aspects of it to be flawed, such as the scientific relevance of the results. The Waterway Self Assessment Form has been shown to be scientifically valid in Chapter Four.

The aim of the research carried out here was to develop a method by which landowners could evaluate the riparian requirements of streams themselves. It was important that it be educational and informative, ecologically and scientifically relevant, whilst still being user-friendly to the target users. Each process of the development of the Waterway Self Assessment Form is described in the following Chapters. Chapter One discusses the ecological relevance, and importance of the form to the end users. Chapter Two is the Waterway Self Assessment Form itself. Chapter Three describes the processes of receiving feedback from a group of landowners, peer review and testing of the inter-observer reliability of the form. Chapter Four provides evidence of the scientific validity of the Waterway Self Assessment Form.

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CHAPTER ONE

Literature review

The riparian zone ('on or of the river bank') can be identified as the interface between the terrestrial and aquatic environment (Gregory et al., 1991). Riparian management involves the manipulation of these zones to act as buffers to land use effects on stream systems. The change in land use from native forest to pastoral agriculture (approximately 50% of New Zealand's land surface has been converted to grazing over the last 150 years (Collier et al., 1995a)) has had obvious adverse impacts on watercourses, particularly on general water quality and aquatic communities. The potential in-stream benefits of riparian management include: reduced sediment and nutrient loads through control of erosion and runoff, reduced flood effects, prevention of nuisance aquatic plant growths, lower water temperatures, and increased biodiversity (Collier et al., 1995a; Collier et al., 1995b; Cooke, 1988; Cooke and Cooper, 1988; Graf, 1980; Howard-Williams and Pickmere, 1994; Large and Petts, 1992; Ormerod et al., 1993; Smith, 1989; Smith et al., 1989). These changes are achieved by the physical nature of riparian vegetation, e.g., increasing the soil's capacity for infiltration and storage reducing runoff, lowering flood peaks and potentially extending periods of increased flow. Riparian vegetation, especially root material, can greatly enhance stream bank integrity by binding soil particles against the forces of bank erosion (Beeson and Doyle, 1995; Glimp and Swanson, 1994).

The need for riparian management is largely where streams flow through production land, therefore the implementation of any management regime is largely up to the landowner. Many landowners do not have the knowledge or desire to effectively manage their streams and bankside habitats. Community or landowner involvement in riparian management is one approach to education on water quality and habitat restoration issues, and has also been shown to trigger interest in such issues (O'Brien, 1993; Parminter et al., 1997; Quinn and Collier, in press). Simple tools for managing waterways and their riparian zones, which take into account the perspectives of individual landowners, are now needed to facilitate interest and education (Quinn and Collier, in press).

The Waterway Self Assessment Form (Chapter Two) which has been developed as part of this research has been designed to meet these aforementioned needs, for both evaluation of and education about, riparian management. The aim of the form is to provide landowners with a means of assessing the riparian management requirements of their own land, and to provide a practical and direct way of introducing issues of riparian management. The form provides a non-regulatory method for landowners to become more proactive in their own riparian management. Its primary function is to pinpoint problem areas of waterways and provide a tool for monitoring management progress. It also gives the user a general idea of how healthy "their" stream is. It is a visual assessment, made on site with no equipment necessary – apart from a copy of the form and a pencil. It is presented as a series of questions, each question has a choice of four categories of which characteristics of the user's stream (or area of stream) can be categorised under. Each category has a corresponding score, the scores for each question are then summed at the end to give an overall measure of riparian management priority. A low score equates to a stream (or section of stream) with a poor riparian zone, low water quality and habitat value, and hence is of a high priority for riparian management. Each question highlights a characteristic of streams and/ or their riparian zones which is important to stream health, and makes the user aware of the ideal state of each stream or riparian characteristic i.e., the ideal condition scores the highest.

The allocation of the scoring categories was also an important part of the form's development. A logarithmic scale was chosen to make distinctions between question categories (or choices) clearer. Some questions were given heavier weightings than others i.e., the scores for each category are doubled. This relates to scale of effect and ease of assessment. Some characteristics have greater effect on stream health than others e.g., the scoring categories for question 4a ('What is the dominant land use 1km upstream?) are doubled, as the effects of land use on stream health are extensive, particularly when compared with the effects of water clarity (question 2c) on stream health. In addition, some questions are easier to assess than others. For example, question 5a ('How big is your stream?') is easier to assess, and there is less likely to be error associated with the assessment, than in question 2d ('What bugs live in your stream?'), which requires skill in observation.

In the following section, the literature pertaining to the ecological relevance of each question in the Waterway Self Assessment Form is reviewed. The importance of each question to the end users, namely the landowners, is also highlighted. The alphanumeric system relates to the questions as they appear in the form e.g., 1a relates to question 1a in the form.

1a. What type of vegetation is along the stream side?
Vegetation is the easiest riparian characteristic to manage, a point that is of particular relevance to landowners preparing to undertake a riparian management regime. The type of vegetation is also a relatively easy characteristic to assess.

Healthy, intact, riparian zones serve many ecologically important functions. They help maintain water quality and clarity by improving soil stability and reducing stream bank erosion. They can decrease water velocity - by vegetation growing either on the bank or in the water - thereby reducing erosion potential, reduce runoff entering the waterway, therefore reducing nutrient and other contaminant inputs, and provide habitat for native plants and animals (Askey-Doran et al., 1996; Collier et al., 1995a; Petersen, 1992). Riparian vegetation also provides terrestrial sources of carbon as food for aquatic animals, such as particulate organic matter (both fine and coarse, FPOM and CPOM), terrestrial invertebrates and woody debris. Woody debris also provides emergence sites and shelter which is important for habitat diversity, and helps increase the retentive capacity of the stream (Malanson, 1993; Quinn et al., 1994). Removal of riparian vegetation directly affects the composition of fish, aquatic plant and invertebrate communities (Edwards and Huryn, 1996; Hanchet, 1989; Large and Petts, 1992).

To a large extent, the ideal type of riparian vegetation is dependent on the desired management goal. Tall trees are ideal for managing nuisance macrophyte growths, however, dense plantings of such species will shade out any understorey which is imperative for the management of runoff (for instance, when the function of the riparian zone is as a nutrient sink) (Bunn and Pusey, 1993; Collier et al., 1995a; Collier et al., 1995b; Cummins, 1993; Gregory et al., 1991; Osborne and Kovacic, 1993; Quinn et al., 1993; Smith et al., 1989). Therefore, for the purpose of the Waterway Self Assessment Form the ideal riparian zone is composed of both tall trees and dense groundcover, hence both management objectives are addressed. At the other end of the scale, grazed pasture provides none of the functions described above for an intact, healthy riparian zone (Fahey and Rowe, 1992; University of Melbourne, 1995; Petersen, 1992; Quinn et al., 1994; Quinn et al., 1997; Quinn et al., 1997; Storey and Cowley, 1997; Environment Waikato, 1996; Wilcock, 1986).

1b. How continuous is the vegetation (other than pasture) in the riparian zone? (*Riparian zone*: 'on or of the stream banks'.)
This question assesses the completeness or continuity of the riparian zone. In addition to width (question 1c), the continuity of the buffer zone is an important variable if optimum management is to be achieved (Large et al., 1992). The wider the riparian zone, the more likely it will have a thick unbroken line of vegetation (University of Melbourne, 1995; Petersen, 1992; Environment Waikato, 1996). This question provides a more detailed evaluation of the riparian vegetation present, and again is relatively easy to assess.

1c. What is the average width of the vegetation (other than pasture) in the riparian zone?
The width of the riparian zone determines its ability to filter light, nutrients and sediment, provide a source of inputs to a stream (namely carbon), and provide habitat and landscape values (University of Melbourne, 1995). Again this characteristic is easy to visually assess and along with question 1b, highlights the importance of riparian zone intactness. It also aims to bring an awareness that the width of the buffer zone affects the ecology of the stream.

Buffers of 30m have been found to maintain bank stability and protect aquatic insect communities from sedimentation (Erman et al., 1977). Aquatic invertebrate community structure has been found to be similar in streams with wide riparian zones (>30m) and streams with forested catchments (Newbold et al., 1980; Storey and Cowley, 1997). Narrower buffers of 10-20 m are adequate for controlling the temperature of small streams (Large and Petts, 1992, Aubertin, 1974). In addition, the removal rate of nutrients increases with riparian buffer width (Cooper and Gilliam, 1987; Doyle et al., 1977; Peterjohn and Correll, 1984). The width of 30m is frequently used as a guideline for optimum protection as a buffer for nutrients, sediments and other contaminants, and 10m as a minimum management compromise (Barling and Moore, 1992; Davies and Nelson, 1993; Macmillan and Kunert, 1990; Mitchell, 1990; Petersen, 1992).

Variations in required buffer widths are a function of soil type, vegetation type, geology, relief and climate (Cummins, 1993; Osborne and Kovacic, 1993; Phillips, 1989; Phillips, 1989). Methods have been developed for determining site specific riparian buffer widths (Xiang, 1993), but are very labour intensive and require expert knowledge. The approach of this question indicates the value of wide buffer strips, whilst only requiring minimal knowledge and time.

1d. What % of the stream is shaded by plants and stream banks?

Most native aquatic plants and animals in New Zealand have developed under low light conditions and stable water temperatures, such as those provided in shaded waterways. New Zealand streams with forested catchments typically provide > 90 % shade (Collier et al., 1995a). Shading is another important component of 'healthy' waterways, which landowners need to be aware of. Shading has a large influence over many in-stream properties. Shading provides hiding places for predators and refuges for prey. It also helps to control nuisance growths of macrophytes. Too much shading however can inhibit the growth of understorey vegetation, which is essential for the riparian zone to have buffering or filtering functions. Very heavy shading, resulting in large areas of bare ground can also cause problems with soil erosion (Askey-Doran et al., 1996; Parminter and Tarbotton, 1996a; Quinn et al., 1994). Therefore 50% shading is recommended as ideal (Collier et al., 1995b).

Light also affects stream temperature. Many aquatic organisms cannot tolerate high temperatures. Hence, temperature has the potential to directly affect the distribution of invertebrate and fish communities in waterways. High water temperatures also affect sensitive organisms by reducing the saturation of dissolved oxygen in the water (Quinn et al., 1994; Quinn et al., 1997; Rankin, 1989).

1e. How stable are the stream banks?

Bank stability is determined to a large extent by the properties of the bank materials. Specifically, uncohesive bank soils, sand, silt and/or gravels, are more susceptible to being washed away than cohesive soils or bedrock (cohesion is dealt with more comprehensively in question 5d). Vegetation increases bank stability through reinforcement by roots, which also use much of the water present in stream banks (Collier, 1992; Collier et al., 1995b; Pfankuch, 1975). As most banks collapse when they are saturated with water, these effects can help stabilise the bank and reduce the risk of sudden collapse.

There are many problems associated with unstable stream banks and subsequent erosion: loss of farmland and fences, damage to roads and bridge supports, downstream build-up of sediments, reduction in primary production and smothering of periphyton by sediments, clogging of substrate interstices by sediments, inputs of nutrients attached to sediments, reduced water clarity, and widening of the stream channel (Collier et al., 1995b). The potential loss of property and production land makes this topic of particular concern to land owners.

1f. How bad is the erosion around or adjacent to your stream?
Erosion of stream banks is directly related to stream bank stability, which has been discussed above (Petersen, 1992; Pfankuch, 1975), however this question also relates to wider scale erosion of the 'upper' banks and surrounding landscape, hence its importance. Large scale erosion is likely to affect structures and land more so than unstable stream banks. Erosion tends to be a more widely recognised problem, compared for example, with the type of invertebrates present, due to the fact that a scarred landscape is immediately obvious to any observer.

Soil conservation practices are desirable in conjunction with riparian management to control large scale erosion (Hicks, 1989a; Hicks, 1989b; Hicks, 1992). The ideal composition of erosion protection vegetation for a small stream is robust continuous grass and other dense vegetative cover, and larger trees and shrubs for larger rivers.

2a. What types of stream plants and mosses are there?
Nuisance growths of macrophytes and algae are associated with in-stream conditions of high nutrient levels, low flows, high temperature and light levels (Quinn et al., 1993). Excessive growths of macrophytes choke stream channels, block fish passage and reduce the recreational value of streams. Mats of algae can smother existing aquatic communities

and reduce flow, degrading the habitat for invertebrates and fish spawning. Excessive growths of aquatic plants are visually unappealing and generally perceived by landowners as being detrimental. They can reduce the suitability and availability of water for stock. Thin periphyton films provide food and oxygen for other life, they recycle and consume nutrients. At low biomass, rooted macrophytes can stabilise the stream bed and help to remove silt and sediment from the water (Collier, 1995a; Davies-Colley and Quinn, 1998; Quinn et al., 1997; Quinn et al., 1997). An intact riparian zone of any description, whether it consists of tall trees, or grasses and shrubs, should prevent nuisance growths either through shading or the filtering of nutrients (both of which are required for nuisance growths to occur) (Collier et al., 1995b). Algae and macrophytes are easily seen which makes this characteristic very easy to assess. It is important for landowners to be aware that riparian management has the potential to control aquatic plant growth, which will return desired qualities, such as recreational and aesthetic values, to streams.

2b. Are there any snags to slow the stream flow?

A stable channel with an intact riparian zone will contain woody debris contributed by the riparian vegetation, which, along with firmly embedded rocks and boulders, will act as retention devices and debris damns (Petersen, 1992; Pfankuch, 1975). Stream retentiveness is important for the conditioning of leaf material, which improves its palatability and nutritional value to invertebrates. The extent to which this process occurs in any one stream reach is dependent on the ability of that stream to retain leaves (Collier et al., 1995a; Collier et al., 1995b). Stable debris damns also have the potential to impede flood flows, thereby reducing the erosive power of flows and reducing flooding in the lowlands (Winterbourn, 1984). Large woody debris is also an important substrate for stream biota, and cover for fish (Quinn et al., 1997). The importance of large woody debris, and rocks and boulders, is unlikely to be recognised by most landowners. This question aims to introduce 'snags' as important components of streams.

2c. How clear is the water?

Water clarity is affected fundamentally by suspended sediments (Collier et al., 1995a). Therefore, this question also has links with questions 1e and 1f, and 3b. Reduced water clarity by suspended sediments affects the ecology of streams and rivers by reducing primary productivity through reduced light penetration. Visual clarity is also reduced, impacting upon sighted aquatic organisms' feeding abilities and affecting native fish migration (Richardson et al., 1998). Riparian management (in severe cases soil conservation measures may also be needed) is the best way to reduce inputs of suspended sediments to streams (Collier et al., 1995b).

Water colour is linked with clarity, and what is observed is a combination of the two. Water colour has similar effects on stream functioning as clarity, and in extreme cases can increase water temperature. Diffuse and point discharges from agriculture can combine over the length of a catchment to have a significant effect on water colour (Parminter and Tarbotton, 1996a). Poor water clarity has been identified as an issue which the general community is very concerned about (Davies-Colley et al., 1995; Reid et al., 1994). This presents an opportunity to introduce riparian management as a means of improving water clarity.

2d. What bugs live in your stream?

Macroinvertebrate communities have been widely recognised as indicators of water quality (Berry et al., 1999; Lenat, 1988; Penny, 1984; Plafkin et al., 1989; Stark, 1984; Stark, 1985). They are also relatively easy to find, and to identify to the level required by the Waterway Self Assessment Form. Many landowners are unaware of the presence of macroinvertebrates in 'their' streams, and discovering this presents a new dimension to streams and stream health, and landowner education.

This question has been developed to follow the method of the Macroinvertebrate Community Index (MCI) (Stark, 1985), however on a much more simplified level. Taxa representative of pristine conditions, for example mayflies and stoneflies, have a high score on the Waterway Self Assessment Form, and pollution tolerant taxa (oligocheates and chironomids), a low score. Many studies have examined the link between macroinvertebrate community structure and land use (Collier, 1995a; Dunning, 1998; Fahey and Rowe, 1992; Friberg and Winterbourn, 1997; Harding and Winterbourn, 1995; Horrox, 1998; Hughes et al., 1986; Osborne and Wiley, 1988; Quinn and Collier, in press; Quinn et al., 1997; Smith, 1993; Townsend et al., 1997; Williamson et al., 1992; Winterbourn, 1986;

Winterbourn, 1987), and how riparian management can ameliorate the negative impacts of land use on community structure and function (Collier et al., 1995a; Cummins, 1993; Howard-Williams and Pickmere, 1994; Large and Petts, 1992; Ormerod et al., 1993; Osborne and Kovacic, 1993; Quinn et al., 1994; Quinn et al., 1993; Quinn et al., 1992; Smith, 1989; Smith, 1993; Smith et al., 1993; Smith et al., 1989; Storey and Cowley, 1997). The general and relatively consistent findings of these studies indicate that where catchments have been converted from native forest to pasture there is a shift from communities dominated by taxa sensitive to eutrophication to those dominated by more tolerant species. The restoration of riparian buffer zones is a first step in the recovery of macroinvertebrate communities.

2e. How often does your stream overtop its banks?

This question assesses the structure of stream banks with respect to their capacity to hold increased discharges, that is the capacity of the banks to hold flood flows. It aims to introduce the concept that flooding is not simply as a result of heavy rainfall, but also of unsustainable land management practices. A stable channel should be able to hold annual peak flows and only overtop its banks on average every 1.5 years. As a result of sedimentation, the depth of the channel gradually lowers and flooding will increase (Petersen, 1992). A category for channelised streams with stop banks is provided, as these streams will not overtop their banks as regularly as natural streams. Channel straightening, deepening and stop banking increase peak flows, and the rate at which flood flows rise and recede (Malanson, 1993). Channelisation leads to loss of habitat and has the potential to initiate substantial erosion. Riparian vegetation can reduce sediment inputs, slowing channel depth lowering, and also slow the rate of overland flow in the occurrence of flooding. It can increase channel roughness slowing flood flows and maintain channel form through reduced potential for erosion (Quinn et al., 1992; Williamson et al., 1992).

3a. Do stock have access to your stream? (Stock access can be prevented by fencing, trees, steep banks, etc.).

Damage to streams and their banks by stock has been well documented (Adams, 1997; Armour et al., 1994; Askey-Doran et al.1996; Fahey and Rowe, 1992; Hicks, 1992; Quinn and Collier, in press; Quinn et al.1992; Williamson et al., 1990; Williamson et al., 1992).

Stock, particularly cattle, trample and break down stream banks (potentially affecting channel morphology), pug and compact wet stream side soils and excrete directly into the stream. Their manure and urine directly contribute phosphorus and nitrogen to streams as well as bacteria and viruses. Grazing of riparian vegetation has a direct effect on vegetative cover and therefore shading. Grazing also reduces the ability of the vegetation's rooting system to bind soils, indirectly influencing erosion and sediment input. Trampling and the collapse of stream banks directly influences erosion and sediment input. Pugging and compaction reduces infiltration and soil permeability which causes increased runoff and therefore higher flows (the extent of this varies with soil type (questions 5d and 5e), stock type (question 4c) and grazing practices). Thus, in the Waterway Self Assessment Form, the more stock have access to the stream, the lower the score. This presents the issue to landowners that stock access is detrimental to stream health. The management solution to preventing stock access is simple - fencing - unlike many other stream management problems that require very complex solutions e.g., erosion.

3b. What is the potential for the input of sediment to your stream? (e.g., from stream banks, stock damage/trampling, stock crossings, surface runoff, runoff from farm roads, slips/erosion, gravel extraction, etc.).

The premise behind this question is simple, if there is a high potential for the input of sediment to a stream, then there is a high priority for managing that input. Increased sediment yields have the potential to: clog substrate interstices reducing invertebrate and fish habitat, decrease the stability of the bed material, reduce in-stream primary productivity and smother periphyton, reduce water clarity, cause widening of the stream channel, and increase nutrient levels (Cooper et al., 1987; Davies-Colley, 1997; Quinn et al., 1997; Smith, 1989). It is therefore important to manage sediment input.

If possible, management of inputs should be at the source. However, often these inputs are from diffuse sources and it is therefore not possible to take this approach. Management of riparian buffer zones, the planting of vegetation with filtering capabilities and the ability to stabilise stream banks, is another effective approach, and one which is advocated here (Cooke, 1988; Cooper et al., 1992; Cooper et al., 1987; Daniels and Gilliam, 1996; Dons, 1987; Lowrance et al., 1984; Quinn and Collier, in press; Quinn et al., 1994; Quinn et al., 1997; Quinn et al., 1993; Smith, 1989; Smith et al., 1993; Smith et al., 1989). Sources of sediment have already been discussed in previous questions, as have the functions of riparian vegetation for reducing sediment inputs.

Potential sediment yields from sources such as farm roads are likely to be vastly underestimated by landowners, if recognised as sources at all. This question gives examples of possible sources of sediment. It also highlights the possibly unidentified fact that this sediment ultimately ends up in streams, and consequently has adverse effects on stream health.

3c. What is the potential for the input of contaminants to your stream? (e.g., from spray drift, sprayer washings (sheep dips), effluent ponds, silage pits, dumps, oil and foam, dead animals, etc.).

Again, if there is a high potential for the input of contaminants, then the management priority is also high. High levels of contamination will severely affect water quality and the 'life supporting capacity' of the stream (Askey-Doran et al., 1996; Davies-Colley et al., 1995). Contaminants that enter streams as point discharges, such as waste from oxidation ponds, are the most easily managed. Again, diffuse sources are more difficult to manage. Most contaminants enter waterways transported by runoff, and often they are attached or bound to sediments, for example, pesticides. The establishment of riparian 'filter' strips is again an effective way of reducing the input of contaminants to watercourses (Askey-Doran et al., 1996; Collier et al., 1995b; Smith et al., 1993). However, wise land management, and careful use and disposal of chemicals, such as sprayer washings, is still imperative. As with sediment inputs, the potential risk to streams from contamination may not be realised by the landowner. Several examples of contaminants are given in the form to increase awareness of potential sources.

3d. Is there any artificial drainage entering the stream? (e.g., tile, mole, storm water, &/ open drains which have the vegetation dredged).

Water from tile and mole drains enters directly into the stream, bypassing riparian soils. Therefore, water from subsurface drains will have increased nutrient levels. Water from open drains will also contain increased nutrient levels if the vegetation within them is regularly removed. Vegetation on the edge of the drain and aquatic macrophytes, will trap and remove nutrients. However, vegetation is regularly dredged from these channels to improve their functioning as drains. In this case the nutrient uptake will be minimal. Artificial drainage also increases flood flows, again because water in the drains bypass riparian soils and any mechanism which would aid in retaining flood flows (Bowler, 1980; Collier et al., 1995a; Collier et al., 1995b; Jacobs and Gilliam, 1985; Reddy et al., 1982). Therefore, streams that receive water from artificial drainage will score relatively low on the Waterway Self Assessment Form. A low score indicates a high management priority for reducing this increased nutrient input from artificial drainage. However, it is important to note that riparian plantings will do little to ameliorate problems associated with artificial drainage, as these drains bypass the riparian zone. The drainage would have to be prevented from directly entering the stream, for instance entering a wetland first, allowing for denitrification and the settling out of sediments and other associated nutrients, e.g., phosphorus (Buxton, 1991; Howard-Williams, 1985). Production soils have been extensively drained (Bowler, 1980), hence most farmers will use some form of drainage system. This question highlights the fact that artificial drainage adversely affects stream health.

3e. How much fertiliser is used by yourself and your neighbours?
Low, moderate and high rates of fertiliser use were determined by consultation with Doug Henderson (Ravensdown Fertiliser Co-operative Ltd.) and Professor Russell Tillman (Institute of Natural Resources, Massey University). The higher the rate of fertiliser use, the higher the potential for some of that fertiliser to end up in waterways. As fertiliser use is widespread, the potential risk of this occurring is likely to be high. This risk has been recognised with the publication of guidelines outlining a code of practice for fertiliser use (New Zealand fertiliser manufacturers research association, 1998). This question aims to increase awareness of this issue.

Nitrogen and phosphorus fertilisers have been addressed here, as these are the nutrients which most affect streams and are the most frequently used components in fertilisers. In-stream primary productivity (periphyton and macrophyte growth) is most affected by increases in nitrogen and phosphorus levels. This is particularly evident during the summer months, when stream flows are low, and excessive growths of algae and macrophytes occur as a result of high nutrient concentrations. Nutrient levels in streams draining undeveloped catchments are such that aquatic plant growth is limited.

Wet riparian soils, which are high in organic matter, have the ability to remove a high percentage of the nitrogen from the groundwater passing through them. This is through the process of denitrification, which can remove over 90% of the dissolved inorganic nitrogen in the water, provided there is sufficient residency time in the riparian zone. Riparian zones can reduce dissolved reactive phosphorus (DRP) levels by filtering out suspended sediments from overland flow, thereby also stopping attached DRP from reaching the waterway. The nutrients are then used by the riparian zone for plant growth, or absorbed into the soil (Daniels and Gilliam, 1996; Howard-Williams, 1985; Howard-Williams et al., 1986; Lowrance et al., 1984; Osborne and Kovacic, 1993; Peterjohn and Correll, 1984; Quinn et al., 1993; Smith, 1989).

4a. What is the dominant land use 1 km upstream?

4b. What is the dominant land use here?

The condition of a stream is largely a product of the landscape through which it is flowing and the associated land use (Hughes et al., 1986; Quinn and Collier, in press; Smith, 1993; Townsend et al., 1997; Winterbourn, 1984). In addition, the quality of the stream habitat at one point is affected by the land use activities in the entire catchment upstream of that point. The headwaters of many New Zealand streams are in native forest or tussock lands, and most will flow at some stage through agriculturally developed land (Collier et al., 1995a). The type of land use a stream flows through may change several times from head waters to the lowlands. Therefore, it is important to determine the land use both upstream (question 4a) and immediately adjacent (question 4b) to where the stream is being assessed. The distance of 1 kilometre upstream is defined in order to simplify situations in which there are several different types of land use sequentially upstream. Also, water quality and stream habitat can respond very quickly to changes in land use (Storey and Cowley, 1997). Many of the questions discussed previously, are components of land use - which is a large scale, broad characteristic. Therefore, the effects of different land use on water quality and stream habitat will only be briefly summarised here.

Conversion of native forest to pasture reduces shade, therefore increasing water temperatures (Quinn et al., 1994; Quinn et al., 1997). Stream morphology can also be affected, with studies showing that stream channel widths are narrower in pasture (Davies-Colley, 1997). As a consequence, current velocity increases, increasing shear stress and erosion potential, and therefore sedimentation, which in turn will affect water clarity (Davies-Colley et al., 1995; Dons, 1987; Hicks, 1989; Watson, 1986). Deforestation will also reduce the availability of woody debris for fish and invertebrate habitat (Broekhuizen and Quinn, 1998; Hanchet, 1990; Winterbourn, 1986). Nutrient concentrations increase, which along with increased light levels can produce prolific growths of algae and macrophytes (Biggs, 1995; Cooper and Thomsen, 1988; Wilcock, 1986). All of these changes have adverse effects on aquatic macroinvertebrate and fish communities (Hanchet, 1989; Winterbourn, 1987). Reforestation with pine plantations can ameliorate many of these problems, however sedimentation and reduced water clarity, along with associated effects on invertebrates continue to be problems. Also there will be obvious deleterious effects when logging occurs (Dunning, 1998; Fahey and Rowe, 1992; Friberg and Winterbourn, 1997; Quinn et al., 1994).

The more intensive the land use, the greater the impact on waterways. Intensive land use for example, dairy farming, requires greater inputs of nutrients and exerts greater pressure on the land per hectare, compared with less intensive farming i.e., sheep and beef (Collier et al., 1995b; Osborne and Wiley, 1988).

These two questions address the longitudinal nature of streams, and aim to make users aware that any impact will not only affect streams at the source but also downstream. They highlight that not all types of land use affect streams to the same extent.

4c. What is the dominant type of stock in the area?

As with land use, the effects on stream health will also vary with stock type. The aim of this question is to create awareness of this. Cattle have the potential to do more damage to streams than do sheep (Armour et al., 1994; Glimp and Swanson, 1994). Cattle are attracted to water, they will stand in the water grazing marginal vegetation, disturbing the substrate and excreting directly into the stream (Malcom Todd, Manawatu-Wanganui Regional Council, pers. comm., 1998). Sheep tend to avoid water and wet soils. Cattle also have the potential to do more damage to stream banks, through their behaviour and by the shear difference in weight (Hicks, 1992; Williamson et al., 1990). In addition, high stock rates will be more damaging, hence dairy farming has the potential to be more damaging than beef farming (Cooke, 1988; Cooke and Cooper, 1988). Deer are also potentially more damaging due to their wallowing behaviour (Collier et al., 1995b). They create mud holes in streams, which they urinate in as part of their wallowing behaviour. They also tend to create deep tracks, which are a source of sediment. The potential for damage to streams by pests and feral animals is also important to note. High fecal coliform levels have been found in steams flowing through large native remnants, and have been attributed to possum and goat droppings (Lewis Metcalfe, Federated Farmers, pers. comm., 1998). Topography is also important, and is dealt with more comprehensively in the following question.

4d. What type of country does your stream flow through?

This question follows a fundamental premise of the River Continuum Concept (RCC) (Vannote et al., 1980). That is, all streams will change in essentially the same way sequentially downstream, and there will be consistent patterns along the length of a river. Hill or mountain country streams, due in part to their topography, will be fast flowing, 'splashing' streams. This will provide for well oxygenated water. Many high altitude streams will also have a lot of riparian cover, compared to downstream reaches. Hence, they will have cooler water temperatures, and will be more likely to have rich and diverse invertebrate fauna (Winterbourn, 1984). Streams in 'rolling country' will still be relatively fast moving, but are more likely to be detrimentally affected by agriculture (Parminter and Tarbotton, 1996a). 'Inland flat country streams' will tend to be slower moving and also affected by agriculture, having increased nutrient and suspended sediment levels, along with other land use effects listed in questions 4a and 4b. 'Coastal flat country streams' suffer cumulative effects from upstream land use practices. They are also important feeding and spawning areas for native fish (Hanchet, 1989; Richardson et al., 1998). This question aims to communicate the concept that streams are continuous systems, and that land use effects can accumulate downstream.

4e. Are there any natural drainage pathways within 100 m of you? (e.g., where runoff is directed into a gully or ephemeral type channel and then into a stream – a large amount of runoff enters the stream at one point).

From a management perspective, it is more effective and efficient to target these specific areas – known as preferential drainage pathways – as opposed to catchment wide approaches when managing runoff (Collier et al., 1995a). Preferential drainage pathways direct runoff so that it becomes somewhat channelised on its passage downslope. Ground waters also concentrate along flow lines, and are indicated by seeps. These channelised pathways lead to variations in contaminant input along the length of a stream. Therefore, it is sensible to target these specific areas of input. If a particular 100m (arbitrary measure) stretch of stream has several preferential drainage pathways, as opposed to another section that has none, then the stretch of stream with several preferential drainage pathways will take priority for management. It is likely that landowners may not be aware that these drainage pathways exist, hence this question addresses this possible lack of awareness. It also indicates that these pathways lead to points of concentrated inputs, which would logically be more easily managed than diffuse runoff.

5a. How big is your stream?

The influence of riparian management on waterways declines as stream size increases (Vannote et al., 1980). In large rivers, management of the riparian zone will do little to ameliorate degraded water quality and stream habitat, which is largely due to the cumulative effects of upstream land use. Riparian management of the smaller, upstream tributaries will not only improve stream conditions on site, but also downstream. Catchment wide approaches are particularly effective (Collier et al., 1995a; Collier et al., 1995b). Riparian zones are still important in large rivers, especially as habitat for fish and birds. Grazing stock will only have access to the bank tops in larger rivers, and therefore, stock will generally have a limited effect on bank stability and channel morphology. Therefore, smaller streams will take priority over large rivers for riparian management, which is the point this question is taking to landowners.

5b. How deeply incised are your stream banks?

This question addresses the importance of the role that floodplains play in the functioning of the stream ecosystem. A stream with very incised banks will not have functional floodplains. Whereas, a stream with very low banks will have a floodplain that is inundated relatively frequently (Malcom Todd, Manawatu-Wanganui Regional Council, pers. comm., 1998). The question aims to make landowners aware that the higher the stream banks the less influence riparian management will have on the waterway (Collier et al., 1995b) and therefore, a stream which has very high stream banks will have a lower priority for management than one with low banks and functional floodplains.

5c. What is on the streambed?

Streambed substrate influences the available habitat for aquatic plants, macroinvertebrates and fish (Collier et al., 1995a). It reflects the amount of sediment in the system, and the ability of the stream to transport it. Catchment development from native forest to pasture and exotic pine plantations often causes increases in sedimentation (Quinn et al., 1994). The siltation of the substrate interstices is an indication of increases in sediment load (Petersen, 1992). Periphyton is more abundant on stable attachment sites such as cobbles, whereas macrophytes prefer fine substrates where roots can establish (Biggs, 1995). Stony bottomed streams are also preferred habitats of mayflies, stoneflies and caddisflies. In comparison, invertebrates such as oligocheates and chironomids are commonly found in silty habitats (Winterbourn, 1986; Winterbourn, 1987). Siltation of the streambed also affects the available habitat for fish, reducing food availability, suitability for spawning and provision of sites as refugia (Hanchet, 1990; Richardson et al., 1998). Riparian vegetation is effective in binding bank soils and reducing inputs of suspended sediments (see questions 1f, 2c, and 3b for more detail). Differences in substrate type may not be appreciated by landowners. The objective of this question is to inform users that differences do exist, and that some substrate types are preferable to others for a healthy stream.

5d. How cohesive are the soils of the stream bank?

The cohesiveness of the stream banks reflects their susceptibility to erosion (Bowler, 1980). Uncohesive soils, such as sand, will obviously be more susceptible to erosion than boulders and bedrock. Vegetation can strongly influence cohesion, binding loose soils together

(Collier et al., 1995a). Hence, stream banks that have uncohesive soils will have a higher priority for riparian management than those with very cohesive soils. This question encourages the user to look more closely at the components of the stream banks, and leads to understanding the connection between loose soils and potential erosion of the stream banks.

5e. How well do your soils drain after rain?

Soils of low permeability tend to produce large, rapid, quickflow responses in streams. This occurs as low permeability leads to a high proportion of rainfall ending up as runoff (P. Singleton, Landcare, pers. comm. in Collier et al., 1995b). Freely draining soils produce a slower, delayed response in-stream, with lower peak flows. Very highly permeable soils, for example sandy or porous soils, will also produce large, rapid quickflow responses, as the water is moving freely through the soil column and reaching waterways quickly through groundwater (Bowler, 1980). Soils which score well in this question are those which slow down the recharge of water to waterways, therefore reducing peak flows. Forest soils typically fall into this category, but this function is lost when the forest is cleared for production use. Effective riparian management can slow the movement of water as runoff and through groundwater. This question brings to the attention of the user the connection between soil type, or permeability, and the effect on stream flow.

The management of entire stream lengths is not only impractical, but also sometimes unnecessary. The task of managing riparian zones can sometimes seem overwhelming. The Waterway Self Assessment Form provides users with a way of pinpointing the priority areas of streams, which are in most need of riparian management. Hence, diminishing the size of the management unit, making the overall task somewhat more attainable.

The individual questions of the Waterway Self Assessment Form address characteristics of stream ecosystems, which in some way affect water quality and stream habitat. Each characteristic can be influenced by riparian management with the desirable end result of improving stream conditions. The ecological relevance of each question of the form has been discussed in detail in this section, and the importance to the end users identified. Other aspects of development of the Waterway Self Assessment Form, such as, testing of the inter-observer reliability and scientific validity, the peer review process, allocation of the scoring categories, and review by farmers, will be discussed in subsequent chapters.

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CHAPTER TWO

The Waterway Self Assessment Form

Waterway Self Assessment Form

Miranda Polglase & Russell Death
Massey University

Acknowledgments

The Waterway Self Assessment form has been developed with funding from the Agricultural Marketing and Research Development Trust (AGMARDT).

Federated Farmers have actively supported this project, and I am especially thankful to Graeme Allomes.

Thank you to staff at the Manawatu-Wanganui Regional Council who provided valuable feedback. Also to Jacalyn Scott (Rural Resource Management Consultant), Carol Greensmith (DoC Wanganui), and Alec McKay (AgResearch) for reviews and feedback.

I would also like to thank the numerous staff at Massey University for technical and expert, support and advice. The supervisors of the project Dr Russell Death and Rosemary Miller (DoC Wanganui). The Stream Team, and many others who have given me encouragement through their support of the project.

Special thanks go to those farmers who gave up their valuable time and assisted in development of the form.

Additional copies can be obtained from:

Federated Farmers
Central Region Office (Farming House)
123 Queen Street
P.O. Box 945
PALMERSTON NORTH
(06) 357 4026

2a. What types of stream plants and mosses are there?

Stones either dull in colour or very bright. Mosses may be present along edge and in pools.	Stones very slippery and dull in colour, with a brownish algae. Long slimes and/or weeds present in summer.	Green and/or brown long slimes present and/or water cress & other weeds.	Stream choked with long green and/or brown slimes and/or large stream plants.
16	8	4	2

2b. Are there any snags to slow the stream flow?

Rocks and old logs firmly set in place.	Rocks and logs back filled with sediment.	Rocks & logs loose, moving with floods.	No obstructions to slow stream flow.
16	8	4	2

2c. How clear is the water?

NB: Do not assess this category after a period of high rainfall.

Water 'crystal' clear.	Water slightly murky.	Water murky.	Water very muddy.
16	8	4	2

2d. What bugs live in your stream? (See back for pictures of some insects you may find).

NB: To find stream insects look under rocks. Or on water weeds, grass, logs & other debris if your stream has no rocks.

Lots of mayflies, stoneflies and other types of insects.	Moderate numbers of mayflies and caddisflies, other types of insects may also be found.	Only a few insects found. No mayflies or stoneflies, but more than just worms & snails.	Worms and snails, but not much else. Or nothing found at all.
16	8	4	2

2e. How often does your stream overtop its banks?

Never known to overtop banks.	Overbank flows rare.	Overbank flows occur during some winter storms.	Overbank flows frequent in winter/ spring storms. Or stream channelised &/ has stop banks.
16	8	4	2

SUBTOTAL 2 =

3a. Do stock have access to your stream? (Stock access can be prevented by fencing, trees, steep banks, etc.).			
Stock do not have access to any of the stream or its banks.	Stock only have access to a small part of the stream.	Stock have access to most of the stream.	Stock have access to the entire stream.
32	16	8	4
3b. What is the potential for the input of sediment to your stream? (e.g., from stream banks, stock damage/trampling, stock crossings, surface runoff, runoff from farm roads, slips/erosion, gravel extraction, etc.).			
No potential.	Low potential.	Moderate potential.	High potential.
32	16	8	4
3c. What is the potential for the input of contaminants to your stream? (e.g., from spray drift, sprayer washings (sheep dips), effluent ponds, silage pits, dumps, oil and foam, dead animals, etc.).			
No contamination.	Low contamination.	Moderate contamination.	High contamination.
32	16	8	4
3d. Is there any artificial drainage entering the stream? (e.g., tile, mole, storm water, &/ open drains which have the vegetation dredged).			
No artificial drainage.	Sparse artificial drainage.	Moderate amount of drainage.	Extensive drainage networks.
32	16	8	4
3e. How much fertiliser is used by yourself and neighbours?			
No fertiliser used here or by neighbours.	Low rates. Less than 150 kg/ha of super (or equivalent), nitrogen fertilisers not used.	Moderate rates. 150-300 kg/ha of super (or equivalent), low use of nitrogen fertilisers.	High rates. More than 300 kg/ha of super (or equivalent), moderate use of nitrogen fertilisers.
32	16	8	4

SUBTOTAL 3 =

Waterway Self Assessment Form

Date & Time

Stream Name

Approx. Location of Site

Important Things to Note *(impt. for future assessments)*

e.g. if your stream is particularly low/high, a major slump has occurred recently, recent stock access upstream, etc.

The following Waterway Self Assessment Form provides you with a tool for pinpointing problem areas of waterways and monitoring your management progress. It will also give you an idea of how 'healthy' your stream is. Management options may include adopting different land management methods near your waterway. If you would like additional advice on 'where to from here', some contacts have been suggested at the end. You may want to photocopy the form for making later assessments.

To use the form read each question thoroughly and circle the score which corresponds to the category best describing your stream (or the specific area of stream you are assessing). Unless stated otherwise, assess each section of stream 100m up-and-downstream from where you are standing. If your stream isn't described exactly by one category you can give it a score halfway between those given. For example, question 1b - the land use may be sheep and beef farming with a significant native remnant on it - give a score of 12, halfway between 16 and 8. Subtotal the scores at the end of each page. For your grand total add the subtotals at the end of the form. To ensure your methods are consistent between surveys, try to carry out your assessment at the same place and when your stream is under similar conditions. For example, if you make your first assessment under low flow conditions and the following assessment at flood flows you will not be able to successfully compare your results.

Only the questions in Sections 1-3 need to be reassessed thoroughly each time you use the form.

1a. What type of vegetation is along the stream side?

Trees with dense groundcover e.g., tussock, toetoe, ferns,flax,rushes.	Tall grasses with patchy trees and groundcover.	Patchy trees, groundcover grazed.	Grazed pasture grasses to stream edge.
16	8	4	2

1b. How continuous is the vegetation (other than pasture) in the riparian zone? (*Riparian Zone: 'on or of the stream banks'*).

Tall vegetation/ trees continuous or with a few small gaps.	Tall vegetation/ trees less continuous, a few large gaps or several small gaps.	Breaks in tall vegetation/ trees frequent - very patchy.	Many large gaps in tall vegetation/trees or no tall vegetation at all.
16	8	4	2

1c. What is the average width of the vegetation (other than pasture) in the riparian zone?

>30 m.	10-30 m.	1-10 m.	0 m.
32	16	8	4

1d. What % of the stream is shaded by plants and stream banks ?

50% or more.	30%.	10%.	Little or no shading.
16	8	4	2

1e. How stable are the stream banks?

Banks stable, rock and soil firmly held by grasses, shrubs and tree roots.	Banks firm but loosely held by grass and shrubs.	Banks of loose soil held by a patchy layer of grass and shrubs.	Banks unstable, of loose soil or sand easily disturbed.
16	8	4	2

1f. How bad is the erosion around or adjacent to your stream?

No evidence of erosion in surrounding land area, no scarring on stream banks, no undercutting.	Some erosion in surrounding land area. Occasional scarring on stream banks and undercutting.	Moderate erosion in surrounding land. Eroding banks slowly widening.	Significant erosion in surrounding land area. Significant areas of stream bank cut away, some loss of farmland.
32	16	8	4

SUBTOTAL 1 =

SUBTOTALS

1. ________ *(range 16-128)* **TARGET**

2. ________ *(range 10-80)* **THESE 3**

3. ________ *(range 20-160)* **CATEGORIES!**

4. ________ *(range 16-128)*

5. ________ *(range 12-96)*

TOTAL SCORE ________

WHAT DOES MY TOTAL SCORE MEAN?

>390 Great! Your stream is very healthy and hence has a low priority for waterway management. It provides important fish and wildlife habitat, and clean water for downstream users. To maintain this quality, try to prevent any alterations or inputs, and continue to monitor your stream for any changes - use this form once a year, or more regularly if you think it necessary. If you are interested I highly recommend reading, Managing Riparian Zones: A Contribution to Protecting NZ's Rivers & Streams, Volumes 1&2 (1995). Published by the Department of Conservation (DoC) and the National Institute for Water and Atmospheric Research (NIWA).

200-390 Your stream has lots of potential and is at an intermediate priority level. It provides habitat for some fish and those stream insects which are more tolerant to pollution. If you want to improve the quality of your waterways and are unsure of where to begin, Federated Farmers, Forest & Bird, Fish & Game, QEII National Trust or DoC will be able to help (see list of contacts). Alternatively, the soil conservators and freshwater biologists at your local Regional Council will be able to offer advice or maybe grant assistance. Landcare and AgResearch offer consultancy services in this area.

0-200 Your stream is adversely effected by management practices in your area, and therefore has a high priority for management. Only pollution tolerant types of stream insects will be found in your stream. To improve the quality of your stream, the same groups as mentioned above will be able to give you a hand. It may be necessary to coordinate with your 'upstream neighbours', as their management practices also affect the health of the stream as it flows through your property.

THESE SIX STEPS MAY BE USEFUL IN HELPING YOU TO DEVELOP A MANAGEMENT PLAN FOR YOUR STREAM(S).

Step 1: Identify your aims for the stream e.g., stock water, irrigation, household water, swimming for children, aesthetic values, ecological values etc.

Step 2: Identify questions from sections 1-3 with low scores which could potentially limit the key uses you have chosen above.

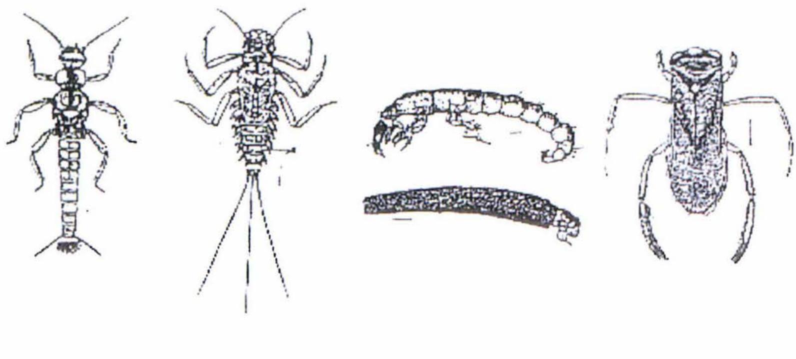
Step 3: From these questions decide what will be your target for improvement over the next 12 months.

Step 4: Develop a plan of action. If you need assistance, refer to the list of contacts.

Step 5: Set yourself a date for the next assessment of the stream, to monitor your improvements. Mark this in your diary.

Step 6: You may wish to create a spreadsheet using a computer package like 'Excel' to compare results from year to year. Simply record the question number (e.g., 1a) and the score circled.

DATE FOR NEXT ASSESSMENT / /



STONEFLY **MAYFLY** **CADDISFLIES** **WATERBOATMAN**

Sensitive Insects *Moderately Sensitive* *Pollution Tolerant*

(Reproduced with kind permission, from Winterbourn, M.J., & Gregson, K.L.D. (1989). *Guide to the aquatic insects of New Zealand*).

NOTES FOR IDENTIFYING INSECTS: *Stoneflies have two 'tails', whereas mayflies have three. Some caddisflies have cases, these can be made of small twigs or sand grains, so look out for those. Those without cases look like worms, except they have legs! You may also find beetles, which along with worms and snails will be easy to identify. These insects are on average only about 1 cm long, so you need to look carefully. Putting them in an ice cream container with a small amount of water makes them easier to see. If you are interested in finding out more about what is living in your stream, contact NIWA (see contact list) and ask about their Stream Health Monitoring & Assessment Kit (SHMAK).*

Your scores for the questions in Sections 4 & 5 are unlikely to change in the short term. Read the questions thoroughly the first time you use the form, after that briefly check through them to see nothing has changed.

4a. What is the dominant land use 1km upstream?			
Ungrazed native forest, wetlands and/or tussock grasslands.	Disturbed native forest, wetlands and/or tussock grasslands.	Exotic forestry, and/or sheep and beef farming.	Intensive farming: dairy or red deer. Cropping systems or urban land use.
32	16	8	4

4b. What is the dominant land use here?			
Ungrazed native forest, wetlands, and/or tussock grasslands.	Disturbed native forest, wetlands and/or tussock grasslands.	Exotic forestry, and/or sheep and beef farming.	Intensive farming: dairy or red deer. Cropping systems or urban land use.
32	16	8	4

4c. What is the dominant type of stock in the area?			
No stock. Stream is not in pastoral land, or stock rarely grazed on surrounding land.	Sheep and/or goats. Pest or feral animals may graze any remnant areas.	Intensive cattle farming (on easy country), or arable land.	Intensive dairy or deer farming, or cattle intensively managed on hill country.
32	16	8	4

4d. What type of country does your stream flow through?			
Hill/mountain country.	Rolling country.	Inland flat country.	Coastal country.
16	8	4	2

4e. Are there any natural drainage pathways within 100 m of you? (e.g., where runoff is directed into a gully or ephemeral type channel and then into a stream - a large amount of runoff enters the stream at one point).			
No natural drainage pathways within 100 m.	1 natural drainage pathway within 100 m.	2-3 natural drainage pathways within 100 m.	>3 natural drainage pathways within 100 m.
16	8	4	2

SUBTOTAL 4 =

5a. How big is your stream?			
Large lowland river, 15 - 100 m wide.	Small river, 5 - 15 m wide.	Medium stream, 2 - 5 m wide.	Small stream, 0 - 2 m wide.
32	16	8	4

5b. How deeply incised are your stream banks?			
Top of stream banks 10 m or higher above stream.	Top of stream banks 10-5 m above stream.	Top of stream banks 5-1 m above stream.	Top of stream banks 1 m or less above stream.
16	8	4	2

5c. What is on the streambed?			
Rocks & stones of different sizes, tightly packed together.	Stones, silt present in gaps between rocks/stones.	Gravel, sand and silt.	Sand and silt, stones absent.
16	8	4	2

5d. How cohesive are the soils of the stream bank?			
Very cohesive. Mostly rock & cemented material (boulders & bedrock).	Reasonably cohesive. Tightly packed gravel or sand in a clayey matrix.	Loose soils with fine aggregates. Tightly packed sands or gravels with some silt or clay.	Very loose soils. Loosely packed sandy, gravelly or pumice material.
16	8	4	2

5e. How well do your soils drain after rain?			
Deep, well draining soils that slow down the recharge of water to waterways and drains.	Moderately well draining soils, but soils are water-logged for long periods in winter.	Excessively well draining soils - water moves freely through the soil, reaching waterways rapidly. Sandy/porous soils.	Poorly draining soils. Soils water-logged for long periods after rain, surface ponding occurs in low areas. Heavy textured soils.
16	8	4	2

SUBTOTAL 5 =

CONTACTS

Federated Farmers	
Graeme Allomes (Central Region)	(06) 357 4026
Fish & Game	
Peter Taylor (Wellington Region)	(06) 359 0409
Forest & Bird	
Peter vanEssen	(06) 356 9099
NIWA	
Cathy Kilroy or Barry Biggs	(03) 348 8987
DoC	
Rosemary Miller (Wanganui Conservancy)	(06) 345 2402
QEII National Trust	
Phillip Lissaman (Wellington)	(06) 472 6626
Manawatu-Wanganui Regional Council	
Lachlan Grant (Soil Conservator)	(06) 345 0705
John Phillips (Environmental Scientist)	(06) 357 9009
Malcom Todd (Land Monitoring Officer)	(06) 357 9009
AgResearch	
Alec McKay	(06) 356 8019
Landcare Research	
Noel Trustrum	(06) 350 3809
Mike Page	(06) 356 7154
Massey University	
Russell Death	(06) 356 9099

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These contacts will also be able to give the name and number of someone in your region, if they are not.

Waterway Self Assessment Form

Miranda Polglase & Russell Death
Massey University

Waterway Self Assessment Form

Date & Time

Stream Name

Approx. Location of Site

Important Things to Note ***(impt. for future assessments)***
e.g. if your stream is particularly low/high, a major slump has occurred recently, recent stock access upstream, etc.

The following Waterway Self Assessment Form provides you with a tool for pinpointing problem areas of waterways and monitoring your management progress. It will also give you an idea of how 'healthy' your stream is. Management options may include adopting different land management methods near your waterway. If you would like additional advice on 'where to from here', some contacts have been suggested at the end. You may want to photocopy the form for making later assessments.

To use the form read each question thoroughly and circle the score which corresponds to the category best describing your stream (or the specific area of stream you are assessing). Unless stated otherwise, assess each section of stream 100m up-and-downstream from where you are standing. If your stream isn't described exactly by one category you can give it a score halfway between those given. For example, question 1b - the land use may be sheep and beef farming with a significant native remnant on it - give a score of 12, halfway between 16 and 8. Subtotal the scores at the end of each page. For your grand total add the subtotals at the end of the form. To ensure your methods are consistent between surveys, try to carry out your assessment at the same place and when your stream is under similar conditions. For example, if you make your first assessment under low flow conditions and the following assessment at flood flows you will not be able to successfully compare your results.

Only the questions in Sections 1-3 need to be reassessed thoroughly each time you use the form.

1a. What type of vegetation is along the stream side?			
Trees with dense groundcover e.g., tussock, toetoe, ferns,flax,rushes.	Tall grasses with patchy trees and groundcover.	Patchy trees, groundcover grazed.	Grazed pasture grasses to stream edge.
16	**8**	**4**	**2**
1b. How continuous is the vegetation (other than pasture) in the riparian zone? (*Riparian Zone: 'on or of the stream banks'*).			
Tall vegetation/ trees continuous or with a few small gaps.	Tall vegetation/ trees less continuous, a few large gaps or several small gaps	Breaks in tall vegetation/ trees frequent - very patchy.	Many large gaps in tall vegetation/trees or no tall vegetation at all.
16	**8**	**4**	**2**
1c. What is the average width of the vegetation (other than pasture) in the riparian zone?			
>30 m.	10-30 m.	1-10 m.	0 m.
32	**16**	**8**	**4**
1d. What % of the stream is shaded by plants and stream banks ?			
50% or more.	30%.	10%.	Little or no shading.
16	**8**	**4**	**2**
1e. How stable are the stream banks?			
Banks stable, rock and soil firmly held by grasses, shrubs and tree roots.	Banks firm but loosely held by grass and shrubs.	Banks of loose soil held by a patchy layer of grass and shrubs.	Banks unstable, of loose soil or sand easily disturbed.
16	**8**	**4**	**2**
1f. How bad is the erosion around or adjacent to your stream?			
No evidence of erosion in surrounding land area, no scarring on stream banks, no undercutting.	Some erosion in surrounding land area. Occasional scarring on stream banks and undercutting.	Moderate erosion in surrounding land. Eroding banks slowly widening.	Significant erosion in surrounding land area. Significant areas of stream bank cut away, some loss of farmland.
32	**16**	**8**	**4**

SUBTOTAL 1 =

2a. What types of stream plants and mosses are there?			
Stones either dull in colour or very bright. Mosses may be present along edge and in pools.	Stones very slippery and dull in colour, with a brownish algae. Long slimes and/or weeds present in summer.	Green and/or brown long slimes present and/or water cress & other weeds.	Stream choked with long green and/or brown slimes and/or large stream plants.
16	**8**	**4**	**2**

2b. Are there any snags to slow the stream flow?			
Rocks and old logs firmly set in place.	Rocks and logs back filled with sediment.	Rocks & logs loose, moving with floods.	No obstructions to slow stream flow.
16	**8**	**4**	**2**

2c. How clear is the water? NB: Do not assess this category after a period of high rainfall.			
Water 'crystal' clear.	Water slightly murky.	Water murky.	Water very muddy.
16	**8**	**4**	**2**

2d. What bugs live in your stream? (See back for pictures of some insects you may find). NB: To find stream insects look under rocks. Or on water weeds, grass, logs & other debris if your stream has no rocks.			
Lots of mayflies, stoneflies and other types of insects.	Moderate numbers of mayflies and caddisflies, other types of insects may also be found.	Only a few insects found. No mayflies or stoneflies, but more than just worms & snails.	Worms and snails, but not much else. Or nothing found at all.
16	**8**	**4**	**2**

2e. How often does your stream overtop its banks?			
Never known to overtop banks.	Overbank flows rare.	Overbank flows occur during some winter storms.	Overbank flows frequent in winter/ spring storms. Or stream channelised &/ has stop banks.
16	**8**	**4**	**2**

SUBTOTAL 2 =

3a. Do stock have access to your stream? (Stock access can be prevented by fencing, trees, steep banks, etc.).			
Stock do not have access to any of the stream or its banks.	Stock only have access to a small part of the stream.	Stock have access to most of the stream.	Stock have access to the entire stream.
32	**16**	**8**	**4**

3b. What is the potential for the input of sediment to your stream? (e.g., from stream banks, stock damage/trampling, stock crossings, surface runoff, runoff from farm roads, slips/erosion, gravel extraction, etc.).			
No potential.	Low potential.	Moderate potential.	High potential.
32	**16**	**8**	**4**

3c. What is the potential for the input of contaminants to your stream? (e.g., from spray drift, sprayer washings (sheep dips), effluent ponds, silage pits, dumps, oil and foam, dead animals, etc.).			
No contamination.	Low contamination.	Moderate contamination.	High contamination.
32	**16**	**8**	**4**

3d. Is there any artificial drainage entering the stream? (e.g., tile, mole, storm water, &/ open drains which have the vegetation dredged).			
No artificial drainage.	Sparse artificial drainage.	Moderate amount of drainage.	Extensive drainage networks.
32	**16**	**8**	**4**

3e. How much fertiliser is used by yourself and neighbours?			
No fertiliser used here or by neighbours.	Low rates. Less than 150 kg/ha of super (or equivalent), nitrogen fertilisers not used.	Moderate rates. 150-300 kg/ha of super (or equivalent), low use of nitrogen fertilisers.	High rates. More than 300 kg/ha of super (or equivalent), moderate use of nitrogen fertilisers.
32	**16**	**8**	**4**

SUBTOTAL 3 =

Your scores for the questions in Sections 4 & 5 are unlikely to change in the short term. Read the questions thoroughly the first time you use the form, after that briefly check through them to see nothing has changed.

4a. What is the dominant land use 1km upstream?			
Ungrazed native forest, wetlands and/or tussock grasslands.	Disturbed native forest, wetlands and/or tussock grasslands.	Exotic forestry, and/or sheep and beef farming.	Intensive farming: dairy or red deer. Cropping systems or urban land use.
32	**16**	**8**	**4**

4b. What is the dominant land use here?			
Ungrazed native forest, wetlands, and/or tussock grasslands.	Disturbed native forest, wetlands and/or tussock grasslands.	Exotic forestry, and/or sheep and beef farming.	Intensive farming: dairy or red deer. Cropping systems or urban land use.
32	**16**	**8**	**4**

4c. What is the dominant type of stock in the area?			
No stock. Stream is not in pastoral land, or stock rarely grazed on surrounding land.	Sheep and/or goats. Pest or feral animals may graze any remnant areas.	Intensive cattle farming (on easy country), or arable land.	Intensive dairy or deer farming, or cattle intensively managed on hill country.
32	**16**	**8**	**4**

4d. What type of country does your stream flow through?			
Hill/mountain country.	Rolling country.	Inland flat country.	Coastal country.
16	**8**	**4**	**2**

4e. Are there any natural drainage pathways within 100 m of you? (e.g., where runoff is directed into a gully or ephemeral type channel and then into a stream - a large amount of runoff enters the stream at one point).			
No natural drainage pathways within 100 m.	1 natural drainage pathway within 100 m.	2-3 natural drainage pathways within 100 m.	>3 natural drainage pathways within 100 m.
16	**8**	**4**	**2**

SUBTOTAL 4 =

5a. How big is your stream?			
Large lowland river, 15 - 100 m wide.	Small river, 5 - 15 m wide.	Medium stream, 2 - 5 m wide.	Small stream, 0 - 2 m wide.
32	**16**	**8**	**4**
5b. How deeply incised are your stream banks?			
Top of stream banks 10 m or higher above stream.	Top of stream banks 10-5 m above stream.	Top of stream banks 5-1 m above stream.	Top of stream banks 1 m or less above stream.
16	**8**	**4**	**2**
5c. What is on the streambed?			
Rocks & stones of different sizes, tightly packed together.	Stones, silt present in gaps between rocks/stones.	Gravel, sand and silt.	Sand and silt, stones absent.
16	**8**	**4**	**2**
5d. How cohesive are the soils of the stream bank?			
Very cohesive. Mostly rock & cemented material (boulders & bedrock).	Reasonably cohesive. Tightly packed gravel or sand in a clayey matrix.	Loose soils with fine aggregates. Tightly packed sands or gravels with some silt or clay.	Very loose soils. Loosely packed sandy, gravelly or pumice material.
16	**8**	**4**	**2**
5e. How well do your soils drain after rain?			
Deep, well draining soils that slow down the recharge of water to waterways and drains.	Moderately well draining soils, but soils are water-logged for long periods in winter.	Excessively well draining soils - water moves freely through the soil, reaching waterways rapidly. Sandy/porous soils.	Poorly draining soils. Soils water-logged for long periods after rain, surface ponding occurs in low areas. Heavy textured soils.
16	**8**	**4**	**2**

SUBTOTAL 5 =

SUBTOTALS

1. ________ *(range 16-128)* **TARGET**

2. ________ *(range 10-80)* **THESE 3**

3. ________ *(range 20-160)* **CATEGORIES!**

4. ________ *(range 16-128)*

5. ________ *(range 12-96)*

TOTAL SCORE ________

WHAT DOES MY TOTAL SCORE MEAN?

>390 Great! Your stream is very healthy and hence has a low priority for waterway management. It provides important fish and wildlife habitat, and clean water for downstream users. To maintain this quality, try to prevent any alterations or inputs, and continue to monitor your stream for any changes - use this form once a year, or more regularly if you think it necessary. If you are interested I highly recommend reading, Managing Riparian Zones: A Contribution to Protecting NZ's Rivers & Streams, Volumes 1&2 (1995). Published by the Department of Conservation (DoC) and the National Institute for Water and Atmospheric Research (NIWA).

200-390 Your stream has lots of potential and is at an intermediate priority level. It provides habitat for some fish and those stream insects which are more tolerant to pollution. If you want to improve the quality of your waterways and are unsure of where to begin, Federated Farmers, Forest & Bird, Fish & Game, QEII National Trust or DoC will be able to help (see list of contacts). Alternatively, the soil conservators and freshwater biologists at your local Regional Council will be able to offer advice or maybe grant assistance. Landcare and AgResearch offer consultancy services in this area.

0-200 Your stream is adversely effected by management practices in your area, and therefore has a high priority for management. Only pollution tolerant types of stream insects will be found in your stream. To improve the quality of your stream, the same groups as mentioned above will be able to give you a hand. It may be necessary to coordinate with your 'upstream neighbours', as their management practices also affect the health of the stream as it flows through your property.

THESE SIX STEPS MAY BE USEFUL IN HELPING YOU TO DEVELOP A MANAGEMENT PLAN FOR YOUR STREAM(S).

Step 1: Identify your aims for the stream e.g., stock water, irrigation, household water, swimming for children, aesthetic values, ecological values etc.

Step 2: Identify questions from sections 1-3 with low scores which could potentially limit the key uses you have chosen above.

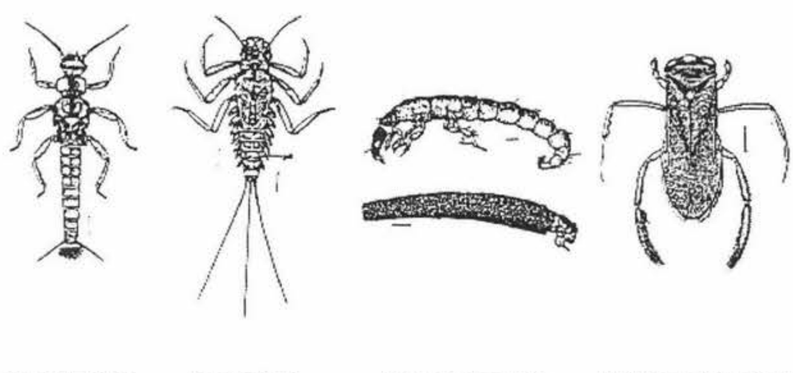
Step 3: From these questions decide what will be your target for improvement over the next 12 months.

Step 4: Develop a plan of action. If you need assistance, refer to the list of contacts.

Step 5: Set yourself a date for the next assessment of the stream, to monitor your improvements. Mark this in your diary.

Step 6: You may wish to create a spreadsheet using a computer package like 'Excel' to compare results from year to year. Simply record the question number (e.g., 1a) and the score circled.

DATE FOR NEXT ASSESSMENT / /



STONEFLY **MAYFLY** **CADDISFLIES** **WATERBOATMAN**

Sensitive Insects *Moderately Sensitive* *Pollution Tolerant*

(Reproduced with kind permission, from Winterbourn, M.J., & Gregson, K.L.D. (1989). *Guide to the aquatic insects of New Zealand*).

NOTES FOR IDENTIFYING INSECTS: *Stoneflies have two 'tails', whereas mayflies have three. Some caddisflies have cases, these can be made of small twigs or sand grains, so look out for those. Those without cases look like worms, except they have legs! You may also find beetles, which along with worms and snails will be easy to identify. These insects are on average only about 1 cm long, so you need to look carefully. Putting them in an ice cream container with a small amount of water makes them easier to see. If you are interested in finding out more about what is living in your stream, contact NIWA (see contact list) and ask about their Stream Health Monitoring & Assessment Kit (SHMAK).*

CONTACTS

Federated Farmers	
Graeme Allomes (Central Region)	(06) 357 4026
Fish & Game	
Peter Taylor (Wellington Region)	(06) 359 0409
Forest & Bird	
Peter vanEssen	(06) 356 9099
NIWA	
Cathy Kilroy or Barry Biggs	(03) 348 8987
DoC	
Rosemary Miller (Wanganui Conservancy)	(06) 345 2402
QEII National Trust	
Phillip Lissaman (Wellington)	(06) 472 6626
Manawatu-Wanganui Regional Council	
Lachlan Grant (Soil Conservator)	(06) 345 0705
John Phillips (Environmental Scientist)	(06) 357 9009
Malcolm Todd (Land Monitoring Officer)	(06) 357 9009
AgResearch	
Alec McKay	(06) 356 8019
Landcare Research	
Noel Trustrum	(06) 350 3809
Mike Page	(06) 356 7154
Massey University	
Russell Death	(06) 356 9099

Ecology
Institute of Natural Resources
Massey University
Private Bag 11 222
PALMERSTON NORTH
e-mail: R.G.Death@massey.ac.nz

These contacts will also be able to give the name and number of someone in your region, if they are not.

CHAPTER THREE

Landowner feedback and peer review of the Waterway Self Assessment Form

Introduction

Feedback from landowners was an important process in the development of the Waterway Self Assessment Form. The aim of taking the form to a group of landowners was to ensure the user-friendliness of the form. This process also presented the opportunity to investigate whether the landowners thought the form was useful and if it was a tool they would promote to other landowners. A peer review process was also undertaken on the form to ensure the questions were practical and realistic. This also provided the critical analysis a number of topics required. Also described in this section is the investigation of the inter-observer reliability of the form.

Landowner Feedback

Introduction

One of the most important stages of development of the Waterway Self Assessment Form was receiving feedback from landowners, who would be the end users of the form. As the form was designed for the purpose of providing a management tool for landowners, it was imperative that it be understandable and user friendly for this target user group. The most effective and efficient means to achieve this was to take the form to the landowners themselves in a pilot study type situation and ask for their feedback and comments, while it was still in draft format. This enabled suggestions made by landowners, or issues raised in discussions to be included in further refinement of the form.

Methods

The Federated Farmers organisation was initially contacted with a view to obtaining contact details of members, from which the sample could be selected. However, for privacy reasons, Federated Farmers were not able to provide this information. Instead, members of the administration of the organisation contacted a number of landowners, assessing their interest and availability to participate in this part of the research, and with their consent, provided the researcher with their telephone contact details.

These landowners were then contacted by telephone. The researcher was introduced and the research outlined. An indication of the requirements of them, as participants was explained. In the event of further agreement being obtained, a date, time and location to meet was arranged and in most cases, encouragement was given to invite along other landowners, for example acquaintances or neighbours. A total of 30 landowners were contacted in this manner, and confirmed their availability.

In all cases, the researcher traveled to the landowners' farms, and meetings were held in homes, wool or dairy sheds. The process of the meetings was consistent across all groups, with the meeting beginning (after introductions) with the researcher outlining the research and introducing the Waterway Self Assessment Form. The group would then go out to a stream and each landowner would complete an assessment of the stream using the form. If at any stage any of the participants indicated that they were having difficulty with understanding a question's requirements, or if discussions arose between landowners along these lines, this was noted and the questions' clarity and intention was discussed later, and if appropriate, amended accordingly.

To further facilitate this pilot study of the form, a standardised set of feedback questions were developed and administered after the form was filled out, asking specific structure and content related questions of the landowners. Essentially, this part of the study asked landowners for their suggestions to further improve the form's usability, relevance and its possible impact on improving awareness of riparian management issues and/or changing attitudes toward stream management. A total of 23 landowners participated in this part of the study and a copy of the questions is provided in Appendix 1.

A summary of landowner responses and feedback provided is presented below.

Results and Discussion

Full documentation of the landowners' responses to the follow up questions, as recorded at the time of the meetings is provided in Appendix 2. The comments are made with respect to an earlier version of the Waterway Self Assessment Form than is presented in Chapter Two.

Q1. Were there any questions which were difficult to follow, or appeared to be repetitive? How could the question be changed to make it clearer?

Almost half (48%) of the respondents did not find any of the questions difficult to follow or repetitive. 52% of respondents indicated ways in which questions could be made clearer.

The comments of the respondents who answered "yes" to this question commented on such factors as, reversing the order of categories in questions for example, "Question 2c - What type of vegetation is along the stream side?" (now question 1a in the final version of the form). As a result of this comment, the second ("Patchy trees; groundcover grazed") and third ("Tall grasses and other patchy vegetation") categories were reversed. This question assesses the filtering capacity of the stream side vegetation. Grazed vegetation will have less filtering capacity than ungrazed vegetation, hence the need to reverse these two categories was recognised.

It was suggested that an "Option [was] required for water levels created by man-made improvements, i.e., stopbanks/channelisation". This comment refers to question 4c - How often does your stream overtop its banks? (now question 2e in the final version of the form). An option for a channelised stream was already available, however, stopbanks had not been considered. The addition of stopbanks will change the natural frequency of overbank flood events, as this is the purpose for which they were created. Stopbanks increase the stream channel's capacity for flow discharges. An option for stopbanks was therefore included.

Several landowners had difficulty with question 3e - What bugs live in your stream?, (now question 2d in the final version of the form). As a result of this pilot study, all reference to the MCI (Macroinvertebrate Community Index), was omitted, as this seemed to be causing the most confusion. It was felt that the lack of understanding towards the MCI far outweighed the increased knowledge that a few gained from this question, hence the decision to remove this information. "Look on logs & other debris", was included as an additional instruction as suggested.

Several landowners also had difficulty with question 5c - Are there any preferential drainage pathways within 100m of you? (now question 4e in the revised version of the form). The word 'preferential' seemed to be causing the most confusion, and was thus replaced by 'natural' drainage pathways. The explanation of a natural drainage pathway has also been altered to clarify the meaning of the question. Storm water has now been included in question 3d (revised version) regarding artificial drainage. Providing space for the actual number of natural drainage pathways was not an option due to the nature and layout of the form, and was deemed unnecessary. Comments included: "Question

5c needs to be read carefully! Perhaps needs explaining a bit clearer"; "5c, explain preferential drainage pathways better"; and "Make a distinction between natural drainage versus storm water".

In some cases, suggestions were made by landowners that were deemed to not necessitate a change to the form, for example one respondent stated in response to question 1a - What is the dominant land use 1 km upstream? (question 4a in revised version), that the question should refer to the dominant land use in the entire catchment. However, the nature of streams and rivers is such that significant changes in their physio-chemical and biological character can occur over relatively short distances with respect to land use (see Chapter One). Therefore no change was made to this question.

Question 4a asked about the stability of stream banks and included an example of one unstable soil type - papa. Following the suggestion of one respondent that giving an example of only one unstable soil type may mislead a user of the form to believing that only papa soil types may be considered unstable, the question was revised to "How stable are the stream banks?" (question 1e in the final version of the form).

One respondent also questioned the necessity of question 5d - How does artificial drainage affect water quality? The respondent was unaware that artificial drainage is a potential source of nutrient input to streams. Nutrient removal can occur within the riparian zone, however water in artificial drainage bypasses riparian soils (see Chapter One). Hence no change was made to this question (3d - Is there any artificial drainage entering the stream? in the final version).

Question 5e - How much fertiliser is used by yourself and neighbours?, (question 3e in revised version), needed clarification as to whether the question referred to weight of total fertiliser applied or weight of nutrient i.e., nitrogen (N) or phosphorus (P). Also it became obvious that it was not practical to refer to N and P use together. This question was significantly modified with the assistance of Prof. R. Tillman (Soil Science, Institute of Natural Resources, Massey University).

At times, respondents' views solicited in this part of the study suggested areas where further information could be added to improve the clarity, and therefore usability of the form. For example, respondents indicated that they would like to have seen definition of terms included sometimes: "2d, define riparian zone", and "Only 2b, which could be a bit more explanatory", and in question 2b it was suggested that it was unclear what is meant by 'incised', height or 'dug in'. Question 2b - How deeply incised are your stream banks? (5b in revised version), was thus reworded to make it easier to understand, and a definition of riparian zone was included in the final version of the form where the question, "How continuous is the vegetation (other than pasture) in the riparian zone?" (question 1b in the final version) was asked.

Two respondents indicated that they had difficulty in "visualising exactly the meaning" in questions 2c and 3c. The wording of question 2c was changed in the final version of the form (1c) from, 'What is the average width of vegetation other that grazed pasture?' to 'What is the average width of vegetation (other than pasture) in the riparian zone?'. Question 3c remains unchanged, Are there any snags to slow the stream flow? (2b in final version of the form), as additional clarification was not possible.

Q2. What changes would you like to see made to the form?

Over half (61%) of the respondents did not want to see any changes made to the form. Below are the comments made by the remaining 39% of respondents, and the ensuing changes made to the revised version of the Waterway Self Assessment Form.

"If it's O.K., call it a questionnaire". This suggestion was considered, however, it was decided to title it a 'form'. Discussions indicated that this term seemed more user-friendly than questionnaire. Questionnaire was seen by some respondents to imply providing information for someone else - this is not the case with the Waterway Self Assessment Form, as the information is for the landowner only.

Suggestions such as "More instructions at the start i.e., assessing over what length of stream", "Separate score sheet", and "Fuller explanation page re: location" were useful contributions and resulted in the final version of the form containing a more comprehensive set of instructions. These include indicating the area over which the assessment is to be made. However, rather than providing a separate score sheet, it is recommended in the final version that photocopying the form for making later assessments is an option for landowners. It is also suggested that creating a spreadsheet for recording the results of each assessment could be useful.

One respondent indicated that the "Questionnaire" was "too broad", and that "...no limestone soils [are] mentioned, and different areas, [would have] different soil types". It was not practical to list all possible soil types that may exist, and this was indeed beyond the scope of the purpose of the form. Instead physical characteristics of soils which have indirect effects on water quality are used in the final version i.e., question 5d – 'How cohesive are the soils of the stream bank?', and 5e - How well do your soils drain after rain? Unfortunately 'broadness' is an inherent feature of self-assessment forms such as this. It is impossible to cover every possible condition.

Some very practical suggestions were made by respondents. For example, "Increase size of font", as a result the size of the text in the tables was changed from 8 to 10 pt, and changed from 'Comic Sans MS' to 'Arial' to improve the readability of the text. "Provide titles for each category" was also a suggestion, but although this respondent wanted to see titles to head each category, this was not possible, as the questions in each category cover a wide range of stream characteristics which are unable to be grouped under one simple heading. Similarly, "Define the categories at the end, to make it clearer what the main problem is" highlights a related problem. Each category covers a wide range of stream characteristics, to pick one of these as the focus for management would risk loss of valuable information and may lead to over-simplification of the problem(s).

Another practical suggestion adopted was, "After the first assessment, you only need to assess some categories again. [You] Could group these together to make it [the form] seem shorter". The questions are now in two broad groups in the final version of the form. The first group includes all of those questions which are likely to change over a relatively short time frame, and which are potentially able to be altered by active stream management i.e., percentage of the stream which is shaded. The second group contains all of the questions which are either unlikely to change in the short term, or are unable to be changed through management i.e., what type of country the stream flows through.

The suggestion to "Underline ... 'circle a score halfway between' ..." was common from landowners and this instruction was frequently overlooked by users of the form. The sentence "If your stream isn't described exactly by one category you can give it a score halfway between those given", has been underlined and highlighted in red in the final version.

There were also suggestions "Rearrange the separate natural geography from farming impacts (sheep/effluent etc.)" and to rearrange the questions in a "geological sequence". The arrangement of the questions into one group of geological based questions and one of farming based questions, was rejected in favour of the arrangement previously mentioned - separating the questions based on the potential for them to be changed through management and over short or long time frames.

It was also suggested that keeping a "running total" was a possibility, however, the layout of tables did not allow for this. Highlighting the scores in red in the final version of the form should lead to simple identification of the scores and easier calculation of the total.

The final suggestion here, to "include open drains", led to open drains now being included in question 3d - Is there any artificial drainage entering the stream? (final version). Only those drains which have the vegetation removed by such means as dredging are included, as marginal vegetation and aquatic plants have the ability to trap and remove nutrients (see Chapter One).

Q3. Do you think there are any questions missing?

78 % of respondents did not think that there were any questions missing. The comments of those respondents that suggested other areas for inclusion follow:

One respondent suggested including a question about the "type of parent material in stream bed, i.e., limestone, greywacke". As reflected in the discussion above ('What changes would you like to see made to the form') it is not possible to list all possible geological types. Instead, the physical appearance of the substrate is assessed (5c - What is on the streambed?). This classification was deemed to be sufficient for the purposes of the form.

One respondent suggested that a question related to "water quality" should be included - "Yes, in relation to water quality". However, all of the questions in the form contribute to answering this general question, by virtue of the visual assessment. The only other way to pose such a question would be with a series of chemical and biological tests, which again is beyond the scope of the Waterway Self Assessment Form.

Two related suggestions - "Has the farmer done any conservation work?" and "What measures are being taken at present?" are questions that raise issues of management regimes already being undertaken. The Waterway Self Assessment Form prioritises areas of streams in terms of need for management. An area of stream which is already undergoing some form of management may still be deemed a priority through use of the form. Stream management is often an ongoing task, and past management strategies may not necessarily mean the stream no longer needs managing. However, areas which have been managed in the past may be identified by scoring well with the form, and hence will be a low priority area for future management. Therefore, inclusion of a specific question related to prior management activities was deemed unnecessary.

One respondent indicated that the length of the form needed attention - "There are probably too many [questions], and some could be shorter i.e., is the stream fenced?". Significant effort has been placed on making the form as precise and brief as possible, so as not to be perceived as a lengthy and time consuming task for landowners. However, sufficient information is still required for the questions to be interpreted as they were intended. All of the questions included in the form are necessary to ensure the scientific validity of the end results obtained through use of the form.

Q4. Would you continue to use the form?

83 % of respondents answered "Yes", that they would continue to use the form, 8.5 % of respondents said "No", they would not continue to use the form and 8.5% of respondents said they were "unsure" if they would continue to use the form. The general consensus was that the form is, "a very useful tool", and that, "the contact list would be very useful". The inclusion of 'If not, why?', would have provided insight into why a small proportion of landowners would not continue to use the form.

Q5. For what purposes? and Q6. How often?

A full list of the respondents' answers to these questions can be found in appendix 2. Two main purposes were identified, and 57% of respondents indicated that they would use the form again annually.

For what purposes?:

33% - Self-regulation and increasing awareness.

67% - Waterway management, monitoring and evaluation of water quality.

How often?:

Once - 5 %

Annually - 57 %

Bi-annually - 14 %

Tri-annually - 5 %

Unsure - 19 %

Q7. Do you think the form has the potential to be a useful tool in marketing produce? (e.g., as part of a quality assurance scheme).

Again a full list of the respondents' answers to this question can be found in Appendix 2. 57% of respondents answered "Yes" that they thought the form had the potential to be a useful marketing tool. 21.5 % answered in the negative, and 21.5% were unsure.

Q8. Would you recommend the form to your neighbour? If not, why?

An encouraging 87 % of respondents answered that they would recommend the form to their neighbour. Interestingly, all of those respondents who answered "no" (13%) to this question also added that it was because their neighbours were not interested in issues of waterway management (Appendix 2).

Q9. Has the form increased your understanding of waterway health and the associated impacts? If so, how?

There was an overwhelmingly positive response to this question with 87% of respondents indicating that the form had increased their understanding of waterway health and the associated impacts. The most common comment added to this question was that the Waterway Self Assessment Form had provided a general increase in awareness about factors affecting water quality.

Q10. Do you think it will change your attitudes/ thinking towards the management of your streams?

Respondents' answers were as follows:

Yes - 43 %

No- 26 %

N/A - 22 %

Unsure - 9 %

The response "N/A" applies to those respondents who believed they were already actively addressing waterway management.

Q11. How will you use the information obtained by using the form?

Three main uses have been identified.

37% - Self-encouragement, to become proactive about waterway management.

42% - As a reference or index, (for monitoring).

21% - To increase my awareness.

Q12. Whose responsibility do you think the management of waterways should be?, (e.g., regional council or your own?).

Own - 17 %

Regional Council - 13 %

Both - 70 %

This finding has possible implications for the Regional Council in that forming some form of partnership with landowners in stream management could be very effective. Horizons. mw is taking steps toward such an approach with the launching of their Land and Riparian Management Strategy (July 1999), in which use of the Waterway Self Assessment Form is promoted.

Q13. What assistance do you require with waterway management?

Four main types of required assistance were identified.

28% - Financial.

36% - Advice on plantings.

12% - Erosion control.

24% - Knowledge, education/ advice, technical expertise.

Again this has possible implications for the Regional Council. The formation of a stream management partnership with landowners would meet many of the requirements listed above. In particular, expert advice and technical support with management activities such as plantings and erosion control would be readily available. Financial assistance is available from the Regional Council, through subsidies. Cost is a major limiting factor to the undertaking of a management programme from a landowners' perspective.

Conclusions

These findings provide support for the general aims of the Waterway Self Assessment Form. A high percentage of landowners felt that the form was useful in raising awareness and served an educational function. It was generally found to be user friendly and in instances where it was not remedial steps have been taken in the final version of the form.

The exercise of contacting landowners and performing a pilot test of the form was particularly useful in that it provided for observation of the form in use. All suggestions and comments made by the landowners were carefully discussed and considered. This resulted in many changes being made such as, additional questions being included, reformatting and the addition of further explanatory material. It is particularly encouraging that such a high percentage of landowners said that they would use the form again.

Peer review

In conjunction with the landowner input, a peer review process to test the usability and applicability of the form was undertaken. This process involved a number of interested parties and processes and focused on: inclusiveness of language and style, understanding - was the form "user friendly", use of lay-language, elimination of jargon and general feedback.

The researcher met with a number of dairy farming cadets from the Wanganui district. Feedback from this process was limited, as the cadets were not available to participate in a field situation. However, as a result of providing the cadets with copies of the form to take away and fill out, some useful suggestions were received and their initial responses highlighted areas for further consideration for example, including an explanation of what the total score means.

Staff at the Department of Conservation, Wanganui conservancy (Rosemary Miller, Senior Conservation Officer – Water Resources and Carol Greensmith, Public Relations), provided useful feedback, particularly in respect to layout, appearance and general wording of the form.

Ongoing contact with the Regional Council (Manawatu Wanganui Regional Council, which in the timeframe of the form's development relaunched itself as Horizons.mw) was useful and informative. Development of parts of the form necessitated critical analysis by experts in the area of stream management. Staff at Horizons.mw, particularly John Phillips, Malcolm Todd, Lauchlan Grant and Ross Quayle provided valuable feedback in this area. The Regional Council were also encouraging, seeing the potential of the form to become an important component in the suite of tools used by the Council in their monitoring programmes.

AgResearch Palmerston North also provided valuable feedback, with Alec McKay adding yet another perspective. Comments provided focused on previous experience of farmers using self-assessment tools to facilitate resource management.

Finally, a rural research consultant was consulted to provide further input and analysis of the form. Jacalyn Scott was able to provide feedback on the form's content and structure.

Discussions with all these groups and individuals contributed to the development of the form and to its final content and presentation. It was useful to receive feedback from such a diverse and wide range of stakeholders, from the farmers of the future to the Regional Council responsible for monitoring and managing streams of the region. Most suggestions led to refinement or redevelopment of questions, and specifically to the wording and structure of the Waterway Self Assessment Form.

Inter-observer Reliability

The robustness or inter-observer reliability of the Waterway Self Assessment Form is an important factor to consider. An inherent characteristic of self assessment forms is that they are subjective. By making the form simple to use and providing clear instructions on use of the form, the variability in results between users should be reduced. The inter-observer reliability of the Waterway Self Assessment Form was tested with a group of third year Massey University students.

The study group was made up of 27 students. Five sites within the Manawatu region were assessed using the Waterway Self Assessment Form by all 27 students. All sites were assessed on the same day. Site one was on the Tiritea Stream, which is a small pasture stream. Site two was on the Manawatu River. Site three and four were both on the Kahuterawa Stream, with site three being further downstream and more impacted by land use than site four. Site five was a small tributary of the Kahuterawa Stream in close proximity to site four.

Although there was some degree of variation in the absolute scores obtained at each site (site 1, 144-240; site 2, 198-350; site 3, 213-366; site 4, 304-496; site 5, 352-502), 74% of students ranked the sites in the same order (1-5). 15% ranked the sites with four and five reversed, and 11% with the sites in some other order.

The sites ranked in the same order will also have the same hierarchy of management priority. This would suggest the form has an acceptable level of reliability between users. This study was carried out with an early version of the Waterway Self Assessment Form. Since then many improvements have been made to the form. If this study was to be carried out again using the final version of the form, an improvement in these results would be expected. These results are only relevant when assessments with the Waterway Self Assessment Form are compared between users. As the form will be used largely by landowners it is likely that any comparisons made between results will be of assessments made by the same landowner.

CHAPTER FOUR

Validation of the Waterway Self Assessment Form

Abstract

The Waterway Self Assessment Form visually evaluates a stream sites' need for riparian management and is also an indicator of overall stream health. It has been developed for use by landowners, and also aims to facilitate education and awareness about riparian management and issues of stream health.

The Waterway Self Assessment Form was used to assess 59 sites within the Rangitikei, Manawatu and eastern Hawkes Bay regions of the North Island, New Zealand. In addition, a range of physio-chemical and biological parameters of stream habitat quality were measured. The scores of the Waterway Self Assessment Form are correlated with these parameters to determine if a low form score does in fact correspond to poor stream and riparian habitat quality. The Waterway Self Assessment Form is shown to accurately assess the quality of riparian and waterway health, and correctly assign management priority to sites.

Keywords: riparian management, landowners, Waterway Self Assessment Form, stream health.

Introduction

The Waterway Self Assessment Form has been developed to facilitate landowner interest and education in issues of riparian management and stream health. It has been designed to provide landowners with a practical and direct way of assessing the riparian management requirements of their own land, to pinpoint problem areas of streams, and to provide a tool for monitoring management progress. It is also shown to be a useful indicator of overall stream health. Education and interest have been shown to be triggered by involvement (O'Brien, 1993; Quinn and Collier, in press), which is one of the aims of the form.

The Waterway Self Assessment Form is a visual assessment made on site with no training or equipment necessary. It is presented as a series of questions, each question has a choice of four categories of which characteristics of the user's stream (or area of stream) can be categorised under. Each category has a corresponding score, the scores for each question are then summed at the end to give an overall measure of riparian management priority.

The ecological relevance of the form and its questions have been defined in Chapter One, as has the relevance and importance of each question to landowners. This chapter aims to provide evidence that the form is scientifically valid. That is, a site with a low Waterway Self Assessment Form score, does in fact have poor quality stream habitat characteristics, and therefore has a high priority for management.

An assessment using the Waterway Self Assessment Form was made at 59 sites within the Rangitikei, Manawatu and eastern Hawkes Bay regions. Sites were chosen so that streams with intact riparian zones, streams with little or no riparian vegetation, and streams with riparian zones between these two conditions, were equally represented. In addition a range of stream habitat characteristics (physio-chemical and biological parameters) were measured at each site. This study explores the relationship between both the scores for the individual questions and total scores of the Waterway Self Assessment Form, and these measured habitat characteristics.

Study Sites

Fifty nine streams were sampled between August and December 1997. Streams were second to fourth order, with the exception of two sites which were fifth order. The sites sampled were scattered over a relatively large area, covering the Rangitikei, Manawatu and eastern Hawkes Bay (Fig 3.1), and ranged in altitude from 30 to 700 m a.s.l. 1:50 000 topographical maps were used to find sites with riparian zones of varying condition within the same sub-catchment. Thus sites were selected to be as similar as possible within each sub-catchment, except for the condition of their riparian zone.

A range of riparian zone conditions were sampled, hence sites also varied in land use. 'Pristine' riparian zones were only found in forest parks and reserves such as the Ruahine forest park. As the three regions sampled are dominated by agriculture, a large proportion of the remaining sites drained farmland of varying intensity land use and stocking rates.

The geology and location of the sites were determined to assist with analysis. Sites were divided into five groups. The first group are the high altitude Ruahine sites, and are of the Jurassic period. The second and third groups are of the Holocene period, with group two those sites east of the Ruahine Range. Group three are those sites in a rough band south of Apiti and north of Ashurst. The fourth group are of the Pleistocene age, and are located south of Ohingaiti and north of Apiti. The final group of sites are of the Pliocene period and found north of Ohingaiti and south of Utiku (Fig. 3.1).

To provide more detail, the specific rock type of each site has also been determined using the New Zealand Land Resource Inventory (1:63360) (National Water and soil Conservation Organisation, 1979a; 1979b; 1979c; 1979d; 1979e; 1979f; 1979g; 1979h; 1981). Here, sites are grouped into one of five rocktypes; mudstone, sandstone/siltstone, greywacke, undifferentiated floodplain alluvium and gravels, or loess. These rocktype groupings are used for further analysis. Sites were also grouped with respect to land use in the riparian zone, being either native, pasture or a combination of both.

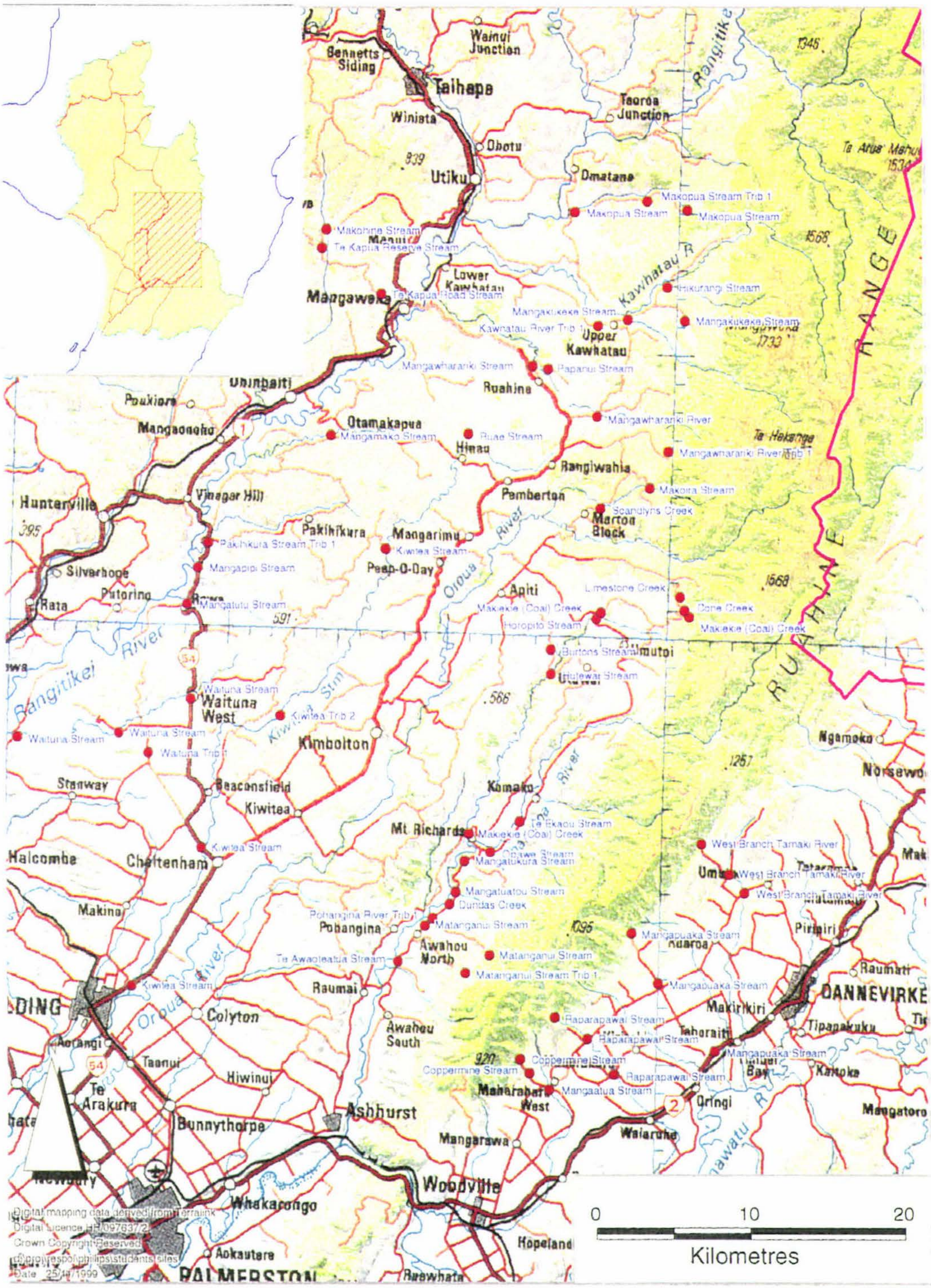


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Fig 3.1. Location of the 59 sites (red circles) sampled between August and December 1997. Stream names are also given.

Materials and Methods

Sampling protocol

At each site benthic macroinvertebrate samples were collected using a 250 μm kick net for one minute. Samples were stored in 70% alcohol until sorting, when they were sieved through 500 μm mesh. Macroinvertebrates were enumerated and identified using a microscope (40x magnification). Identification was to the lowest possible taxonomic level using keys (Cowley, 1978; McFarlane, 1951; Winterbourn, 1973; Winterbourn and Gregson, 1989). Those taxa unable to be identified to species level were assigned to apparent morphospecies.

For periphyton analysis, three small stones (mean surface area = 35.1 cm^2) were collected from each site and frozen for later pigment extraction. Photosynthetic pigments (phaeophytin *a* and chlorophyll *a*) were extracted in 90% acetone at 5 ^{o}C for 24 hours. Absorbancies at 410, 430, 665 and 750 nm were read using a Jenway 6105 UV/Visible Spectrophotometer. Total pigment concentrations were calculated applying the method of Moss (1967a and 1967b) and corrected for stone surface area (Graham et al., 1988).

Conductivity and temperature were measured using an Orion 122 conductivity meter, and pH using an Orion Quickcheck model 106 pocket meter. Water clarity was measured using a black disc (Davies-Colley, 1988). Three measurements of depth and velocity were made across the stream using a meter rule and Marsh McBinnery Velocity meter respectively. Stream width was also recorded. The Pfankuch stability index (Pfankuch, 1975) was used to assess channel stability at each site. This involves evaluating the upper banks, lower banks and stream bottom by scoring 15 characteristics according to provided criteria. The scores are summed to give an overall stability rating, the lower the rating the more stable the site. The bottom component of the index and the total stability scores were used for analysis. The bottom component assesses the stability of the substrate and was used in addition to the total stability score in statistical analysis, as it is deemed to be more relevant to macroinvertebrate community dynamics (Death and Winterbourn, 1994; Death and Winterbourn, 1995; Winterbourn and Collier, 1987). Percentage substrate composition (bedrock, boulders (>26 cm diameter), large cobbles (13-26 cm), small cobbles (6-12 cm), gravel (0.2-6 cm), sand (<0.2 cm) and silt) was assessed visually and converted to a substrate index (Jowett and Richardson, 1990). Type of riparian vegetation (percentage riparian forest, exotic woodland, scrub, crop/pasture and tussock) and the percentage of channel covered were also assessed visually.

A water sample was taken at each site and frozen at -20 °C (Smith, 1989) for analysis of turbidity, reactive phosphorus (orthophosphate) and nitrate. Samples were thawed overnight to room temperature and filtered using Whatman Gf/C filter papers (pore size 0.7 µm). The filter and accumulated sediments were dried at 105 °C until a constant weight. The dry weight was recorded and corrected for filter weight. The sediment concentration C_s (calculated using Gordon et al., 1993), is expressed in terms of sediment mass per measured volume of water sample:

$$C_s(mg / L) = \frac{(m+s)-(m)}{V} x10^3$$

where m = mass of the filter in grams, s = mass of the sediment and V = volume of the water sample in litres. Nutrient concentrations of the filtrate were determined using a Hach DR/2010 Portable Datalogging Spectrophotometer. Reactive phosphorus concentrations (mg/L PO_4^{3-}) were determined using the Ascorbic Acid method, and nitrate (mg/L NO_3^--N) using the Cadmium Reduction method, as described in the accompanying procedures manual (Hach Company, 1996).

An assessment using the Waterway Self Assessment Form (Polglase and Death, in press) was also made at each site.

Diversity Indices

Several diversity indices were calculated for each site from the species data and used in correlation analyses. These were: Margalef's index (Clifford and Stephenson, 1975), a measure of species richness given by:

$$D = \frac{(S-1)}{\ln N}$$

where N = the total number of individuals collected, and S the number of species.

The Berger-Parker index (Berger and Parker, 1970) is a measure of evenness (or dominance if expressed as a reciprocal), and is given by:

$$D = \frac{N_{\max}}{N}$$

where N_{max} = the number of individuals in the most abundant species and N = the total number of individuals collected.

The Simpson's index (Simpson, 1949) is also a measure of evenness and is given by:

$$D = \sum \left(\frac{n_i(n_i - 1)}{N(N-1)} \right)$$

where n_i = the number of individuals in the i^{th} species and N = the total number of individuals collected. So that in all indices an increase in the index means a respective increase in diversity, Berger-Parker and Simpson's indices were expressed as reciprocals (Death and Winterbourn, 1995).

In addition to these diversity indices, species richness (the number of species found at each site) and total abundance (the total number of individuals at each site) were also calculated.

Biotic Indices

The Macroinvertebrate Community Index (MCI), Quantitative MCI (QMCI) and percentage of Ephemeroptera, Plecoptera and Trichoptera (%EPT) were also calculated for each site. These indices were used to examine the relationship between water quality and Waterway Self Assessment Form scores. The MCI (Stark, 1985) is a general indicator of water quality, which is based upon the presence of macroinvertebrates which have been previously assigned scores depending on their organic pollution tolerances (from 10 for those species found in pristine conditions, to 1 for those species which can tolerate high levels of enrichment). MCI scores are calculated using the following equation:

$$MCI = \frac{S}{N} x20$$

where S = the sum of individual taxon scores for all taxa present in a sample, N = the number of scoring taxa and 20 is a scaling factor. A site scoring >120 may be regarded as pristine, whereas a score of <50 indicates an extremely polluted site. The QMCI (Stark, 1993) uses quantitative macroinvertebrate data, and is given by:

$$QMCI = \sum_{i=1}^{i=S} \frac{(n_i x a_i)}{N}$$

where S = the total number of taxa in the sample, n_i = the number of individuals in the i^{th} scoring taxon, a_i is the score for the i^{th} taxon, and N is the total number of individuals. The EPT (Lenat, 1988) is calculated by:

$$\% EPT = \frac{(E + P + T)}{N}$$

where E = the number of Ephemeroptera found in the sample, P = the number of Plecoptera, T = the number of Trichoptera, and N = the total number of individuals. Taxa from these three orders generally prefer 'cleaner' water conditions, hence a high EPT score indicates high water quality.

Statistical Analysis

Correlation analysis (Spearman rank correlation coefficients) using SAS (SAS, 1996) was used to investigate the link between the Waterway Self Assessment Form scores and actual biological and physical conditions at the stream. Bonferroni adjusted probabilities were used for multiple comparisons. Ordination of the question scores was performed with Principal Components Analysis (PCA) and Ordination of macroinvertebrate communities with Detrended Correspondence Analysis (DECORANA), using PC-ORD for Windows (McCune and Mefford, 1997). Macroinvertebrates are a key integrator of water and stream habitat quality which is why this data was analysed with DECORANA. A PCA was used for Ordination of the question scores due to the linear nature of the data, while DECORANA was used for Ordination of the macroinvertebrate data as biological data is non-linear. In the PCA sites were plotted in ordination space according to their scores for each of the 26 questions of the Waterway Self Assessment Form, and environmental variables correlated with the PCA axes using Pearson and Kendall correlations. In the DECORANA sites were plotted in ordination space according to their macroinvertebrate communities. As with the PCA, environmental variables were correlated with the axes. Data were log transformed ($\log_{10}(x+1)$) prior to the DECORANA being performed to increase variance homogeneity.

Results

Correlations

Of the 26 questions in the Waterway Self Assessment Form, 17 had measured physio-chemical and, or biological variables with which it seemed appropriate to perform correlation analysis. There were no relevant parameters measured to correlate with the other nine questions for example, question 4b ('What is the dominant land use here?'). These questions contribute no less to the educational and evaluative purposes of the form, they simply do not have measurable habitat characteristics with which to make comparisons. Correlations were made between the scores for the question and the corresponding physical, chemical and, or biological parameter, measured at each site, with which there could be expected to be a relationship (Table 3.1). This was repeated for all 17 questions. The majority of the evaluated relationships were significant (33 of the 49).

For the remaining correlation analysis the total Waterway Self Assessment Form scores were used. Table 3.2 shows Spearman rank correlation coefficients for total Waterway Self Assessment Form scores and environmental variables measured at each site. Almost all 22 evaluated variables (exceptions are Margalef's index, nitrate concentration, phosphate concentration and pH) were significantly correlated with the total Waterway Self Assessment Form scores. No conclusions have been drawn regarding the negative correlations of Simpson's and the Berger-Parker indices with the total form scores, as it is not clear whether an increase in either index indicates a site of high or poor habitat quality (Death, 1996).

Table 3.1. Spearman rank correlation coefficients (r) for questions of the Waterway Self Assessment Form and corresponding measured parameters. Descriptive labels are given for each question to aid with interpretation: Temp = temperature, Peri = periphyton, Sub 1+2 = total of Pfankuch subtotals 1 and 2 (upper and lower bank components), Sub 1 = Pfankuch subtotal 1 (upper bank component), SS = suspended solids, Obstr = Pfankuch question on obstructions, Chanel = Pfankuch question on channel capacity, N = nitrogen, P = phosphorus, Cond = conductivity, Sub 3 = Pfankuch subtotal 3 (bottom component), Sub Index = substrate index.
Significant values are in bold, * indicates $P < 0.05$, ** $P < 0.001$.

Question Number	Temp	Peri	% Cover	Sub 1+2	Sub 1	SS			
1d (Shading)	-0.19	-0.20	**0.88** **	-	-	-	-	-	-
1e (Stability)	-	-	-	**-0.36** *	-	-	-	-	-
1f (Erosion)	-	-	-	-	**-0.33** *	0.01	-	-	-
	Peri	**% Cover**	**Obstr**	**Black Disc**	**SS**	**MCI**	**QMCI**	**EPT**	**Chanel**
2a (Plants)	**-0.50** **	-0.04	-	-	-	-	-	-	-
2b (Snags)	-	-	**-0.37** *	-	-	-	-	-	-
2c (Clarity)	-	-	-	**0.74** **	**-0.56** **	-	-	-	-
2d (Bugs)	-	-	-	-	-	**0.79** **	**0.76** **	**0.80** **	-
2e (Floods)	-	-	-	-	-	-	-	-	**-0.89** **
	SS	**Black Disc**	**% Sand & Silt**	**MCI**	**QMCI**	**EPT**	**N**	**P**	**Cond**
3b (Sediment)	**-0.28** *	**0.30** *	**-0.29** *	-	-	-	-	-	-
3c (Contam)	-	-	-	**0.52** **	**0.61** **	**0.65** **	-	-	-
3d (Drains)	**-0.38** *	**0.35** *	-	-	-	-	-0.14	-0.25	**-0.53** **
3e (Fert)	-	-	-	-	-	-	-0.12	-0.19	**-0.41** *
	SS	**Black Disc**	**N**	**P**	**Cond**				
4d (Topo)	-0.19	0.08	-	-	-	-	-	-	-
4e (Runoff)	**-0.34** *	**0.49** **	-0.12	-0.02	**-0.50** **	-	-	-	-
	Width	**Sub 3**	**Sub Index**	**SS**	**Black Disc**	**N**	**P**	**Cond**	
5a (Size)	**0.89** **	-	-	-	-	-	-	-	-
5c (Bottom)	-	**-0.51** **	**0.66** **	-	-	-	-	-	-
5d (Cohesve)	-	-	-	**-0.32** *	0.14	-0.16	-0.01	**-0.51** **	-
5e (Sepage)	-	-	-	**-0.30** *	**0.30** *	-0.03	**-0.34** *	**-0.43** **	-

Table 3.2. Spearman rank correlation coefficients (r) for the total Waterway Self Assessment Form scores and measured environmental variables. * indicates $P < 0.05$, ** $P < 0.001$.

Environmental Variable	Correlation Coefficient (*r*)
Temperature (^{0}c)	-0.46**
% Cover	0.38*
Black Disc (m)	0.39*
Suspended Solids (mg/L)	-0.40*
% Sand & Silt	-0.39*
Pfankuch 'Bottom' Component	-0.44**
MCI	0.68**
QMCI	0.67**
EPT	0.75**
% Native Vegetation	0.84**
% Pasture	-0.80**
Pfankuch Stability Index	-0.51**
Simpson's Index	-0.33*
Margalef's Index	0.22
Berger-Parker Index	-0.35*
Conductivity (μS/cm)	-0.58**
Periphyton (mg/cm^2)	-0.39*
Nitrate (mg/L)	-0.23
Phosphorus (mg/L)	-0.17
Substrate Index	0.54**
pH	-0.13
Velocity (m/s)	0.28*

Principal Components Analysis (PCA)

The PCA of the question scores separated sites in terms of land use in the riparian zone (defined as 'Native' by >80% native riparian vegetation, 'Pasture' 0-5%, and 'Mixed' 6-79%) (Fig 3.2). Correlating the question scores with the PCA axes, the individual questions correlate either negatively with axis one or positively with axis two ($P < 0.001$), with the exception of question 5a ('How big is your stream?') which correlates negatively with axis two. Questions 1d ('What % of the stream is shaded by plants and stream banks?'), 1e ('How stable are the stream banks?') and 1f ('How bad is the erosion around or adjacent to your stream?') correlate positively with axis two. The remaining questions correlate negatively with axis one.

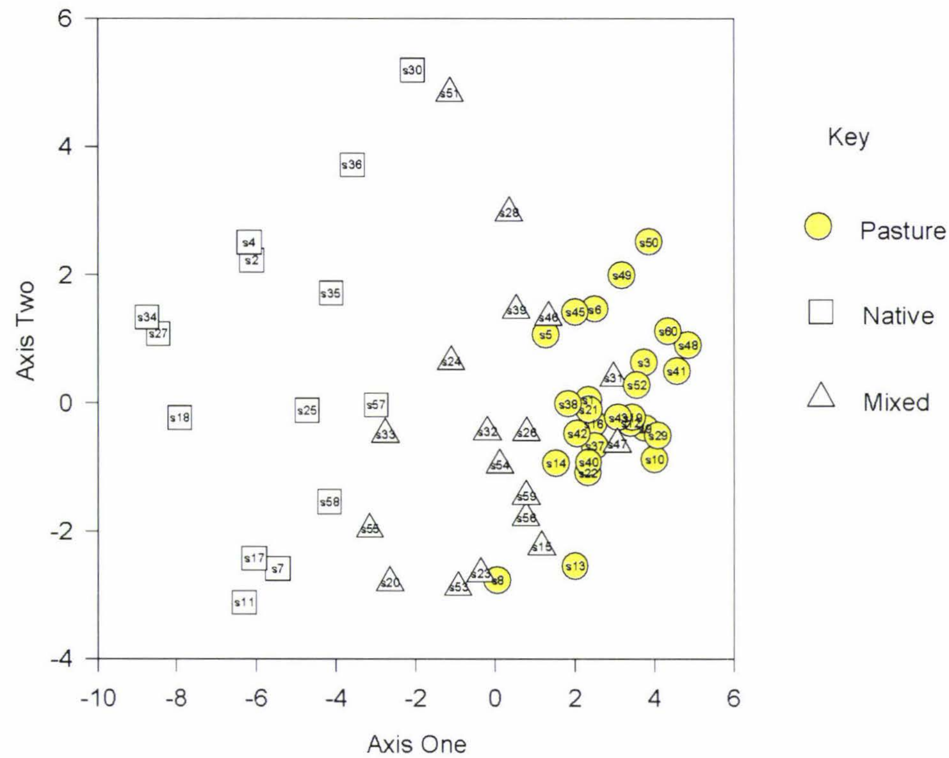

Fig 3.2. Axis one as a function of axis two of a Principal Components Analysis (PCA) of scores for the individual questions of the Waterway Self Assessment Form. Site number and land use in the riparian zone (pasture, native or mixed land use) are shown (defined as 'Native' by >80% native riparian vegetation, 'Pasture' 0-5%, and 'Mixed' 6-79%). Temperature, conductivity, Pfankuch subtotal 2 and 3, Pfankuch total stability score and % pasture riparian vegetation correlated positively with axis one. % native riparian vegetation, % boulders in the substrate, MCI, QMCI, and EPT all correlated negatively with axis 1. Velocity correlated negatively with axis two, and % cover positively with axis two ($p<0.001$).

Table 3.3. Pearson correlation coefficients (*r*) of environmental variables correlated with Principal Components Analysis (PCA) axes of scores for questions of the Waterway Self Assessment Form. * indicates $P < 0.05$, ** $P < 0.001$.

Environmental Variable	Axis 1	Axis 2
Altitude	-0.42*	0.20
Stream Order	0.17	-0.29*
Temperature	0.46**	-0.15
Conductivity	0.47**	0.30*
Width	-0.14	-0.31*
Velocity	-0.25	-0.46**
Pfankuch Subtotal 1	0.40*	0.01
Pfankuch Subtotal 2	0.49**	-0.36*
Pfankuch Subtotal 3	0.45**	-0.32*
Pfankuch Total	0.55**	-0.32*
% Cover	-0.29*	0.67**
% Native Riparian	-0.87**	0.13
% Exotic Riparian	0.37*	-0.01
% Pasture Riparian	0.79**	-0.08
Black Disc	-0.41*	-0.36*
% Bedrock	-0.06	0.37*
% Boulders	-0.49**	0.18
% Large Cobbles	-0.16	-0.30*
% Small Cobbles	-0.06	-0.32*
% Silt	0.38*	0.16
Suspended Solids	0.08	0.27*
MCI	-0.56**	-0.18
QMCI	-0.57**	-0.22
Margalef's Index	-0.19	0.35*
Berger-Parker Index	0.34*	0.29*
Simpson's Index	0.32*	0.33*
EPT	-0.65**	-0.22

Table 3.3 shows those environmental variables which correlate with the PCA axes. Percentage cover correlated positively with axis two. In addition, the percentage of native riparian vegetation correlated negatively with axis one, as did MCI, QMCI, EPT and percentage of boulders in the substrate. Temperature, conductivity, Pfankuch stability scores and the percentage of pasture in the riparian zone correlated positively with axis one ($p<0.001$). This indicates more pristine, stable sites with intact native riparian zones, are found high on axis two and to the left on axis one. Conversely, more impacted and unstable pasture sites with no riparian cover are found low on axis two and to the right of axis one. These correlations suggest that these measured variables

are those most strongly influencing the scores of the Waterway Self Assessment Form questions. Axis one accounted for 50.98 % of the variation in the data, and axis two a further 12.82 %.

No distinct groupings are identified in terms of geology and geographic location of sites. This indicates that the Waterway Self Assessment Form is not simply differentiating between sites with regard to their geology and location, and that these two factors have no overriding effects on the functioning of the form.

Detrended Correspondence Analysis (DECORANA)

The DECORANA of invertebrate communities generally separated sites with respect to the state of the riparian zone (Fig. 3.3). Sites with intact native forest riparian zones were located to the left of axis one, and those with a poor riparian zone i.e., of pasture grass, to the right of axis one. The total Waterway Self Assessment Form scores correlate negatively with axis one. Therefore, sites which score highly on the Waterway Self Assessment Form also have, for example, a high percentage of native riparian cover. Parameters which correlate with the DECORANA axes for example, the Waterway Self Assessment Form scores, % native riparian vegetation, % pasture in the riparian zone and the % silt in the substrate composition, are shown in Table 3.4.

Those taxa which negatively correlate with axis one, are those which are indicative of high water quality, e.g., *Deleatidium sp., Coloburiscus sp., Zelandoperla agnetis, Zelandobius furcillatus,* and *Zelandoperla decorata.* Those taxa positively correlated with axis one, are those found in lower quality habitats, e.g., *Xanthocnemis, Sigara, Anisops wakefieldi,* small Oligocheates, *Potomopyrgus, Physa, Austrosimulium tillyardianum,* and *Orthocladiinae sp.* Axis one accounted for 22.9 % of the variation in the data, and axis two a further 0.9 %.

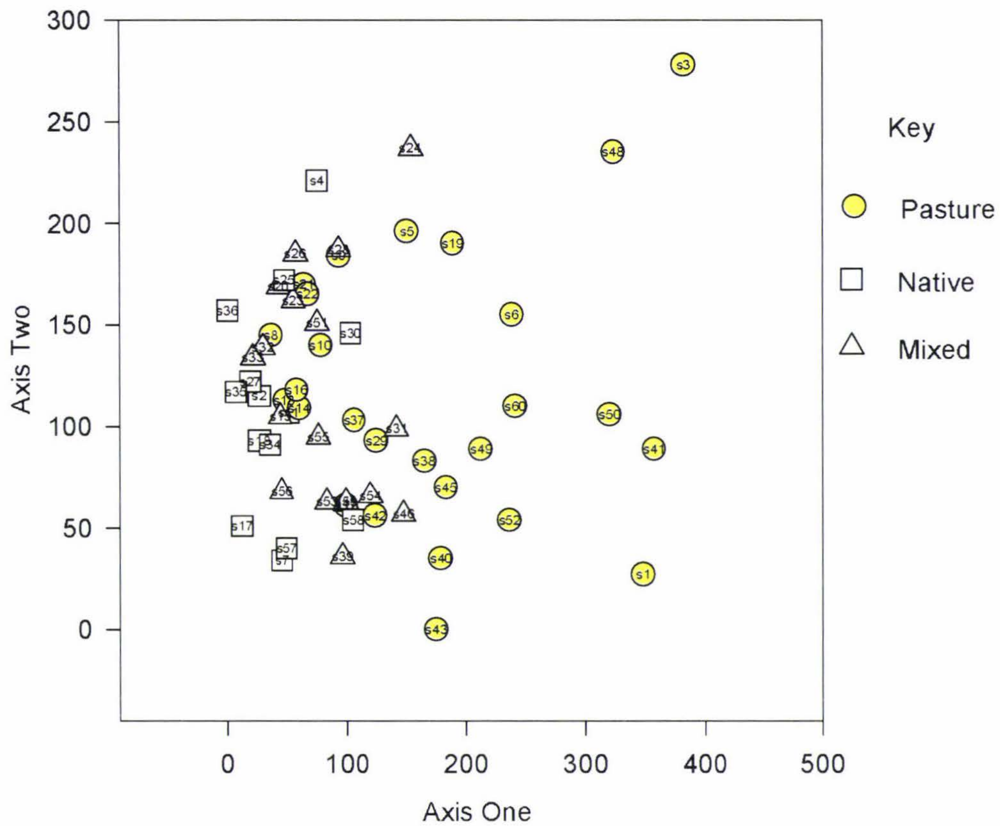

Fig 3.3. Axis one as a function of axis two of a Detrended Correspondence Analysis (DECORANA) of macroinvertebrate communities collected at 59 sites, between August and December 1997. Composition of the riparian zone is indicated (defined as 'Native' by >80% native riparian vegetation, 'Pasture' 0-5%, and 'Mixed' 6-79%) and site number shown. Velocity, % native riparian vegetation and black disc correlated negatively with axis 1. Conductivity, total Pfankuch stability score, % pasture riparian vegetation and % silt of the substrate correlated positively with axis 1. Temperature correlated negatively with axis 2 ($p<0.001$).

Table 3.4. Pearson correlation coefficients (r) of environmental variables correlated with Detrended Correspondence Analysis axes of macroinvertebrate communities.
* indicates $P < 0.05$, ** $P < 0.001$.

Environmental Variable	**Axis 1**	**Axis 2**
Stream Order	0.01	-0.41*
Temperature	0.26	-0.48**
Conductivity	0.56**	0.03
Velocity	-0.45**	-0.41**
Pfankuch Subtotal 2	0.35*	-0.10
Pfankuch Subtotal 3	0.31*	0.07
Pfankuch Total	0.36*	-0.04
Form Score	-0.61**	-0.01
% Native Riparian	-0.54**	-0.01
% Exotic Riparian	0.32*	-0.20
% Pasture Riparian	0.52**	0.08
Black Disc	-0.48**	-0.37*
% Boulders	-0.31*	-0.13
% Large Cobbles	-0.34*	0.17
% Small Cobbles	-0.31*	-0.11
% Gravel	-0.19	-0.37*
% Sand	-0.02	-0.31*
% Silt	0.65**	0.38*
Phosphate Concentration	0.29*	-0.21
Suspended Solids	0.30*	0.38*

Discussion

Many of the correlations in Table 3.1 are between two directly related variables e.g., stream width (in metres) is correlated with the score for question 5a, which visually assesses stream size. Therefore, a high correlation between these two variables is expected and would have indicated a flaw in this question had a significant correlation not been observed. Of more interest are the relationships between variables that are less directly related. Question 2c ('How clear is the water?') is shown to accurately visually assess water clarity by the high correlations between the scores for the question and both black disc distance, and suspended sediment concentration. Also, the basic approach of question 2d ('What bugs live in your stream?') which describes the type of macroinvertebrates present, appears to be a good substitute for far more comprehensive indices of invertebrate communities, such as the MCI, QMCI and EPT. This is supported by the high correlations between the scores for question 2d and these biotic indices. Another question which has strong relationships with these three indices is 3c ('What is the potential for the input of contaminants to you stream?'). These indices are commonly used as indicators of water quality (Berry et al., 1999; Lenat, 1988; Penny, 1984; Plafkin et al., 1989; Stark, 1984; Stark, 1985). As contaminants have adverse effects on water quality, the correlation of these two variables is also expected. The relationships discussed here support the ability of the Waterway Self Assessment Form to accurately assess stream habitat and water quality, as do the other significant relationships shown in Table 3.1.

No significant correlation was found between the scores for question 4d ('What type of country does your stream flow through?') and suspended sediment concentration, and black disc as anticipated. It is expected that sites further downstream from their source will have higher suspended sediment loads and hence reduced water clarity than those of upstream sites (see Chapter One) (Howard-Williams, 1991; Lowrance et al., 1986; Malanson, 1993). The possible explanation for the lack of any direct relationship here is that not a wide enough cross section of stream types were sampled with respect to distance inland. Hence there was not enough variability in the scores for this question to be compared with another variable. This in no way reduces the importance of question 4d to the overall functioning of the form.

The correlations shown in Table 3.2 indicate that the total Waterway Self Assessment Form scores are also related to measures of habitat quality. Of particular interest are the strong relationships between the total form scores and MCI, QMCI and EPT. This indicates that a site with a high MCI, QMCI or EPT, will also score highly on the Waterway Self Assessment Form. As these biotic indices are commonly used as indicators of stream habitat quality (Berry et al., 1999; Lenat, 1988; Penny, 1984; Plafkin et al., 1989; Stark, 1984; Stark, 1985), the strong correlation with the form scores indicates that the form also has the potential to be used as an indicator of habitat quality. A high score on the form equates to a low priority for riparian management, and hence a site of high habitat quality.

The relative percentages of native vegetation and pasture in the riparian zone are also strongly correlated with the total form scores. These correlations indicate a site that has a high form score is also likely to have a high percentage of native vegetation in the riparian zone. Conversely a site which scores poorly with the form is likely to have a riparian zone composed of a high percentage of pasture and little or no native vegetation. Therefore the total form score is also related to land use. Streams which have only pasture in the riparian zone are lower in habitat quality, and hence have a higher management priority than those with intact native riparian zones (see Chapter One) (Biggs, 1995; Collier et al., 1995b; Cooper and Thomsen, 1988; Davies-Colley, 1997; Davies-Colley et al., 1995; Fahey and Rowe, 1992; Friberg and Winterbourn, 1997; Hanchet, 1990; Osborne and Wiley, 1988; Quinn et al., 1994; Quinn et al., 1997; Winterbourn, 1986; Winterbourn, 1987). Riparian management is one approach to restoring habitat values to pasture streams (Howard-Williams and Pickmere, 1994; Osborne and Kovacic, 1993). Hence, the Waterway Self Assessment Form is again accurately assessing habitat quality and correctly assigning management priority.

A significant inverse relationship of the total form score with conductivity was found. High conductivity equated to a low form score. Conductivity is a measure of aquatic ion concentration, which is commonly used as a substitute for general levels of total nutrients. In-stream nutrient concentrations are expected to increase as land use intensifies (see Chapter One) (Collier et al., 1995b; Osborne and Wiley, 1988), and as land use is related to total form score, this result was anticipated. However, no significant relationship was observed between total form score and either nitrate (N) or phosphorus (P) concentrations, which was also predicted. Further investigation showed no significant relationship between conductivity and either N or P concentrations. This indicates that conductivity may not be useful as an indicator of nitrate and phosphorus concentrations. The relationship observed between conductivity and total form score may be due to other nutrients such as ammonia, nitrite and calcium (Lowrance et al., 1985; Lowrance et al., 1984), which can also be products of land use.

The PCA of the questions of the form, differentiated between sites with respect to land use (Fig 3.2). The habitat characteristics the questions are assessing which discriminate most between sites, are those which correlate strongly with the ordination axes. These include: percentage cover, percentage riparian vegetation, MCI, QMCI, EPT, percentage boulders in the substrate, temperature, conductivity, Pfankuch stability scores and percentage pasture in the riparian zone. The questions of the form distinguish between a site with a lot of native riparian cover, low water temperatures and conductivity, high stability and macroinvertebrate community structure represented by high biotic indices, and a pasture site which has little or no riparian cover, high water temperatures and conductivity, low stability and low biotic indices. This indicates that the questions of the form are accurately assessing stream habitat characteristics to differentiate between sites.

The DECORANA of macroinvertebrate community structure shows some distinction between sites with respect to land use in the riparian zone (Fig. 3.3). Macroinvertebrate communities were used for analysis with DECORANA as macroinvertebrates are a key integrator of water and stream habitat quality. Those habitat characteristics which correlate with differences in invertebrate community structure are: the percentage of native riparian vegetation, percentage of pasture in the riparian zone, conductivity and percentage of silt in the substrate composition. The Waterway Self Assessment Form total scores also correlates with axis one, this infers that the form is also distinguishing between sites in terms of invertebrate community structure. A high score on the form equates to a site with a high percentage of native riparian vegetation, low conductivity and high current velocity. It is also likely to have invertebrates present which are representative of high biotic indices and good habitat quality e.g., *Coloburiscus sp.*, *Zelandoperla agnetis*, *Zelandobius furcillatus* and *Zelandoperla decorata* (these taxa correlate negatively with axis one). Conversely a site with a low form score is indicative of low habitat quality, with invertebrate communities representative of this e.g., *Xanthocnemis, Sigara, Anisops wakefieldi, Potomopyrgus, Physa, Austrosimulium tillyardianum* and *Orthocladiinae* (these taxa correlate positively with axis one).

When the two ordinations are compared it is apparent that the Waterway Self Assessment Form is distinguishing between sites more strongly than macroinvertebrate community structure. This is with respect to differences in characteristics of habitat quality which are related to land use effects. This is due to the fact that other variables which are not related to land use also affect macroinvertebrate community structure, e.g., altitude (Collier, 1995a; Townsend et al., 1997; Winterbourn, 1987). Macroinvertebrates are often used as indicators of land use effects on stream habitat quality (Berry et al., 1999; Dudgeon, 1994; Newbold et al., 1980; Penny, 1984; Storey and Cowley, 1997). This finding suggests that the Waterway Self Assessment Form may be a better tool for comparing stream habitat quality between sites, with respect to land use, than are biotic indices.

Riparian management is one way of restoring habitat values to degraded streams, or those of poor habitat quality (Howard-Williams and Pickmere, 1994; Osborne and Kovacic, 1993). These streams will have a relatively high priority for management and, as has been shown here, will also have a low Waterway Self Assessment Form score. Therefore, the form is also meeting its aim of evaluating sites for their need of riparian management.

The Waterway Self Assessment Form provides the user, namely landowners, with a relatively quick and simple way of visually assessing the quality of riparian and waterway health, and assigning management priority to sites. The analyses presented here provide evidence that the results of a site assessment using the form will also be scientifically valid. That is, a stream which has a high Waterway Self Assessment Form score does in fact also have characteristics of high stream, and riparian habitat quality. In effect the form, which takes approximately 10 minutes to complete, is providing similar results to that of a wide range of physio-chemical and biological parameters, which are considerably more time consuming to measure and interpret, and require expert knowledge and skills.

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APPENDICES

APPENDIX 1

NAME:

LOCATION:

FARMING ENTERPRISE:

QUESTIONS TO CONSIDER:

Q1. Where there any questions which were difficult to follow, or appeared to be repetitive? How could the question be changed to make it clearer?

Q2. What changes would you like to see made to the form?

Q3. Do you think there are any question missing?

Q4. Would you continue to use the form?

Q5. For what purposes?

Q6. How often?

Q7. Do you think the form has the potential to be a useful tool in marketing produce? (e.g., as part of a quality assurance scheme).

Q8. Would you recommend the form to your neighbour? If not, why?

Q9. Has the form increased your understanding of waterway health and the associated impacts? If so, how?

Q10. Do you think it will change your attitudes/thinking towards the management of your streams?

Q11. How will you use the information obtained by using the form?

Q12. Who's responsibility do you think the monitoring of waterways should be? (regional council or your own?).

Q13. What assistance would you/do you require with waterway management?

APPENDIX 2

Replies to the Questionnaire on the 'Waterway Self Assessment Form'

(Comments made on an early version of the form).

Q1. Where there any questions which were difficult to follow, or appeared to be repetitive? How could the question be changed to make it clearer?

- 11 respondents answered "No".
- Possibly reverse order in question 2c.
- Option required for water levels created by man-made improvements, i.e., stopbanks/channelisation.
- 3e, perhaps list bugs by common name, rather than introducing that technical jargon.
- Question 5c needs to be read carefully! Perhaps needs explaining a bit clearer.
- 1a, change to a catchment type question. 1c, sometimes this can not be avoided. 2d, define riparian zone. 3e, add "look on logs/debris in stream". 4a, exclude "e.g. papa." 5c, explain preferential drainage pathways better. 5d, is it needed?, how does artificial drainage effect water quality? 5e, change fertiliser rates to high concentration or rate.
- Define what a riparian zone is. Make a distinction between natural drainage versus storm water.
- The question assessing the insect population, and the question about continuance of vegetation need to be clearer.
- Fertiliser re: measure of N may need reviewing.
- Only 2b, which could be a bit more explanatory.
- 5c, actual numbers of drainage pathways.
- 2b, unclear what is meant by 'incised' = height or 'dug in'?
- 2e, 3c, 3e, hard to answer in our situation - small river. I had difficulty visualising exactly the meaning. Insect life in our river hard to assess.

Q2. What changes would you like to see made to the guide?

- 12 respondents answered "None".
- If it's O.K. call it a questionnaire.
- None at present.
- More instructions at the start, i.e., assessing over what length of stream. Separate score sheet.
- Questionnaire too broad. No limestone soils mentioned - different areas, different soil types.
- Increase size of font.
- Provide titles for each category. After the first assessment, you only need to assess some categories again. Could group these together to make it seem shorter. Underline "...circle a score halfway between...". Define the categories at the end, to make it clearer what the main problem is.
- Fuller explanation page re: location. Fertiliser question to assess units of P and N.
- Rearrange to separate natural geography from farming impacts (sheep/effluent etc.).
- A running total. The questions in a geological sequence.
- Include open drains.

- Most questions are pretty good.

Q3. Do you think there are any question missing?

- 17 respondents answered "No".
- Not that I can think of.
- Type of parent materials in stream bed, i.e., limestone, greywacke.
- Yes, in relation to water quality?
- Has the farmer done any conservation work?
- What measures are being taken at present?
- There are probably too many, and some could be shorter, i.e., is the stream fenced?

Q4. Would you continue to use the guide?

- Two respondents answered "Unsure".
- 17 respondents answered "Yes".
- Two respondents answered "No".
- Yes, it would be considered a very useful tool.
- Yes, contact name list very useful.

Q5. For what purposes?

- To assess the quality of our stream.
- As a reference and guide of expectations.
- Long term waterway management.
- Monitor improvements after fencing.
- To establish progress, or otherwise.
- Recreational use.
- Unsure.
- To make sure the river stays in pristine condition.
- To keep aware of the status.
- To monitor changes.
- See what is happening to our waterways.
- To improve awareness of water quality and ways to achieve this.
- Self assessment.
- Evaluation of water quality.
- To avoid regulation by Regional and District council.
- Comparing my stream to others that are the same and seeing how other farmers have handled erosion.
- Self assess my stream and it's needs.
- To monitor the state of the river (stream). To maintain stockwater quality.
- For continuing to progress sustainable agricultural use.
- Assessing stream 'health' and management issues.
- For my own interest.

Q6. How often?

- Once at each site.
- Four respondents answered "Unsure".
- Seven respondents answered "Annually".
- Annually, until waterways are all planted.
- Annually, in the spring.

- Annually - may sample seasonal cycles to identify variability.
- As discussed, it needs to be done at the same time of year and under similar conditions.
- 1-2 yearly.
- Every two years.
- 2 yearly.
- Bi-yearly.
- 3 yearly.

Q7. Do you think the guide has the potential to be a useful tool in marketing produce? (e.g., as part of a quality assurance scheme).

- Not in the short or medium term.
- Not uniformly.
- Yes, in the long term.
- Two respondents answered "Possibly".
- Three respondents answered "No".
- Six respondents answered "Yes".
- Yes, in conjunction with a farm/environmental plan.
- Perhaps one day.
- Yes, we need to maintain our clean green image (farmers need to practice what they preach).
- With my stream no, others maybe?
- No, other than a stream with a polluted history and needed to be put right.
- Yes, could be used in conjunction with something like Graham McBrides Q.A. manual in Dairy Exporter Vol 74 no. 4, October 98.
- Stock water obtained from known pristine water must have some benefits in the marketing field.
- Enhances 'clean green' idea, and promotes excellence.
- Yes, but!, Selling farm produce within a sustainable label because of the unpolluted waterways may be a lot more difficult than selling produce from the top of a high hill where distance makes the environment look pristine.

Q8. Would you recommend the guide to your neighbour? If not, why?

- 14 respondents answered "Yes".
- No, because they put low priorities on these issues.
- No, because they don't share the same interest in the environment.
- Yes, to some only.
- No, because they don't like trees.
- Yes, to make them aware.
- To certain neighbours, yes.
- Yes, so he is aware of any problems or potential problems with erosion.
- If I had a farming neighbour yes, but I will generally promote this as a useful tool in my policy work.
- In our cases we share the same problems. Maybe we should be sitting down as a group and doing the questionnaire together.

Q9. Has the guide increased your understanding of waterway health and the associated impacts? If so, how?

- No.
- No, I'm already interested.
- Not really.
- Yes.
- Yes, I now know much more about my stream, and it's MCI life in the stream.
- Yes, more aware of factors affecting water quality.
- Yes, become more aware of stream life and how everyday farming practices can impact on it.
- Yes, understanding the factors etc., that increase water quality.
- Yes, improved awareness of management away from the waterway and how this affects water quality. It is a good educational tool.
- Yes, shading to kill weeds, bugs as a measure of water quality.
- Yes, I am more aware.
- Yes, by standing and looking you tend to think about the waterway and the state of it (when filling in the form). Never thought about it before. You usually fly past on the motorbike not taking much notice of the stream, this actually makes you stop and look and think.
- Makes one think about it.
- Water life as in bugs etc.
- Yes. More aware of the ecology of the waterway.
- Yes. I am now aware of the large number of factors that contribute to the health/state of the stream.
- It has made me think about it.
- Yes, made me aware of animal life in the stream.
- Yes, by thinking about the existing waterway.
- Knowing types or amounts of vegetation cover (land use).
- Yes, MCI index and reliability.
- As it is the field I am working in it has again heightened my awareness.
- Yes, impact of shading in relation to slime, and the detrimental effects of some willows.

Q10. Do you think it will change your attitudes/thinking towards the management of your streams?

- I'd like to think so.
- Slightly, I am already committed to reducing soil erosion along stream banks.
- Four respondents answered "Yes".
- No, I am already addressing these issues by retiring and replanting.
- No, I am already aware of the factors affecting water quality.
- No, just reinforced them.
- Slightly.
- Five respondents answered "No".
- Unsure.
- Most certainly.
- Yes, it makes you think about your actions.
- Maybe.
- Yes, makes one conscious of the need to maintain and strive to improve water quality.
- I think most farmers have an affinity with stream erosion.

- Not in the short term.
- In part, I am already aware of environmental impacts.

Q11. How will you use the information obtained by using the guide?

- I would become more encouraged to fence off streams and retire them.
- As a reference.
- For stream and waterway management, e.g., grazing, retiring land.
- Three respondents answered "Unsure".
- As an index of progress.
- For future reference.
- To be more aware.
- Share with neighbours.
- To look at the changes.
- As a comparison from year to year to see what is happening to my local waterway.
- Can be used as a baseline and monitoring instrument.
- To remove obstructions and improve water flow, thereby aiding erosion problems.
- To see if I can have a clear conscience, or have to do something about it.
- Yearly assessment, should show improvement. If not need to ask oneself why?
- Awareness.
- To become even more worried.
- Self checking.
- To monitor annually stream quality.
- To help farmers understand their responsibilities.
- In planting decisions on stream edge. Could use name list for contacts.
- I don't think I have obtained new information from the guide.

Q12. Who's responsibility do you think the monitoring of waterways should be? (regional council or your own?).

- Regional council - farmers in total will never monitor their own streams - some will.
- Mine.
- Should be landowners, with the guidance of regional council.
- Four respondents answered "Both".
- Regional council - farmers do not have the expertise to monitor waterways on their own.
- Two respondents answered "My own".
- No regional authority - we don't want the regional council around here.
- Should be our own responsibility. Using the regional council to advise landowners.
- 1st own, 2nd regional council.
- You monitor your own. Regional council oversees all catchments.
- Regional council.
- Farmers for minor waterways.
- Joint approach. Regional council to fall back on if their is a break down in management, i.e., new owners, new neighbours.
- A combination could be beneficial, but interpretations by certain councils could be dubious.
- Combination, sharing information.
- Joint.

- The obvious answer is it is better to do it yourself, but it is impractical for chemical tests. So therefore, regional council should monitor as required by the RMA.
- Both, because of the impact on downstream owners of any change to rivers.
- In my case I monitor it and ask for assistance from the regional council with limited success.

Q13. What assistance would you/do you require with waterway management?

- Financial.
- Financial, and research as to tree types, weed control etc., best suited for different areas.
- Financial, and information on planting, species etc.
- Ideas about trees to plant, and more information about waterway management.
- Technical expertise to confirm my observations of progress.
- Perhaps advice on tree species.
- None.
- Unsure.
- Money.
- None at present.
- Some idea of good types of plants to control water quality.
- Odd plantings and bank stabilisation.
- Knowledge - ignorance is bliss! Some scientific input to monitor impacts/effects of management decisions.
- Erosion control programmes.
- Depends on the size of the waterway.
- Planting species, and wetland advice.
- Advice, education, money/finance.
- Cost of poles.
- Financial assistance with erosion control. Fencing costs etc., my work upstream benefits many downstream.
- Empirical measurements, ecological development suggestions, e.g., vegetation types.
- None now, unless it is to help one catch more fish!
- Early warning of floods, advice on plantings.
- Our problem is too great for individuals. We need a district scheme to slow down river bank erosion and a developing eye-sore.

APPENDIX 3	**Physio-Chemical and Biological Data**		
Site number	**Site 1**	**Site 2**	**Site 3**
Stream name	Kiwitea Stream	Mangawharariki Stream	Papanui Stream
Date	11/8/97	11/8/97	11/8/97
Time	10.00 am	12.30 pm	1.30 pm
Map Co-ordinates	T22478358	T22574477	T22584475
Altitude(m)	400	380	440
Stream order	4	4	2
Temperature	5	6.3	6.3
Conductivity	150	90	202
pH	7.8	7.9	7.9
Width(m)	20	20	3
Depth 1 (m)	0.25	0.23	0.78
Depth 2	0.32	0.32	0.78
Depth 3	0.47	0.26	0.78
Velocity 1 (m/s)	1.1	0.82	0
Velocity 2	0.79	0.84	0
Velocity 3	0.59	0.27	0
Pfankuch sub1	33	14	21
SubTotal 2	30	15	33
SubTotal 3	22	25	43
Total	85	54	97
Waterway self assessment	237	486	201
% Cover	70	20	0
% Native	0	90	0
% Exotic	60	5	0
% Scrub	0	0	0
% Pasture	40	5	95
% Tussock	0	0	5
Black disc (m)	0.44	2	0.33
Bedrock	0	33	0
Boulders	11	13	0
Large cobbles	22	7	0
Small cobbles	44	27	0
Gravel	11	20	5
Sand	12	0	0
Silt	0	0	95
Total Pigment conc.	0.003380885	0.000566245	0.001241249
Nitrates NO3- (mg/l)	0.2	0.1	0.09
Phosphates PO43- (mg/l)	0.61	0.02	0.03
Suspended Solids (mg/l)	0.209	0.086	1.44

Site number	**Site 4**	**Site 5**	**Site 6**
Stream name	Te Kapua Reserve Stream	Makohine Stream	Te Kapua Road Stream
Date	11/8/97	11/8/97	11/8/97
Time	2.30 pm	3.30 pm	4.30 pm
Map Co-ordinates	T22438554	T22441566	T22476524
Altitude(m)	540	520	380
Stream order	2	3	3
Temperature	5.1	5.9	7.9
Conductivity	194	121	183
pH	8	8.3	8
Width(m)	1.15	3.1	1.1
Depth 1 (m)	0.1	0.23	0.13
Depth 2	0.21	0.27	0.36
Depth 3	0.08	0.27	0.2
Velocity 1 (m/s)	0.45	0.33	0.55
Velocity 2	0.07	0.68	0.15
Velocity 3	0.31	0.51	0.16
Pfankuch sub1	20	25	28
SubTotal 2	31	25	22
SubTotal 3	28	29	23
Total	79	79	73
Waterway self assessment	476	246	230
% Cover	90	15	0
% Native	95	5	0
% Exotic	0	5	0
% Scrub	0	0	0
% Pasture	5	90	100
% Tussock	0	0	0
Black disc (m)	1.2	0.8	0.1
Bedrock	15	0	90
Boulders	4	11	10
Large cobbles	7.5	45	0
Small cobbles	44	33	0
Gravel	7.5	11	0
Sand	0	0	0
Silt	22	0	0
Total Pigment conc.	0.000119054	0.006124377	0
Nitrates NO3- (mg/l)	0.04	0.04	0.03
Phosphates PO43- (mg/l)	0.05	0.03	0.04
Suspended Solids (mg/l)	2.994	0.295	1.561

Site number	**Site 7**	**Site 8**
Stream name	West Branch Tamaki River	West Branch Tamaki River
Date	18/8/97	18/8/97
Time	2.00 pm	3.00 pm
Map Co-ordinates	T23682165	T23700145
Altitude(m)	420	340
Stream order	2	3
Temperature	8.5	9.6
Conductivity	63.5	62.7
pH	8.7	8.3
Width(m)	4.4	7.4
Depth 1 (m)	0.25	0.19
Depth 2	0.2	0.24
Depth 3	0.17	0.26
Velocity 1 (m/s)	0.58	0.58
Velocity 2	0.79	0.85
Velocity 3	0.73	0.08
Pfankuch sub1	17	27
SubTotal 2	25	27
SubTotal 3	18	43
Total	60	97
Waterway self assessment	421	296
% Cover	5	0
% Native	100	0
% Exotic	0	0
% Scrub	0	0
% Pasture	0	100
% Tussock	0	0
Black disc (m)	3.1	2.5
Bedrock	0	0
Boulders	0	0
Large cobbles	5	5
Small cobbles	90	45
Gravel	5	45
Sand	0	5
Silt	0	0
Total Pigment conc.	0.001563892	0.000470858
Nitrates NO3- (mg/l)	0.04	0.05
Phosphates PO43- (mg/l)	0.05	0.04
Suspended Solids (mg/l)	0.148	0.056

Site number	**Site 9**	**Site 10**	**Site 11**
Stream name	West Branch Tamaki River	Mangapuaka Stream	Mangapuaka Stream
Date	18/8/97	18/8/97	19/8/97
Time	4.00 pm	4.50 pm	12.00 pm
Map Co-ordinates	U23710133	T23690030	T23636107
Altitude(m)	260	180	380
Stream order	3	3	2
Temperature	11.6	11.8	7.2
Conductivity	78.5	113.4	71.2
pH	8.2	7.9	8
Width(m)	3.8	3.8	2
Depth 1 (m)	0.29	0.19	0.08
Depth 2	0.24	0.18	0.1
Depth 3	0.23	0.17	0.13
Velocity 1 (m/s)	0.33	0.98	0.85
Velocity 2	0.76	0.95	0.18
Velocity 3	0.76	0.78	0.52
Pfankuch sub1	29	19	21
SubTotal 2	41	31	37
SubTotal 3	42	48	41
Total	112	98	99
Waterway self assessment	174	170	452
% Cover	0	0	0
% Native	0	0	100
% Exotic	0	0	0
% Scrub	0	0	0
% Pasture	100	100	0
% Tussock	0	0	0
Black disc (m)	0.75	1.2	2.1
Bedrock	0	0	0
Boulders	0	0	1
Large cobbles	5	0	17
Small cobbles	40	50	69
Gravel	30	40	9
Sand	0	10	0
Silt	25	0	4
Total Pigment conc.	0.001038007	0.001271212	0.001888583
Nitrates NO3- (mg/l)	0.55	1.31	0.03
Phosphates PO43- (mg/l)	0.04	0.08	0.01
Suspended Solids (mg/l)	0.183	0.302	0.091

Site number	**Site 12**	**Site 13**	**Site 14**
Stream name	Mangapuaka Stream	Raparapawai Stream	Mangaatua Stream
Date	19/8/97	19/8/97	19/8/97
Time	12.45 pm	1.30 pm	2.30 pm
Map Co-ordinates	T23653074	T23607038	T23582005
Altitude(m)	280	280	220
Stream order	2	3	3
Temperature	12.2	10.2	10.7
Conductivity	78.7	76.1	82.7
pH	8	8	8.2
Width(m)	2.4	6.4	8.9
Depth 1 (m)	0.1	0.16	0.25
Depth 2	0.11	0.24	0.35
Depth 3	0.13	0.32	0.31
Velocity 1 (m/s)	0.47	0.55	0.12
Velocity 2	0.7	0.77	0.65
Velocity 3	0.34	0.72	0.62
Pfankuch sub1	30	29	28
SubTotal 2	34	29	30
SubTotal 3	39	30	31
Total	103	88	89
Waterway self assessment	190	244	264
% Cover	2	0	5
% Native	0	0	0
% Exotic	5	5	10
% Scrub	5	45	70
% Pasture	90	50	20
% Tussock	0	0	0
Black disc (m)	1.2	2.2	1.6
Bedrock	0	0	0
Boulders	0	4	4
Large cobbles	30	17.5	26
Small cobbles	50	35	43
Gravel	10	26	18
Sand	10	17.5	9
Silt	0	0	0
Total Pigment conc.	0.006514057	0.003660162	0.004382179
Nitrates NO3- (mg/l)	0.19	0.07	0.02
Phosphates PO43- (mg/l)	0.02	0.02	0.03
Suspended Solids (mg/l)	0.103	0.119	0.126

Site number	**Site 15**	**Site 16**	**Site 17**
Stream name	Coppermine Stream	Raparapawai Stream	Raparapawai Stream
Date	19/8/97	19/8/97	24/8/97
Time	3.15 pm	4.00 pm	2.00 pm
Map Co-ordinates	T23569016	T23624015	T23586052
Altitude(m)	280	230	360
Stream order	3	3	3
Temperature	9.2	9.9	7.3
Conductivity	83.7	80.2	59.8
pH	8	7.9	8.1
Width(m)	4.9	3.7	7.8
Depth 1 (m)	0.2	0.21	0.28
Depth 2	0.2	0.36	0.43
Depth 3	0.3	0.28	0.42
Velocity 1 (m/s)	0.26	0.42	0.72
Velocity 2	0.79	0.53	0.53
Velocity 3	0.12	0.46	0.96
Pfankuch sub1	30	26	20
SubTotal 2	43	26	33
SubTotal 3	41	33	32
Total	114	85	85
Waterway self assessment	237	222	462
% Cover	0	20	0
% Native	0	0	85
% Exotic	0	60	0
% Scrub	0	20	5
% Pasture	100	20	10
% Tussock	0	0	0
Black disc (m)	2.6	1.5	1.3
Bedrock	0	0	0
Boulders	24	2	20
Large cobbles	4	20	30
Small cobbles	16	39	20
Gravel	24	16	30
Sand	32	23	0
Silt	0	0	0
Total Pigment conc.	0.003512156	0.001162778	8.96304E-05
Nitrates NO3- (mg/l)	0.02	0.18	0.01
Phosphates PO43- (mg/l)	0.02	0.01	0.01
Suspended Solids (mg/l)	0.199	0.178	0.118

Site number	**Site 18**	**Site 19**	**Site 20**
Stream name	Coppermine Stream	Burtons Stream	Hutewai Stream
Date	24/8/97	30/8/97	30/8/97
Time	4.00 pm	1.00 pm	1.50 pm
Map Co-ordinates	T23563025	T23585292	T23585276
Altitude(m)	340	400	400
Stream order	3	2	3
Temperature	7.3	8.4	8.9
Conductivity	69.9	96.2	115.9
pH	7.9	8.1	8.3
Width(m)	5.3	1	16.9
Depth 1 (m)	0.25	0.22	0.4
Depth 2	0.27	0.22	0.34
Depth 3	0.36	0.28	0.17
Velocity 1 (m/s)	0.26	0.36	1.21
Velocity 2	0.4	0.1	0.98
Velocity 3	1.25	0.14	0.48
Pfankuch sub1	26	29	28
SubTotal 2	22	38	28
SubTotal 3	23	48	29
Total	71	105	85
Waterway self assessment	514	176	369
% Cover	15	1	10
% Native	100	0	90
% Exotic	0	0	0
% Scrub	0	0	5
% Pasture	0	100	5
% Tussock	0	0	0
Black disc (m)	0.7	1.3	0.9
Bedrock	0	0	0
Boulders	40	0	6
Large cobbles	30	0	44
Small cobbles	10	40	44
Gravel	20	0	0
Sand	0	0	6
Silt	0	60	0
Total Pigment conc.	0.000252731	0.001538889	0.001414708
Nitrates NO3- (mg/l)	0.01	0.13	0.24
Phosphates PO43- (mg/l)	0.03	0.03	0.05
Suspended Solids (mg/l)	0.164	0.144	0.437

Site number	**Site 21**	**Site 22**	**Site 23**
Stream name	Te Ekaou Stream	Opawe Stream	Makiekie (Coal) Creek
Date	30/8/97	30/8/97	30/8/97
Time	3.20 pm	3.50 pm	4.35 pm
Map Co-ordinates	T23564180	T23545160	T23531172
Altitude(m)	180	160	160
Stream order	3	4	4
Temperature	9	10.2	10.4
Conductivity	122.2	110.1	139.9
pH	7.9	8.6	8
Width(m)	5.9	5.3	16.6
Depth 1 (m)	0.15	0.11	0.25
Depth 2	0.22	0.2	0.37
Depth 3	0.23	0.24	0.37
Velocity 1 (m/s)	0.08	0.33	0.93
Velocity 2	0.49	1.14	1.06
Velocity 3	0.2	0.72	0.8
Pfankuch sub1	29	24	29
SubTotal 2	30	31	34
SubTotal 3	33	41	34
Total	92	96	97
Waterway self assessment	222	221	292
% Cover	20	0	10
% Native	0	5	60
% Exotic	20	5	10
% Scrub	5	0	10
% Pasture	70	90	20
% Tussock	5	0	0
Black disc (m)	0.5	1.3	0.75
Bedrock	0	0	0
Boulders	6	10	10
Large cobbles	44	20	45
Small cobbles	33	40	45
Gravel	11	20	0
Sand	0	10	0
Silt	6	0	0
Total Pigment conc.	0.000832152	0.003361255	0.000302216
Nitrates NO3- (mg/l)	0.01	0.04	0.18
Phosphates PO43- (mg/l)	0.04	0.02	0.01
Suspended Solids (mg/l)	0.24	0.112	0.455

Site number	**Site 24**	**Site 25**	**Site 26**
Stream name	Mangatukura Stream	Mangatuatou Stream	Dundas Creek
Date	30/8/97	20/9/97	20/9/97
Time	5.00 pm	12.10pm	1.15 pm
Map Co-ordinates	T23528154	T23522134	T23518126
Altitude(m)	180	140	160
Stream order	2	3	3
Temperature	9.8	9.8	11.1
Conductivity	119	128	258
pH	7.8	8.3	8.8
Width(m)	1	3.7	4.9
Depth 1 (m)	0.1	0.17	0.11
Depth 2	0.1	0.47	0.13
Depth 3	0.15	0.3	0.12
Velocity 1 (m/s)	0.03	0.6	0.23
Velocity 2	0.21	0.17	0.43
Velocity 3	0.1	0.94	0.31
Pfankuch sub1	25	27	28
SubTotal 2	26	38	33
SubTotal 3	27	35	30
Total	78	90	91
Waterway self assessment	304	414	254
% Cover	50	60	30
% Native	60	90	30
% Exotic	10	0	5
% Scrub	0	7	0
% Pasture	30	3	65
% Tussock	0	0	0
Black disc (m)	0.85	2.8	0.78
Bedrock	0	0	0
Boulders	0	0	0
Large cobbles	40	15	20
Small cobbles	40	46.5	20
Gravel	10	15	30
Sand	10	23.5	0
Silt	0	0	30
Total Pigment conc.	0.010691092	0.001620137	0.008029497
Nitrates NO3- (mg/l)	0.67	0.03	0.03
Phosphates PO43- (mg/l)	0.03	0.03	0.01
Suspended Solids (mg/l)	0.29	0.355	0.627

Site number	**Site 27**	**Site 28**	**Site 29**
Stream name	Matanganui Stream	Pohangina River Trib. 1	Matanganui Stream
Date	20/9/97	20/9/97	20/9/97
Time	2.45 pm	4.00 pm	4.30 pm
Map Co-ordinates	T23544093	T23507117	T23502112
Altitude(m)	400	140	130
Stream order	3	3	4
Temperature	7.4	11.5	11.3
Conductivity	71	179	136
pH	7.8	7.8	9.3
Width(m)	3.8	2.4	4.6
Depth 1 (m)	0.48	0.11	0.46
Depth 2	0.28	0.13	0.27
Depth 3	0.29	0.14	0.2
Velocity 1 (m/s)	0.07	0.41	0.63
Velocity 2	0.46	0.5	0.77
Velocity 3	0.55	0.21	0.92
Pfankuch sub1	18	24	24
SubTotal 2	17	19	37
SubTotal 3	25	25	27
Total	60	68	88
Waterway self assessment	540	316	165
% Cover	15	60	1
% Native	100	95	0
% Exotic	0	0	10
% Scrub	0	2	0
% Pasture	0	3	90
% Tussock	0	0	0
Black disc (m)	2.6	0.64	2
Bedrock	0	0	0
Boulders	30	0	30
Large cobbles	5	15	20
Small cobbles	15	40	10
Gravel	25	40	30
Sand	25	5	10
Silt	0	0	0
Total Pigment conc.	0.000402265	0.01123063	0.002900888
Nitrates NO3- (mg/l)	0.02	0.02	0.01
Phosphates PO43- (mg/l)	0.39	0.04	0.07
Suspended Solids (mg/l)	0.196	0.455	0.984

Site number	**Site 30**	**Site 31**	**Site 32**
Stream name	Matanganui Stream Trib. 1	Te Awaoteatua Stream	Horopito Stream
Date	20/9/97	20/9/97	4/10/97
Time	5.30 pm	6.00 pm	10.30 am
Map Co-ordinates	T23528081	T23484089	T22615312
Altitude(m)	420	120	440
Stream order	2	3	3
Temperature	7.9	11.4	10.1
Conductivity	67	157	81
pH	7.9	8	8.4
Width(m)	1.5	5.7	4.7
Depth 1 (m)	0.16	0.15	0.16
Depth 2	0.1	0.24	0.23
Depth 3	0.15	0.19	0.45
Velocity 1 (m/s)	0.07	0.5	0.54
Velocity 2	0.07	0.33	0.58
Velocity 3	0.27	0.33	0.58
Pfankuch sub1	23	24	27
SubTotal 2	19	32	35
SubTotal 3	22	29	38
Total	64	85	100
Waterway self assessment	366	199	296
% Cover	90	5	5
% Native	100	0	50
% Exotic	0	10	15
% Scrub	0	0	5
% Pasture	0	90	30
% Tussock	0	0	0
Black disc (m)	0.35	0.9	0.7
Bedrock	0	0	0
Boulders	50	0	0
Large cobbles	10	28	60
Small cobbles	20	18	25
Gravel	10	45	10
Sand	10	0	5
Silt	0	9	0
Total Pigment conc.	8.2825E-05	0.003197662	0.000998944
Nitrates NO3- (mg/l)	0.01	0.03	0.06
Phosphates PO43- (mg/l)	0.01	0.04	0.03
Suspended Solids (mg/l)	0.144	0.289	0.125

Site number	**Site 33**	**Site 34**	**Site 35**
Stream name	Makiekie (Coal) Creek	Makiekie (Coal) Creek	Cone Creek
Date	4/10/97	4/10/97	4/10/97
Time	11.30 am	1.00 pm	2.15 pm
Map Co-ordinates	T22618316	T22675313	T22672317
Altitude(m)	420	620	600
Stream order	4	3	3
Temperature	10.4	7.8	8.1
Conductivity	96	51	51
pH	8.4	7.8	7.6
Width(m)	10	3.3	4.7
Depth 1 (m)	0.28	0.24	0.37
Depth 2	0.36	0.35	0.26
Depth 3	0.33	0.44	0.29
Velocity 1 (m/s)	0.82	0.75	0
Velocity 2	1	0.52	0.43
Velocity 3	0.45	0.57	0.49
Pfankuch sub1	32	21	29
SubTotal 2	34	15	23
SubTotal 3	26	17	32
Total	92	53	84
Waterway self assessment	352	552	418
% Cover	20	40	80
% Native	70	95	90
% Exotic	10	0	5
% Scrub	10	0	0
% Pasture	10	5	5
% Tussock	0	0	0
Black disc (m)	1	2	3
Bedrock	5	5	0
Boulders	30	60	40
Large cobbles	30	5	10
Small cobbles	20	10	10
Gravel	10	5	30
Sand	5	15	10
Silt	0	0	0
Total Pigment conc.	0.000961885	0.000473367	5.93783E-05
Nitrates NO3- (mg/l)	0.11	0.03	0.02
Phosphates PO43- (mg/l)	0.01	0.02	0.03
Suspended Solids (mg/l)	0.167	0.101	0.038

Site number	**Site 36**	**Site 37**	**Site 38**	**Site 39**
Stream name	Limestone Creek	Kiwitea Stream	Kiwitea Stream	Waituna Stream
Date	4/10/97	1/11/97	1/11/97	1/11/97
Time	3.15 pm	9.10 am	10.00 am	10.45 am
Map Co-ordinates	T22669326	T23311073	T23357163	T23351260
Altitude(m)	620	100	180	300
Stream order	2	4	3	4
Temperature	8.1	14.8	15	13.6
Conductivity	106	173	157	129
pH	7.9	8.2	8.1	8
Width(m)	3.3	9.6	12.2	2.2
Depth 1 (m)	0.1	0.2	0.24	0.21
Depth 2	0.13	0.17	0.18	0.1
Depth 3	0.24	0.3	0.2	0.12
Velocity 1 (m/s)	0.49	0.92	0.5	0.46
Velocity 2	0.6	0.4	0.98	0.48
Velocity 3	0.42	0.78	0.95	0.45
Pfankuch sub1	31	30	23	24
SubTotal 2	27	34	26	35
SubTotal 3	23	45	31	31
Total	81	109	80	90
Waterway self assessment	398	221	252	266
% Cover	50	2	5	90
% Native	100	0	0	90
% Exotic	0	67	30	10
% Scrub	0	11	0	0
% Pasture	0	22	70	0
% Tussock	0	0	0	0
Black disc (m)	0.8	1	1.4	2.9
Bedrock	0	0	0	0
Boulders	2.5	5	0	0
Large cobbles	2.5	0	0	5
Small cobbles	40	70	50	45
Gravel	50	10	40	40
Sand	5	15	10	5
Silt	0	0	0	5
Total Pigment conc.	0.002046305	0.000214726	0.000225446	0.000123995
Nitrates NO3- (mg/l)	0.06	0.49	0.07	0.07
Phosphates PO43- (mg/l)	0.07	0.04	0.09	0.07
Suspended Solids (mg/l)	0.218	0.256	0.329	0.076

Site number	**Site 40**	**Site 41**	**Site 42**	**Site 43**
Stream name	Waituna Stream	Waituna Trib 1	Kiwitea Trib 2	Waituna Stream
Date	1/11/97	1/11/97	1/11/97	1/11/97
Time	11.25 am	12.15 pm	12.45 pm	3.00 pm
Map Co-ordinates	T23304238	T23323225	T23410249	S23238235
Altitude(m)	200	260	280	100
Stream order	4	2	3	5
Temperature	16.3	17.9	18	23.1
Conductivity	141	194	160	268
pH	8	7.9	8.3	8.7
Width(m)	4.8	1	7.3	2.9
Depth 1 (m)	0.13	0.2	0.22	0.12
Depth 2	0.1	0.12	0.29	0.11
Depth 3	0.16	0.13	0.21	0.14
Velocity 1 (m/s)	0.7	0.09	1.2	0.28
Velocity 2	0.67	0.05	0.79	0.45
Velocity 3	0.52	0.07	0.82	0.64
Pfankuch sub1	22	29	28	29
SubTotal 2	39	37	38	30
SubTotal 3	30	45	30	31
Total	91	111	96	90
Waterway self assessment	211	162	226	192
% Cover	5	0	10	5
% Native	0	0	10	10
% Exotic	10	10	20	15
% Scrub	0	0	0	0
% Pasture	90	90	70	75
% Tussock	0	0	0	0
Black disc (m)	2	0.8	1	2
Bedrock	0	0	0	0
Boulders	0	0	0	0
Large cobbles	0	0	5	0
Small cobbles	50	0	40	45
Gravel	45	30	40	35
Sand	5	0	15	20
Silt	0	70	0	0
Total Pigment conc.	0.00187254	0.002509994	0.000257709	0.037831919
Nitrates NO3- (mg/l)	0.06	0.02	0.03	0.02
Phosphates PO43- (mg/l)	0.04	0.04	0.03	0.02
Suspended Solids (mg/l)	0.1	0.251	0.386	0.513

Site number	**Site 45**	**Site 46**	**Site 47**
Stream name	Pakihikura Stream Trib 1	Mangapipi Stream	Mangatutu Stream
Date	12/11/97	12/11/97	12/11/97
Time	10.15 am	11.00 am	11.45 am
Map Co-ordinates	T22363362	T22356346	T22349322
Altitude(m)	180	160	180
Stream order	3	3	3
Temperature	10.7	10.3	13.7
Conductivity	309	378	251
pH	8.1	8.3	8.8
Width(m)	1.4	2.2	1.6
Depth 1 (m)	0.11	0.14	0.11
Depth 2	0.15	0.15	0.14
Depth 3	0.11	0.14	0.08
Velocity 1 (m/s)	0.06	0.19	0.32
Velocity 2	0.23	0.23	0.23
Velocity 3	0.66	0.32	0.49
Pfankuch sub1	26	32	28
SubTotal 2	37	36	32
SubTotal 3	31	30	46
Total	94	98	106
Waterway self assessment	221	236	198
% Cover	30	30	5
% Native	0	70	0
% Exotic	20	0	30
% Scrub	5	0	0
% Pasture	75	30	70
% Tussock	0	0	0
Black disc (m)	1.25	1.04	0.74
Bedrock	0	0	0
Boulders	0	5	0
Large cobbles	10	10	0
Small cobbles	40	50	10
Gravel	30	15	70
Sand	20	20	20
Silt	0	0	0
Total Pigment conc.	0.002169491	0.003136797	0.001254097
Nitrates NO3- (mg/l)	0.03	0.16	0.05
Phosphates PO43- (mg/l)	0.03	0.07	0.04
Suspended Solids (mg/l)	0.658	0.923	0.541

Site number	**Site 48**	**Site 49**	**Site 50**
Stream name	Mangamako Stream	Makopua Stream	Makopua Stream Trib 1
Date	12/11/97	9/12/97	9/12/97
Time	2.10 pm	11.00 am	12.50 pm
Map Co-ordinates	T22443432	T22602577	T22649584
Altitude(m)	300	400	540
Stream order	4	4	3
Temperature	10.7	14.7	12.3
Conductivity	231	195.4	271
pH	7.7	8.9	8.4
Width(m)	1.6	3.6	0.25
Depth 1 (m)	0.5	0.18	0.05
Depth 2	0.63	0.1	0.03
Depth 3	0.81	0.15	0.22
Velocity 1 (m/s)	0.01	0.58	0.02
Velocity 2	0.03	0.6	0.03
Velocity 3	0.03	0.56	0.03
Pfankuch sub1	26	26	32
SubTotal 2	45	32	43
SubTotal 3	60	28	53
Total	131	86	128
Waterway self assessment	152	211	199
% Cover	30	2	80
% Native	5	1	0
% Exotic	20	4	50
% Scrub	0	0	0
% Pasture	75	95	50
% Tussock	0	0	0
Black disc (m)	0.2	0.7	0.5
Bedrock	0	0	0
Boulders	0	40	0
Large cobbles	0	30	0
Small cobbles	0	20	5
Gravel	0	10	0
Sand	10	0	45
Silt	90	0	50
Total Pigment conc.	0	0.003722789	0.002120313
Nitrates NO3- (mg/l)	0.13	0.02	0.03
Phosphates PO43- (mg/l)	0.03	0.07	0.08
Suspended Solids (mg/l)	0.72	0.34	0.496

Site number	**Site 51**	**Site 52**	**Site 53**
Stream name	Makopua Stream	Kawhatau River Trib 1	Hikurangi Stream
Date	9/12/97	9/12/97	9/12/97
Time	1.55 pm	3.20 pm	4.05 pm
Map Co-ordinates	T22675578	T22617503	T22662528
Altitude(m)	640	500	500
Stream order	2	4	4
Temperature	10.9	19.2	16.1
Conductivity	97.5	133.6	77.1
pH	8.2	8.1	8
Width(m)	2	2.4	4.9
Depth 1 (m)	0.31	17.5	0.31
Depth 2	0.2	0.1	0.31
Depth 3	0.1	0.18	0.29
Velocity 1 (m/s)	0.61	0.19	0.8
Velocity 2	0.97	0.19	1.02
Velocity 3	0.92	0.17	0.86
Pfankuch sub1	28	19	29
SubTotal 2	13	31	35
SubTotal 3	16	32	43
Total	57	83	107
Waterway self assessment	334	191	310
% Cover	95	15	0
% Native	80	0	100
% Exotic	0	5	0
% Scrub	0	0	0
% Pasture	20	95	0
% Tussock	0	0	0
Black disc (m)	0.54	0.45	1.6
Bedrock	83	0	0
Boulders	11	0	20
Large cobbles	0	1	20
Small cobbles	0	40	20
Gravel	6	40	20
Sand	0	0	20
Silt	0	19	0
Total Pigment conc.	0.000982205	0.003731235	8.95575E-05
Nitrates NO3- (mg/l)	0.05	0.16	0.04
Phosphates PO43- (mg/l)	0.08	0.13	0.06
Suspended Solids (mg/l)	0.282	0.266	0.143

Site number	**Site 54**	**Site 55**	**Site 56**
Stream name	Mangakukeke Stream	Mangakukeke Stream	Mangawharariki River
Date	9/12/97	9/12/97	10/12/97
Time	4.40 pm	5.05 pm	10.40 am
Map Co-ordinates	T22673506	T22636507	T22616444
Altitude(m)	560	420	500
Stream order	4	4	5
Temperature	16.8	17.1	13.6
Conductivity	70.4	77.7	71.1
pH	8.1	8	8.2
Width(m)	3.6	3.4	7.2
Depth 1 (m)	0.23	0.25	0.26
Depth 2	0.24	0.21	0.26
Depth 3	0.24	0.16	0.42
Velocity 1 (m/s)	0.85	1.29	0.99
Velocity 2	0.8	1.12	1.17
Velocity 3	1.21	1.31	0.99
Pfankuch sub1	19	19	26
SubTotal 2	29	27	34
SubTotal 3	42	39	39
Total	90	85	99
Waterway self assessment	282	372	262
% Cover	20	5	5
% Native	60	80	25
% Exotic	0	10	15
% Scrub	0	0	0
% Pasture	40	0	60
% Tussock	0	10	0
Black disc (m)	2.3	1.15	2.05
Bedrock	0	0	0
Boulders	20	11	20
Large cobbles	10	51	20
Small cobbles	20	21	30
Gravel	25	11	10
Sand	25	6	15
Silt	0	0	5
Total Pigment conc.	0.000800677	8.51869E-05	9.2012E-05
Nitrates NO3- (mg/l)	0.02	0.25	0.06
Phosphates PO43- (mg/l)	0.07	0.05	0.07
Suspended Solids (mg/l)	0.028	0.132	0.138

Site number	**Site 57**	**Site 58**	**Site 59**
Stream name	Mangawharariki River Trib 1	Makoira Stream	Scandlyns Creek
Date	10/12/97	10/12/97	10/12/97
Time	12.00 pm	1.05 pm	2.00 pm
Map Co-ordinates	T22662421	T22650397	T22618384
Altitude(m)	700	660	540
Stream order	3	4	4
Temperature	11.6	11.4	15.5
Conductivity	66.9	63.3	79
pH	8	8	7.8
Width(m)	5.5	3.2	4.9
Depth 1 (m)	0.17	0.21	0.17
Depth 2	0.21	0.17	0.44
Depth 3	0.45	0.13	0.28
Velocity 1 (m/s)	1.17	0.77	0.62
Velocity 2	0.88	1.17	0.62
Velocity 3	1.25	0.88	0.88
Pfankuch sub1	27	28	32
SubTotal 2	36	39	33
SubTotal 3	45	45	44
Total	108	112	109
Waterway self assessment	390	394	244
% Cover	50	50	0
% Native	70	90	40
% Exotic	0	5	10
% Scrub	0	0	0
% Pasture	30	5	50
% Tussock	0	0	0
Black disc (m)	1.6	2.3	1
Bedrock	0	0	0
Boulders	20	20	5
Large cobbles	0	10	20
Small cobbles	10	10	20
Gravel	50	30	20
Sand	10	30	30
Silt	10	0	5
Total Pigment conc.	4.43103E-05	0	4.85758E-05
Nitrates NO3- (mg/l)	0.08	0.06	0.06
Phosphates PO43- (mg/l)	0.03	0.06	0.04
Suspended Solids (mg/l)	0.152	0.083	0.311

Site number	**Site 60**
Stream name	Ruae Stream
Date	10/12/97
Time	3.15 pm
Map Co-ordinates	T22532433
Altitude(m)	460
Stream order	3
Temperature	20.3
Conductivity	173.4
pH	7.8
Width(m)	3.2
Depth 1 (m)	0.3
Depth 2	0.3
Depth 3	0.21
Velocity 1 (m/s)	0.44
Velocity 2	0.44
Velocity 3	0.62
Pfankuch sub1	36
SubTotal 2	47
SubTotal 3	57
Total	140
Waterway self assessment	166
% Cover	5
% Native	0
% Exotic	10
% Scrub	0
% Pasture	90
% Tussock	0
Black disc (m)	0.45
Bedrock	0
Boulders	0
Large cobbles	0
Small cobbles	0
Gravel	0
Sand	0
Silt	100
Total Pigment conc.	0.002133428
Nitrates NO3- (mg/l)	0.53
Phosphates PO43- (mg/l)	0.1
Suspended Solids (mg/l)	0.61

APPENDIX 5	Waterway Self Assessment Form Scores							
Question	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**	**Site 8**
1a	6	12	2	16	4	2	16	4
1b	4	12	2	16	4	2	16	2
1c	6	32	4	32	8	4	24	6
1d	4	16	2	16	4	2	2	2
1e	8	16	8	8	16	16	2	2
1f	4	24	32	32	8	32	16	16
2a	12	16	8	16	12	8	16	16
2b	6	16	2	16	4	4	8	4
2c	4	16	4	8	12	4	16	16
2d	3	16	3	16	8	4	16	16
2e	8	16	4	16	16	8	4	4
3a	8	24	4	32	8	4	32	32
3b	8	28	8	24	16	16	32	16
3c	8	28	8	24	16	12	24	24
3d	16	32	8	32	16	12	32	16
3e	16	28	16	24	16	16	32	16
4a	8	8	8	24	8	8	32	24
4b	8	16	8	24	8	8	24	8
4c	8	12	8	16	8	8	16	6
4d	12	12	16	16	8	8	16	8
4e	8	16	4	16	8	8	16	8
5a	16	16	8	4	8	4	8	16
5b	4	12	2	16	4	2	2	4
5c	12	16	2	8	16	16	12	8
5d	4	16	4	4	4	4	3	6
5e	8	16	16	16	8	16	16	16
Total	209	472	191	472	248	228	433	296

Question	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16
1a	2	2	12	4	4	4	3	8
1b	2	2	16	4	4	4	2	8
1c	4	4	32	6	6	8	4	8
1d	2	2	2	2	2	2	2	4
1e	6	4	2	4	4	8	4	4
1f	16	16	16	16	16	32	8	16
2a	6	16	16	6	16	16	16	8
2b	4	4	4	4	4	4	4	4
2c	4	8	16	12	16	8	16	8
2d	4	6	16	4	16	16	12	8
2e	4	4	4	8	4	4	4	8
3a	4	4	32	12	8	16	6	12
3b	12	8	32	8	8	12	16	12
3c	16	12	32	16	16	16	16	16
3d	16	8	32	16	16	16	16	8
3e	12	8	32	8	8	12	16	12
4a	6	8	32	6	12	8	24	8
4b	6	8	24	6	6	6	8	8
4c	4	4	16	2	2	4	6	4
4d	4	4	16	6	4	8	8	8
4e	8	6	16	8	16	8	8	4
5a	8	8	8	8	16	16	8	16
5b	2	2	2	2	2	4	2	2
5c	8	8	16	8	12	12	16	8
5d	4	4	8	4	2	4	4	4
5e	16	12	32	12	12	16	16	16
Total	180	172	466	192	232	264	245	222

Question	Site 17	Site 18	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24
1a	12	16	2	8	4	3	8	12
1b	16	16	2	8	4	2	8	4
1c	24	32	4	16	6	4	16	16
1d	4	8	2	3	4	2	4	16
1e	2	12	6	4	8	2	4	4
1f	32	24	12	8	16	24	6	12
2a	16	16	16	16	6	6	16	8
2b	6	16	4	6	4	4	4	8
2c	16	16	8	8	6	16	8	8
2d	16	16	8	16	8	8	16	8
2e	6	8	8	8	8	4	6	8
3a	24	32	6	24	12	6	12	16
3b	32	32	12	24	16	16	24	24
3c	32	32	16	16	16	16	16	24
3d	32	32	8	32	8	24	16	16
3e	32	32	12	24	16	16	24	24
4a	32	32	8	8	12	12	12	24
4b	24	30	8	16	8	8	8	12
4c	12	12	4	12	8	4	6	8
4d	16	16	8	12	8	8	12	12
4e	16	16	4	16	4	8	12	8
5a	16	16	4	32	16	8	32	4
5b	8	12	2	8	2	2	6	8
5c	16	16	6	8	8	8	8	8
5d	4	8	4	8	4	4	2	4
5e	32	24	8	32	16	8	16	16
Total	478	522	182	373	228	223	302	312

Question	Site 25	Site 26	Site 27	Site 28	Site 29	Site 30	Site 31	Site 32
1a	12	8	16	8	2	16	6	8
1b	16	8	16	16	2	16	4	8
1c	32	12	32	16	4	24	6	14
1d	16	6	4	16	2	16	3	4
1e	8	6	16	8	2	16	4	4
1f	12	12	32	32	16	32	24	24
2a	8	8	16	4	4	8	4	16
2b	8	4	16	4	4	8	4	4
2c	16	8	16	8	16	8	8	8
2d	16	16	16	8	6	12	8	16
2e	8	6	12	16	6	16	8	6
3a	24	6	32	24	4	8	6	16
3b	24	16	32	8	6	16	12	16
3c	30	20	32	16	16	16	16	16
3d	32	16	32	8	8	16	8	16
3e	24	16	32	8	6	16	12	16
4a	16	12	32	12	8	12	8	12
4b	24	8	24	8	8	8	8	12
4c	12	8	16	16	3	8	8	12
4d	12	12	16	8	6	12	8	12
4e	16	8	16	8	8	6	8	8
5a	8	8	8	8	8	4	8	8
5b	8	2	16	8	2	16	2	8
5c	8	8	16	8	8	16	6	8
5d	6	4	12	4	4	16	4	4
5e	24	16	32	16	4	8	8	16
Total	420	254	540	296	163	350	201	292

Question	Site 33	Site 34	Site 35	Site 36	Site 37	Site 38	Site 39	Site 40
1a	12	12	16	16	4	6	8	4
1b	6	16	16	16	8	4	16	2
1c	24	32	16	32	8	8	12	4
1d	16	16	16	12	3	6	16	3
1e	4	16	12	12	4	8	4	4
1f	6	32	32	32	16	32	12	16
2a	12	16	16	8	16	8	16	8
2b	8	16	8	12	8	4	4	4
2c	12	16	16	8	6	8	8	8
2d	16	16	16	12	8	8	8	8
2e	8	8	16	16	8	6	16	4
3a	24	32	24	16	12	16	16	8
3b	24	32	24	24	12	16	16	16
3c	16	32	24	24	12	16	16	16
3d	24	32	24	16	8	8	8	16
3e	24	32	24	24	12	16	16	16
4a	16	32	32	12	4	8	8	8
4b	16	32	8	24	8	8	8	8
4c	12	16	12	12	6	8	8	8
4d	16	16	16	16	4	4	8	8
4e	8	16	16	8	8	12	8	8
5a	16	8	8	8	16	16	8	8
5b	8	12	8	16	4	4	8	2
5c	12	16	8	8	8	8	12	8
5d	4	16	4	4	2	4	2	4
5e	16	32	6	6	16	12	8	16
Total	360	552	418	394	221	254	270	215

Question	Site 41	Site 42	Site 43	Site 45	Site 46	Site 47	Site 48	Site 49
1a	2	6	4	4	8	4	2	4
1b	2	4	4	6	8	4	2	2
1c	4	8	6	8	16	8	6	4
1d	2	4	2	6	16	4	4	4
1e	4	8	8	8	6	4	2	8
1f	32	12	16	16	8	16	32	32
2a	2	16	8	6	8	16	4	6
2b	2	4	4	4	4	4	2	4
2c	8	6	8	8	12	12	2	4
2d	2	8	3	8	8	8	2	4
2e	4	8	4	16	8	4	4	16
3a	4	12	6	8	6	6	4	6
3b	12	16	16	16	16	12	12	12
3c	8	12	16	16	16	12	8	12
3d	8	16	8	16	16	8	16	16
3e	12	16	16	16	16	12	12	12
4a	8	8	8	8	8	8	6	8
4b	8	8	8	8	8	6	6	8
4c	4	4	4	8	4	4	4	8
4d	8	8	8	8	8	8	8	8
4e	8	8	8	8	4	6	4	8
5a	4	16	8	4	8	4	4	8
5b	2	6	3	4	12	2	2	2
5c	2	8	4	8	8	8	2	8
5d	4	2	4	3	4	4	4	4
5e	8	8	12	8	4	8	4	4
Total	164	232	196	229	240	192	158	212

Question	Site 50	Site 51	Site 52	Site 53	Site 54	Site 55	Site 56	Site 57
1a	4	8	2	12	8	12	6	12
1b	8	16	2	8	8	12	4	12
1c	8	8	4	12	12	24	8	24
1d	16	16	4	2	4	4	4	12
1e	4	16	4	2	2	2	2	2
1f	32	32	32	16	24	16	24	32
2a	16	8	4	16	16	16	16	16
2b	2	16	2	4	4	8	4	8
2c	4	8	4	16	16	16	16	16
2d	4	16	4	16	16	16	12	16
2e	16	16	4	4	4	4	4	8
3a	6	6	4	16	8	24	6	8
3b	8	12	16	16	16	24	16	16
3c	8	12	16	16	16	24	16	24
3d	8	16	16	8	24	16	16	24
3e	8	12	16	16	16	24	16	16
4a	8	16	8	8	8	16	16	32
4b	8	8	8	12	12	16	8	8
4c	4	8	4	16	8	12	6	8
4d	8	16	8	12	12	8	8	16
4e	4	8	8	16	8	16	16	8
5a	4	4	8	16	8	8	16	16
5b	2	4	2	2	4	6	4	12
5c	2	16	6	8	8	12	8	12
5d	3	16	4	4	8	8	8	8
5e	4	4	6	32	8	24	8	24
Total	199	318	196	306	278	368	268	390

Question	Site 58	Site 59	Site 60
1a	12	8	3
1b	16	4	2
1c	32	16	4
1d	12	2	2
1e	2	2	2
1f	12	8	32
2a	16	16	8
2b	4	4	2
2c	16	8	4
2d	16	8	8
2e	4	4	16
3a	24	16	4
3b	24	16	12
3c	24	16	8
3d	24	16	6
3e	24	16	12
4a	24	12	8
4b	8	8	8
4c	12	8	3
4d	16	12	8
4e	16	16	8
5a	8	8	8
5b	8	2	2
5c	12	8	2
5d	8	8	3
5e	24	4	4
Total	398	246	179

APPENDIX 4

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Macroinvertebrate Data						
Zephlebia versicolor	0	0	1	1	0	0
Nesameletus	0	0	0	2	0	0
Zephlebia borealis	0	0	0	0	0	0
Zephlebia dentata	0	0	0	29	3	0
Neozephlebia	0	0	0	35	58	0
Deleatidium	0	125	0	329	58	11
Coloburiscus	0	0	0	4	2	0
Acanthophlebia cruentata	0	0	0	0	0	0
Austroclima sepia	0	0	0	0	0	0
Oniscigaster distans	0	0	0	0	0	0
Stenoperla prasina	0	1	0	0	0	0
Spaniocerca	0	0	0	6	0	0
Zelandoperla agnetis	0	0	0	4	0	0
Zelandobius furcillatus	0	0	0	28	6	14
Acroperla spiniger	0	0	0	0	0	0
Acroperla trivacuata	0	0	0	0	69	1
Acroperla pupae	0	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	0	0
Zelandobius confusus	0	0	0	0	0	1
Zelandoperla decorata	0	0	0	0	0	0
Austroperla cyrene	0	0	0	0	0	0
Megaleptoperla grandis	0	0	0	0	0	0
Megalptoperla diminuta	0	0	0	0	0	0
Polycentopodidae sp.	0	0	0	1	0	0
Hydrobiosidae larvae	0	0	1	0	0	2
Neurochorema confusum	0	1	0	2	3	0
Olinga	0	26	0	0	3	0
Triplectides obsoleta/dolichos	0	0	10	0	0	0
Triplectides cephalotes	0	0	0	0	0	0
Pycnocentri funerea	0	0	0	4	10	0
Aoteapsyche	0	0	0	13	0	0
Orthopsyche	0	0	0	0	0	0
Hydrobosis (early instar)	0	1	0	0	0	4
Psilochorema mimicum	0	0	0	6	9	0
Psilochorema sp. A	0	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0	0
Hydrobosis parumbripennis	0	0	0	0	2	0
Oxyethira albiceps	0	0	0	0	0	1
Hydrobosis umbripennis	0	0	0	0	0	1
Paroxyethira	0	0	0	0	0	1
Beraeoptera roria	0	0	0	0	0	0
Hydrobosis clavigera	0	0	0	0	0	0
Hudsonema amabilis	0	0	0	0	3	0
Costachorema psaroptera	0	0	0	0	0	0
Costachorema xanthoptera	0	0	0	0	0	0
Costachorema callista	0	0	0	0	0	0
Costachorema brachyptera	0	0	0	0	0	0
Pycnocentrella eruensis	0	0	0	0	1	0
Helicopsyche	0	0	0	0	0	0

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Pycnocentrodes	0	0	0	0	0	0
Pycnocentrodes evecta	0	0	0	0	0	0
Psilochorema nemorale	0	0	0	0	0	0
Plectrocnemia maclachlani	0	0	0	0	0	0
Polyplectropus	0	0	0	0	0	0
Alloecentrella	0	0	0	0	0	0
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0	0
Trichopteran pupae 1	0	0	0	0	0	0
Trichopteran pupae 2	0	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0	0
Pycnocentria pupae	0	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	0	0
Hydraenidae orchymontia	0	1	0	7	0	0
Elmidae	0	0	0	0	0	0
Ptilodactylidae	0	0	0	0	0	0
Hydraenidae homalaena	0	0	0	0	0	0
Elmidae adult	0	0	0	0	0	0
Berosus sp.	0	0	0	0	0	0
Liodessus plicatus	0	0	0	0	0	0
Hydraenidae podaena	0	0	0	0	0	0
Potamopyrgus	0	0	71	1	306	98
Physa	0	0	51	0	0	17
Gyraulus	0	0	0	0	0	0
Copepod	0	0	0	0	0	0
Pisidium casertanum	0	0	0	0	0	0
Ostracod	0	0	9	0	0	1
Amphipod	0	0	0	2	0	0
Eriopterini sp.	0	0	0	0	0	0
Mischoderus	0	0	0	1	0	0
Molophilus	0	0	0	1	0	0
Empididae (A)	0	0	0	1	0	0
Thaumaleidae	0	0	0	0	1	0
Psychodidae	0	0	0	0	1	0
Aphrophila neozelandica	0	0	0	0	7	0
Aphrophila pupae	0	0	0	0	0	0
Austrosimulium tillyardianum	0	0	0	0	0	36
Austrosimulium pupae	0	0	0	0	0	0
Paralimnophila skusei	0	0	0	0	0	0
Neoscatella vitithorax	0	0	0	0	0	0
Nothodixa campbelli	0	0	0	0	0	0
Dipteran pupae 1	0	0	0	0	0	0
Pupae 1	0	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0	0
Chironomidae pupae	0	0	0	0	22	5
Sigara	0	0	1	0	0	0
Anisops wakefieldi	0	0	2	0	0	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	1	0	0	0	0	0
Medium Oligocheate	0	0	0	0	0	0

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Large Oligocheate	0	0	0	0	0	0
Xanthocnemis	0	0	2	0	0	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	0	0	0
Hygraula nitens	0	0	0	0	0	0
Archichauliodes	0	4	0	1	2	0
Terrestrial	0	1	0	8	2	7
Orthocladiinae sp.	2	1	2	11	34	159
Chironominae sp.	0	0	6	6	3	2
Diamesinae sp.	0	0	0	0	230	31
Podonominae sp.	0	0	0	0	18	100
Tanypodinae sp.	0	0	0	0	0	0

Species	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
Zephlebia versicolor	0	0	0	0	0	0
Nesameletus	1	3	0	0	0	0
Zephlebia borealis	0	0	0	0	0	0
Zephlebia dentata	0	0	13	0	0	0
Neozephlebia	0	0	0	0	0	0
Deleatidium	674	429	159	243	140	33
Coloburiscus	1	278	77	9	0	0
Acanthophlebia cruentata	0	0	0	0	0	0
Austroclima sepia	0	0	30	6	0	0
Oniscigaster distans	0	0	0	0	0	0
Stenoperla prasina	1	0	0	0	1	0
Spaniocerca	0	0	0	0	0	0
Zelandoperla agnetis	17	0	0	0	0	0
Zelandobius furcillatus	17	7	2	0	3	0
Acroperla spiniger	0	0	0	0	0	0
Acroperla trivacuata	0	0	0	0	0	0
Acroperla pupae	0	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	0	0
Zelandobius confusus	0	0	0	0	0	0
Zelandoperla decorata	31	25	0	0	13	0
Austroperla cyrene	34	0	0	0	2	0
Megaleptoperla grandis	20	2	0	0	2	0
Megalptoperla diminuta	0	0	0	0	0	0
Polycentopodidae sp.	0	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0	0
Neurochorema confusum	0	0	11	0	0	0
Olinga	7	3	45	46	2	0
Triplectides obsoleta/dolichos	1	0	0	0	0	0
Triplectides cephalotes	0	0	0	0	0	0
Pycnocentri funerea	0	0	0	0	0	0
Aoteapsyche	0	4	5	3	0	0
Orthopsyche	0	0	0	0	0	0
Hydrobosis (early instar)	0	0	3	0	0	0
Psilochorema mimicum	3	5	0	0	0	0
Psilochorema sp. A	0	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0	0
Hydrobosis parumbripennis	0	0	1	1	0	0
Oxyethira albiceps	0	0	0	0	0	0
Hydrobosis umbripennis	0	0	1	0	0	0
Paroxyethira	0	0	0	0	0	0
Beraeoptera roria	31	10	0	0	0	0
Hydrobosis clavigera	1	0	1	0	0	0
Hudsonema amabilis	0	0	0	0	0	0
Costachorema psaroptera	7	0	0	0	0	0
Costachorema xanthoptera	0	0	0	0	0	0
Costachorema callista	0	0	0	0	0	0
Costachorema brachyptera	0	0	0	0	0	0
Pycnocentrella eruensis	0	0	0	0	0	0
Helicopsyche	0	7	58	0	0	0

Species	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
Pycnocentrodes	0	14	183	9	1	0
Pycnocentrodes evecta	0	4	19	6	0	0
Psilochorema nemorale	0	0	11	0	0	0
Plectrocnemia maclachlani	0	0	0	0	0	0
Polyplectropus	0	0	0	0	0	0
Alloecentrella	0	0	0	0	0	0
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0	0
Trichopteran pupae 1	0	0	0	0	0	0
Trichopteran pupae 2	0	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0	0
Pycnocentria pupae	0	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	0	0
Hydraenidae orchymontia	1	0	13	0	0	0
Elmidae	64	98	142	116	10	2
Ptilodactylidae	0	0	0	0	0	0
Hydraenidae homalaena	9	0	0	0	1	0
Elmidae adult	0	0	0	0	0	0
Berosus sp.	0	0	0	0	0	0
Liodessus plicatus	0	0	0	0	0	0
Hydraenidae podaena	0	0	1	0	0	0
Potamopyrgus	0	0	21	0	0	0
Physa	0	0	0	0	0	0
Gyraulus	0	0	0	0	0	0
Copepod	0	0	0	0	0	0
Pisidium casertanum	0	0	0	0	0	0
Ostracod	0	0	0	0	0	0
Amphipod	1	0	0	0	0	0
Eriopterini sp.	0	0	0	0	0	0
Mischoderus	0	0	0	0	0	0
Molophilus	0	0	0	0	0	2
Empididae (A)	0	0	0	0	0	0
Thaumaleidae	0	0	0	0	0	0
Psychodidae	0	0	0	0	0	0
Aphrophila neozelandica	18	11	1	0	1	0
Aphrophila pupae	0	0	0	0	0	0
Austrosimulium tillyardianum	0	0	15	0	0	0
Austrosimulium pupae	0	0	0	0	0	0
Paralimnophila skusei	0	0	0	0	0	0
Neoscatella vitithorax	0	0	0	0	0	0
Nothodixa campbelli	0	0	0	0	0	0
Dipteran pupae 1	0	0	0	0	0	0
Pupae 1	1	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0	0
Chironomidae pupae	4	4	4	0	0	0
Sigara	0	0	0	0	0	0
Anisops wakefieldi	0	0	0	0	0	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	0	0	0	9	1	0
Medium Oligocheate	0	0	0	0	0	0

Species	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
Large Oligocheate	0	0	0	0	0	0
Xanthocnemis	0	0	0	0	0	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	0	0	0
Hygraula nitens	0	0	0	0	0	0
Archichauliodes	0	0	2	1	0	0
Terrestrial	3	0	5	2	0	8
Orthocladiinae sp.	114	11	8	4	8	2
Chironominae sp.	0	0	0	0	0	0
Diamesinae sp.	2	3	12	3	1	0
Podonominae sp.	22	0	5	0	2	0
Tanypodinae sp.	0	0	0	0	0	0

Species	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
Zephlebia versicolor	0	0	0	0	0	0
Nesameletus	32	4	12	5	1	5
Zephlebia borealis	0	0	0	0	0	0
Zephlebia dentata	0	0	0	0	0	0
Neozephlebia	0	0	0	0	0	0
Deleatidium	557	228	472	436	267	481
Coloburiscus	3	1	6	38	0	25
Acanthophlebia cruentata	0	0	4	0	0	0
Austroclima sepia	0	5	1	0	0	0
Oniscigaster distans	0	0	0	0	0	0
Stenoperla prasina	1	0	13	0	3	4
Spaniocerca	0	0	0	0	0	0
Zelandoperla agnetis	0	0	12	0	7	22
Zelandobius furcillatus	28	9	11	14	7	16
Acroperla spiniger	0	0	0	0	2	0
Acroperla trivacuata	0	0	9	9	15	1
Acroperla pupae	0	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	7	0
Zelandobius confusus	0	0	9	0	9	18
Zelandoperla decorata	38	4	14	6	33	40
Austroperla cyrene	1	0	14	7	0	7
Megaleptoperla grandis	0	0	0	0	0	0
Megalptoperla diminuta	1	0	0	0	4	8
Polycentopodidae sp.	0	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0	0
Neurochorema confusum	0	0	0	0	0	1
Olinga	8	0	16	30	0	1
Triplectides obsoleta/dolichos	0	0	0	0	0	0
Triplectides cephalotes	0	0	0	0	0	0
Pycnocentri funerea	0	0	0	0	1	0
Aoteapsyche	1	0	0	0	0	3
Orthopsyche	0	0	0	0	0	0
Hydrobosis (early instar)	1	2	0	6	0	1
Psilochorema mimicum	8	0	7	0	0	0
Psilochorema sp. A	0	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0	0
Hydrobosis parumbripennis	2	0	1	1	0	0
Oxyethira albiceps	0	0	0	0	0	0
Hydrobosis umbripennis	0	1	0	0	1	0
Paroxyethira	0	0	0	0	0	0
Beraeoptera roria	1	2	4	0	2	2
Hydrobosis clavigera	0	0	0	1	0	0
Hudsonema amabilis	0	0	0	0	0	0
Costachorema psaroptera	2	0	0	0	0	2
Costachorema xanthoptera	0	0	0	0	0	1
Costachorema callista	0	0	0	0	0	0
Costachorema brachyptera	0	0	0	0	0	0
Pycnocentrella eruensis	0	0	0	0	0	0
Helicopsyche	0	0	1	0	0	0

Species	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
Pycnocentrodes	2	3	2	3	0	0
Pycnocentrodes evecta	2	0	0	10	0	0
Psilochorema nemorale	0	2	3	0	0	1
Plectrocnemia maclachlani	0	0	0	0	0	0
Polyplectropus	0	0	0	0	0	0
Alloecentrella	0	0	0	0	0	0
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0	0
Trichopteran pupae 1	0	0	0	0	0	0
Trichopteran pupae 2	0	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0	0
Pycnocentria pupae	0	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	0	0
Hydraenidae orchymontia	1	0	1	1	0	0
Elmidae	67	20	87	26	3	6
Ptilodactylidae	0	0	0	0	0	0
Hydraenidae homalaena	0	0	0	0	0	0
Elmidae adult	0	0	0	0	0	0
Berosus sp.	0	0	0	0	0	0
Liodessus plicatus	0	0	0	0	0	0
Hydraenidae podaena	0	0	0	0	0	0
Potamopyrgus	2	0	1	0	0	0
Physa	0	0	0	0	0	0
Gyraulus	0	0	0	0	0	0
Copepod	0	0	0	0	0	0
Pisidium casertanum	0	0	0	0	0	0
Ostracod	0	0	0	0	0	0
Amphipod	1	0	0	1	0	0
Eriopterini sp.	1	3	0	4	0	0
Mischoderus	0	0	0	0	0	0
Molophilus	0	0	0	0	0	0
Empididae (A)	6	0	5	0	0	2
Thaumaleidae	0	0	0	0	0	0
Psychodidae	0	0	0	0	0	2
Aphrophila neozelandica	0	0	2	0	0	2
Aphrophila pupae	0	0	0	0	0	0
Austrosimulium tillyardianum	2	0	0	2	0	0
Austrosimulium pupae	0	0	0	0	0	0
Paralimnophila skusei	1	0	0	0	0	0
Neoscatella vitithorax	0	0	0	0	0	0
Nothodixa campbelli	0	0	0	0	0	0
Dipteran pupae 1	0	0	0	0	0	0
Pupae 1	0	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0	0
Chironomidae pupae	1	1	6	3	2	2
Sigara	0	0	0	0	0	0
Anisops wakefieldi	0	0	0	0	0	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	0	0	0	0	2	0
Medium Oligocheate	0	0	0	0	0	0

Species	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18
Large Oligocheate	0	0	0	0	0	0
Xanthocnemis	0	0	0	0	0	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	0	0	0
Hygraula nitens	0	0	0	0	0	0
Archichauliodes	1	0	5	1	0	3
Terrestrial	4	4	25	7	4	2
Orthocladiinae sp.	6	2	12	4	25	15
Chironominae sp.	1	0	10	0	0	2
Diamesinae sp.	0	0	0	0	1	1
Podonominae sp.	14	10	15	10	9	3
Tanypodinae sp.	1	0	0	0	0	0

Species	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24
Zephlebia versicolor	0	0	0	0	0	19
Nesameletus	0	4	2	0	1	0
Zephlebia borealis	0	0	0	0	0	2
Zephlebia dentata	18	1	0	0	1	21
Neozephlebia	0	9	9	4	0	96
Deleatidium	138	130	201	74	165	98
Coloburiscus	0	166	23	8	18	4
Acanthophlebia cruentata	0	0	0	0	0	4
Austroclima sepia	12	18	13	0	5	4
Oniscigaster distans	0	0	0	0	0	0
Stenoperla prasina	0	0	1	0	0	0
Spaniocerca	0	0	0	0	0	0
Zelandoperla agnetis	0	0	0	0	0	0
Zelandobius furcillatus	0	5	9	0	16	14
Acroperla spiniger	0	0	0	0	0	0
Acroperla trivacuata	0	0	0	0	0	0
Acroperla pupae	0	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	0	0
Zelandobius confusus	1	3	4	5	0	20
Zelandoperla decorata	0	6	1	0	5	0
Austroperla cyrene	0	0	0	0	0	0
Megaleptoperla grandis	0	0	0	0	0	0
Megalptoperla diminuta	0	0	0	0	1	0
Polycentopodidae sp.	0	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0	0
Neurochorema confusum	0	1	0	0	0	3
Olinga	0	39	69	24	7	0
Triplectides obsoleta/dolichos	9	4	4	0	0	0
Triplectides cephalotes	0	0	0	0	0	0
Pycnocentri funerea	0	0	1	0	0	0
Aoteapsyche	0	13	11	6	14	0
Orthopsyche	0	0	0	0	0	0
Hydrobosis (early instar)	2	0	3	1	0	3
Psilochorema mimicum	4	1	0	1	0	0
Psilochorema sp. A	2	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0	0
Hydrobosis parumbripennis	6	0	2	0	0	0
Oxyethira albiceps	0	0	0	0	0	0
Hydrobosis umbripennis	2	0	0	0	0	0
Paroxyethira	0	0	0	0	0	0
Beraeoptera roria	0	18	7	0	0	0
Hydrobosis clavigera	0	0	0	0	0	0
Hudsonema amabilis	0	1	0	0	0	0
Costachorema psaroptera	0	0	0	0	0	0
Costachorema xanthoptera	0	0	0	0	0	0
Costachorema callista	0	0	0	0	0	0
Costachorema brachyptera	0	0	0	0	0	0
Pycnocentrella eruensis	0	0	0	0	0	0
Helicopsyche	0	2	36	12	0	0

Species	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24
Pycnocentrodes	0	175	106	32	33	0
Pycnocentrodes evecta	0	2	13	0	1	0
Psilochorema nemorale	7	2	0	0	0	0
Plectrocnemia maclachlani	0	0	0	0	0	3
Polyplectropus	0	0	0	0	0	0
Alloecentrella	0	0	0	0	0	0
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0	3
Trichopteran pupae 1	0	0	0	0	0	0
Trichopteran pupae 2	0	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0	0
Pycnocentria pupae	0	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	0	0
Hydraenidae orchymontia	0	3	4	0	0	0
Elmidae	2	82	63	53	9	0
Ptilodactylidae	0	0	0	0	0	0
Hydraenidae homalaena	0	0	0	0	0	0
Elmidae adult	0	0	0	0	0	0
Berosus sp.	0	0	0	0	0	0
Liodessus plicatus	0	0	0	0	0	0
Hydraenidae podaena	0	0	0	0	0	0
Potamopyrgus	230	2	8	23	9	20
Physa	0	0	0	0	0	0
Gyraulus	0	0	0	0	0	0
Copepod	0	0	0	0	0	0
Pisidium casertanum	0	0	0	0	0	0
Ostracod	0	0	0	0	0	0
Amphipod	0	0	0	0	0	15
Eriopterini sp.	0	0	0	0	0	0
Mischoderus	2	0	0	0	0	0
Molophilus	1	0	0	0	0	0
Empididae (A)	0	1	1	0	0	0
Thaumaleidae	0	0	0	0	0	0
Psychodidae	0	0	0	0	0	0
Aphrophila neozelandica	0	10	6	0	5	0
Aphrophila pupae	0	0	0	0	0	0
Austrosimulium tillyardianum	7	1	0	0	0	18
Austrosimulium pupae	0	0	0	0	0	0
Paralimnophila skusei	0	0	0	0	0	0
Neoscatella vitithorax	0	0	0	0	0	0
Nothodixa campbelli	0	0	0	0	0	0
Dipteran pupae 1	0	0	0	0	0	0
Pupae 1	0	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0	0
Chironomidae pupae	7	0	1	1	0	1
Sigara	0	0	0	0	0	0
Anisops wakefieldi	0	0	0	0	0	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	0	0	2	0	0	1
Medium Oligocheate	5	0	0	0	0	1

Species	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24
Large Oligocheate	0	0	0	0	0	0
Xanthocnemis	0	0	0	0	0	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	0	0	0
Hygraula nitens	0	0	0	0	0	0
Archichauliodes	0	12	17	7	0	2
Terrestrial	2	2	0	0	1	6
Orthocladiinae sp.	21	1	1	5	0	2
Chironominae sp.	26	3	6	1	2	2
Diamesinae sp.	6	3	3	0	0	0
Podonominae sp.	41	0	9	7	4	3
Tanypodinae sp.	2	0	0	1	0	2

Species	Site 25	Site 26	Site 27	Site 28	Site 29	Site 30
Zephlebia versicolor	0	0	0	2	0	0
Nesameletus	0	0	9	0	0	7
Zephlebia borealis	0	0	0	0	0	0
Zephlebia dentata	2	12	0	9	0	0
Neozephlebia	4	33	0	8	0	2
Deleatidium	150	92	510	43	47	220
Coloburiscus	401	210	120	4	4	74
Acanthophlebia cruentata	0	0	1	0	0	0
Austroclima sepia	15	87	9	17	0	13
Oniscigaster distans	0	0	0	0	0	0
Stenoperla prasina	0	0	0	0	0	0
Spaniocerca	0	0	0	0	0	5
Zelandoperla agnetis	0	0	54	0	0	3
Zelandobius furcillatus	7	21	12	5	1	6
Acroperla spiniger	0	0	0	0	0	0
Acroperla trivacuata	4	23	1	12	0	26
Acroperla pupae	0	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	0	0
Zelandobius confusus	0	28	5	4	1	3
Zelandoperla decorata	1	2	14	0	0	3
Austroperla cyrene	0	0	15	0	0	0
Megaleptoperla grandis	0	0	5	0	0	0
Megalptoperla diminuta	0	0	0	0	0	0
Polycentopodidae sp.	0	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0	0
Neurochorema confusum	0	0	0	0	0	0
Olinga	36	21	22	1	1	1
Triplectides obsoleta/dolichos	1	0	0	0	0	0
Triplectides cephalotes	0	0	0	0	0	0
Pycnocentri funerea	0	0	0	0	0	0
Aoteapsyche	3	36	4	3	0	0
Orthopsyche	0	0	0	0	0	3
Hydrobosis (early instar)	0	2	2	4	0	3
Psilochorema mimicum	0	0	0	1	0	0
Psilochorema sp. A	0	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0	0
Hydrobosis parumbripennis	0	0	0	2	0	1
Oxyethira albiceps	0	0	0	0	0	0
Hydrobosis umbripennis	0	0	0	0	0	0
Paroxyethira	0	0	0	0	0	0
Beraeoptera roria	0	7	43	0	0	0
Hydrobosis clavigera	0	0	0	0	0	0
Hudsonema amabilis	0	4	0	1	0	0
Costachorema psaroptera	0	0	0	0	0	0
Costachorema xanthoptera	0	0	0	0	0	0
Costachorema callista	0	0	5	0	0	0
Costachorema brachyptera	0	0	0	0	0	1
Pycnocentrella eruensis	0	0	0	3	0	0
Helicopsyche	3	22	163	0	6	2

Species	Site 25	Site 26	Site 27	Site 28	Site 29	Site 30
Pycnocentrodes	7	308	0	46	2	0
Pycnocentrodes evecta	20	25	0	0	0	0
Psilochorema nemorale	0	0	0	1	0	0
Plectrocnemia maclachlani	0	0	0	0	0	0
Polyplectropus	0	0	0	0	0	0
Alloecentrella	0	0	0	0	0	0
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0	1
Trichopteran pupae 1	0	0	0	0	0	0
Trichopteran pupae 2	0	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0	0
Pycnocentria pupae	0	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	0	0
Hydraenidae orchymontia	8	3	4	0	1	6
Elmidae	52	54	0	7	12	4
Ptilodactylidae	0	4	0	0	0	1
Hydraenidae homalaena	0	0	0	0	0	0
Elmidae adult	0	0	0	0	0	0
Berosus sp.	0	0	0	0	0	0
Liodessus plicatus	0	0	0	0	0	0
Hydraenidae podaena	0	0	0	0	0	0
Potamopyrgus	3	34	1	5	0	4
Physa	0	0	0	0	0	0
Gyraulus	0	0	0	0	0	0
Copepod	0	0	0	0	0	0
Pisidium casertanum	0	0	0	0	0	0
Ostracod	0	0	0	0	0	2
Amphipod	0	0	0	0	0	0
Eriopterini sp.	0	0	0	0	0	0
Mischoderus	0	0	0	0	0	0
Molophilus	0	0	0	1	0	1
Empididae (A)	0	1	0	0	0	1
Thaumaleidae	0	0	0	0	0	0
Psychodidae	0	0	0	0	0	0
Aphrophila neozelandica	2	52	1	0	3	0
Aphrophila pupae	0	0	0	0	0	0
Austrosimulium tillyardianum	0	1	0	5	0	0
Austrosimulium pupae	0	0	0	0	0	0
Paralimnophila skusei	0	0	0	1	0	0
Neoscatella vitithorax	0	0	0	0	1	0
Nothodixa campbelli	0	0	0	0	0	3
Dipteran pupae 1	0	0	0	0	0	0
Pupae 1	0	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0	0
Chironomidae pupae	3	5	2	5	4	3
Sigara	0	0	0	0	0	0
Anisops wakefieldi	0	0	0	0	0	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	0	0	0	0	0	0
Medium Oligocheate	0	0	0	0	0	0

Species	Site 25	Site 26	Site 27	Site 28	Site 29	Site 30
Large Oligocheate	0	0	0	0	0	0
Xanthocnemis	0	0	0	0	0	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	0	0	0
Hygraula nitens	0	0	0	0	0	0
Archichauliodes	6	22	4	2	0	8
Terrestrial	6	7	2	3	7	10
Orthocladiinae sp.	2	2	36	59	20	12
Chironominae sp.	1	1	5	2	4	2
Diamesinae sp.	0	1	0	0	0	1
Podonominae sp.	0	11	8	1	4	7
Tanypodinae sp.	0	0	0	0	1	7

Species	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
Zephlebia versicolor	0	0	0	0	0	0
Nesameletus	0	0	5	28	1	12
Zephlebia borealis	0	0	0	0	0	0
Zephlebia dentata	0	2	0	0	0	1
Neozephlebia	6	4	1	0	2	3
Deleatidium	36	387	183	576	730	112
Coloburiscus	34	189	82	21	35	18
Acanthophlebia cruentata	0	1	0	0	0	0
Austroclima sepia	9	3	0	0	0	5
Oniscigaster distans	0	0	0	0	0	2
Stenoperla prasina	0	2	1	3	3	11
Spaniocerca	0	0	0	0	0	0
Zelandoperla agnetis	0	13	5	9	17	0
Zelandobius furcillatus	0	4	2	5	8	0
Acroperla spiniger	0	0	0	0	0	0
Acroperla trivacuata	4	8	8	0	1	2
Acroperla pupae	0	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	0	0
Zelandobius confusus	0	0	0	8	13	31
Zelandoperla decorata	2	118	27	13	23	1
Austroperla cyrene	0	0	0	14	20	2
Megaleptoperla grandis	0	0	0	0	1	1
Megalptoperla diminuta	0	0	0	18	3	0
Polycentopodidae sp.	0	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0	0
Neurochorema confusum	0	0	1	0	0	1
Olinga	44	65	34	19	41	0
Triplectides obsoleta/dolichos	1	0	0	0	0	0
Triplectides cephalotes	0	0	0	0	0	1
Pycnocentri funerea	0	0	0	0	0	0
Aoteapsyche	11	9	13	2	6	3
Orthopsyche	0	0	0	9	0	0
Hydrobosis (early instar)	5	2	0	5	3	0
Psilochorema mimicum	0	0	0	0	0	0
Psilochorema sp. A	0	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0	0
Hydrobosis parumbripennis	3	0	0	0	3	0
Oxyethira albiceps	0	0	0	0	0	0
Hydrobosis umbripennis	2	0	0	0	0	0
Paroxyethira	0	0	0	0	0	0
Beraeoptera roria	0	11	78	67	35	0
Hydrobosis clavigera	0	2	0	0	0	0
Hudsonema amabilis	3	0	1	0	0	0
Costachorema psaroptera	0	0	0	1	0	0
Costachorema xanthoptera	0	0	0	0	0	0
Costachorema callista	0	0	0	0	0	0
Costachorema brachyptera	0	0	0	0	0	0
Pycnocentrella eruensis	2	0	0	0	0	8
Helicopsyche	9	126	49	1	17	10

Species	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
Pycnocentrodes	135	15	60	0	3	0
Pycnocentrodes evecta	0	0	0	0	0	0
Psilochorema nemorale	1	3	0	2	2	3
Plectrocnemia maclachlani	0	0	0	0	0	0
Polyplectropus	0	0	0	0	0	0
Alloecentrella	0	0	0	0	0	1
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	3	5	4
Trichopteran pupae 1	0	0	0	0	0	0
Trichopteran pupae 2	0	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0	0
Pycnocentria pupae	0	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	0	0
Hydraenidae orchymontia	2	4	6	13	50	13
Elmidae	67	31	48	22	17	5
Ptilodactylidae	1	0	0	0	0	4
Hydraenidae homalaena	0	0	0	0	2	0
Elmidae adult	0	0	0	0	0	0
Berosus sp.	0	0	0	0	0	0
Liodessus plicatus	0	0	0	0	0	0
Hydraenidae podaena	0	0	0	1	18	2
Potamopyrgus	9	0	1	1	2	0
Physa	0	0	0	0	0	0
Gyraulus	0	0	0	0	0	0
Copepod	0	0	0	0	0	0
Pisidium casertanum	0	0	0	0	0	0
Ostracod	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0
Eriopterini sp.	0	0	3	1	1	0
Mischoderus	0	0	0	0	0	0
Molophilus	8	0	0	0	0	0
Empididae (A)	0	2	0	1	3	0
Thaumaleidae	0	0	0	0	0	0
Psychodidae	1	0	0	0	0	0
Aphrophila neozelandica	9	14	16	9	2	0
Aphrophila pupae	0	0	0	0	0	0
Austrosimulium tillyardianum	0	0	1	0	0	0
Austrosimulium pupae	0	0	0	0	0	0
Paralimnophila skusei	0	0	0	0	0	1
Neoscatella vitithorax	0	0	0	0	0	0
Nothodixa campbelli	0	0	0	0	0	0
Dipteran pupae 1	0	0	0	0	0	0
Pupae 1	0	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	1	0
Chironomidae pupae	93	0	1	4	1	1
Sigara	0	0	0	0	0	0
Anisops wakefieldi	0	0	0	0	0	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	0	0	0	0	0	0
Medium Oligocheate	2	0	0	0	0	0

Species	Site 31	Site 32	Site 33	Site 34	Site 35	Site 36
Large Oligocheate	0	0	0	0	0	0
Xanthocnemis	0	0	0	0	0	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	1	0	0
Hygraula nitens	0	0	0	0	1	0
Archichauliodes	10	1	9	0	5	0
Terrestrial	9	25	0	3	5	2
Orthocladiinae sp.	295	1	14	7	1	1
Chironominae sp.	119	4	1	15	3	2
Diamesinae sp.	446	0	0	2	0	0
Podonominae sp.	856	0	2	31	33	39
Tanypodinae sp.	3	0	1	0	0	0

Species	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42
Zephlebia versicolor	0	0	0	0	0	0
Nesameletus	0	0	0	0	0	0
Zephlebia borealis	0	0	0	0	0	0
Zephlebia dentata	0	0	0	0	0	0
Neozephlebia	0	0	0	0	0	0
Deleatidium	485	55	179	40	0	162
Coloburiscus	1	0	0	0	0	2
Acanthophlebia cruentata	0	0	1	0	0	0
Austroclima sepia	5	8	4	3	0	2
Oniscigaster distans	0	0	0	0	0	0
Stenoperla prasina	0	0	0	0	0	0
Spaniocerca	0	0	0	0	0	0
Zelandoperla agnetis	0	0	0	0	0	0
Zelandobius furcillatus	0	0	0	0	0	0
Acroperla spiniger	0	0	0	0	0	0
Acroperla trivacuata	0	0	1	7	0	3
Acroperla pupae	0	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	0	0
Zelandobius confusus	0	0	0	0	0	0
Zelandoperla decorata	0	0	0	0	0	0
Austroperla cyrene	0	0	0	0	0	0
Megaleptoperla grandis	0	0	0	0	0	0
Megalptoperla diminuta	0	0	0	0	0	0
Polycentopodidae sp.	0	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0	0
Neurochorema confusum	0	0	0	0	0	0
Olinga	0	0	0	0	0	0
Triplectides obsoleta/dolichos	0	0	0	0	0	0
Triplectides cephalotes	0	0	0	0	0	0
Pycnocentri funerea	0	0	0	0	0	0
Aoteapsyche	3	0	2	1	0	0
Orthopsyche	0	0	0	0	0	0
Hydrobosis (early instar)	1	1	2	5	0	0
Psilochorema mimicum	0	0	0	0	0	0
Psilochorema sp. A	0	0	0	0	0	0
Psilochorema bidens	0	0	2	0	0	0
Hydrobosis parumbripennis	0	1	0	2	0	0
Oxyethira albiceps	0	0	0	0	957	0
Hydrobosis umbripennis	0	1	0	3	2	0
Paroxyethira	0	0	0	0	0	0
Beraeoptera roria	0	0	0	0	0	0
Hydrobosis clavigera	1	0	0	0	0	0
Hudsonema amabilis	0	0	0	0	0	0
Costachorema psaroptera	0	0	0	0	0	0
Costachorema xanthoptera	0	0	0	0	0	0
Costachorema callista	0	2	0	0	0	0
Costachorema brachyptera	0	0	0	0	0	0
Pycnocentrella eruensis	0	0	0	0	0	0
Helicopsyche	0	0	0	0	0	0

Species	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42
Pycnocentrodes	0	0	0	0	0	0
Pycnocentrodes evecta	0	0	0	0	0	0
Psilochorema nemorale	0	0	0	1	4	0
Plectrocnemia maclachlani	0	0	0	0	0	0
Polyplectropus	0	0	0	0	0	0
Alloecentrella	0	0	0	0	0	0
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0	0
Trichopteran pupae 1	0	0	4	2	0	0
Trichopteran pupae 2	0	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0	0
Pycnocentria pupae	0	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	7	0
Hydraenidae orchymontia	0	0	0	0	0	0
Elmidae	374	296	259	355	0	104
Ptilodactylidae	0	0	0	0	0	0
Hydraenidae homalaena	0	0	0	0	0	0
Elmidae adult	1	3	0	21	2	18
Berosus sp.	0	0	3	0	0	0
Liodessus plicatus	0	0	0	0	0	0
Hydraenidae podaena	0	0	0	0	0	0
Potamopyrgus	2	1	1	1	160	0
Physa	0	0	0	0	88	0
Gyraulus	0	0	0	0	36	0
Copepod	0	0	0	0	26	0
Pisidium casertanum	0	0	0	0	1	0
Ostracod	0	0	0	0	0	0
Amphipod	0	0	0	0	0	0
Eriopterini sp.	0	0	0	0	0	1
Mischoderus	0	0	0	0	0	0
Molophilus	0	0	1	0	0	0
Empididae (A)	0	1	0	0	0	0
Thaumaleidae	0	0	0	0	0	0
Psychodidae	0	0	0	0	0	0
Aphrophila neozelandica	0	2	0	1	2	3
Aphrophila pupae	0	0	0	0	0	0
Austrosimulium tillyardianum	1	2	1	9	175	0
Austrosimulium pupae	0	0	0	0	30	0
Paralimnophila skusei	0	0	0	0	0	0
Neoscatella vitithorax	0	0	0	0	0	0
Nothodixa campbelli	0	0	0	0	0	0
Dipteran pupae 1	0	0	0	0	0	0
Pupae 1	0	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0	0
Chironomidae pupae	0	1	0	2	12	2
Sigara	0	0	0	0	6	0
Anisops wakefieldi	0	0	0	0	15	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	1	0	1	3	35	0
Medium Oligocheate	0	4	0	0	0	0

Species	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42
Large Oligocheate	0	0	3	0	0	0
Xanthocnemis	0	0	0	0	4	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	0	0	0
Hygraula nitens	0	1	0	1	0	0
Archichauliodes	2	0	9	1	0	1
Terrestrial	4	4	9	6	36	3
Orthocladiinae sp.	0	26	0	1	215	0
Chironominae sp.	0	17	1	0	91	6
Diamesinae sp.	6	0	0	175	0	0
Podonominae sp.	17	78	23	149	11	5
Tanypodinae sp.	0	0	0	0	66	0

Species	Site 43	Site 45	Site 46	Site 47	Site 48	Site 49
Zephlebia versicolor	0	0	0	0	1	1
Nesameletus	0	0	0	0	0	0
Zephlebia borealis	0	0	0	0	0	0
Zephlebia dentata	0	0	0	0	0	4
Neozephlebia	0	0	0	0	0	2
Deleatidium	58	27	70	186	0	13
Coloburiscus	0	1	10	4	0	1
Acanthophlebia cruentata	0	0	0	0	0	0
Austroclima sepia	0	2	0	3	0	0
Oniscigaster distans	0	0	0	0	0	0
Stenoperla prasina	0	0	0	0	0	0
Spaniocerca	0	0	0	0	0	0
Zelandoperla agnetis	0	0	0	5	1	0
Zelandobius furcillatus	0	0	0	0	0	0
Acroperla spiniger	0	0	0	0	0	0
Acroperla trivacuata	1	2	2	4	0	10
Acroperla pupae	0	0	0	0	0	1
Zelandoperla fenestrata	0	0	0	0	0	0
Zelandobius confusus	1	0	0	1	0	0
Zelandoperla decorata	0	0	0	0	0	0
Austroperla cyrene	0	0	0	0	0	0
Megaleptoperla grandis	0	0	0	0	0	0
Megalptoperla diminuta	0	0	0	0	0	0
Polycentopodidae sp.	0	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0	0
Neurochorema confusum	0	0	0	0	0	0
Olinga	0	0	0	0	0	4
Triplectides obsoleta/dolichos	0	0	0	0	1	0
Triplectides cephalotes	0	0	0	0	0	0
Pycnocentri funerea	0	0	0	0	0	0
Aoteapsyche	0	7	0	0	0	0
Orthopsyche	0	0	0	0	0	16
Hydrobosis (early instar)	2	11	15	2	0	1
Psilochorema mimicum	0	0	0	0	0	0
Psilochorema sp. A	0	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0	0
Hydrobosis parumbripennis	0	4	3	0	0	0
Oxyethira albiceps	0	24	0	0	0	31
Hydrobosis umbripennis	0	0	0	0	0	1
Paroxyethira	0	0	0	0	0	0
Beraeoptera roria	0	0	0	0	0	0
Hydrobosis clavigera	0	0	0	0	0	0
Hudsonema amabilis	0	3	0	0	0	0
Costachorema psaroptera	0	0	0	0	0	0
Costachorema xanthoptera	0	0	0	0	0	0
Costachorema callista	0	0	0	0	0	1
Costachorema brachyptera	0	0	0	0	0	0
Pycnocentrella eruensis	0	0	0	0	0	0
Helicopsyche	0	0	0	0	0	0

Species	Site 43	Site 45	Site 46	Site 47	Site 48	Site 49
Pycnocentrodes	0	0	0	0	0	0
Pycnocentrodes evecta	0	0	0	0	0	0
Psilochorema nemorale	0	1	0	0	0	0
Plectrocnemia maclachlani	0	0	0	0	0	0
Polyplectropus	0	0	0	0	0	0
Alloecentrella	0	0	0	0	0	0
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0	0
Trichopteran pupae 1	0	0	0	0	0	0
Trichopteran pupae 2	0	1	0	0	0	0
Trichopteran pupae 3	0	1	0	0	0	0
Pycnocentria pupae	0	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	0	0
Hydraenidae orchymontia	0	0	0	0	0	1
Elmidae	102	132	24	37	0	88
Ptilodactylidae	0	0	0	0	0	0
Hydraenidae homalaena	0	0	0	0	0	0
Elmidae adult	29	2	3	16	0	13
Berosus sp.	0	0	0	0	0	1
Liodessus plicatus	0	0	0	0	0	1
Hydraenidae podaena	0	0	0	0	0	0
Potamopyrgus	1	4	1	0	9	64
Physa	0	0	0	0	0	0
Gyraulus	0	0	0	0	0	0
Copepod	0	0	0	0	1	0
Pisidium casertanum	0	0	0	0	0	0
Ostracod	0	0	0	0	0	0
Amphipod	0	0	1	0	88	0
Eriopterini sp.	1	0	1	1	0	0
Mischoderus	0	0	0	0	0	0
Molophilus	0	0	0	0	0	0
Empididae (A)	0	0	0	0	0	0
Thaumaleidae	0	0	1	0	0	2
Psychodidae	0	0	1	1	0	2
Aphrophila neozelandica	1	77	4	1	0	3
Aphrophila pupae	0	0	0	0	0	0
Austrosimulium tillyardianum	0	13	0	1	10	32
Austrosimulium pupae	0	0	0	0	0	14
Paralimnophila skusei	0	0	0	0	1	0
Neoscatella vitithorax	0	0	0	0	0	0
Nothodixa campbelli	0	0	0	0	0	0
Dipteran pupae 1	0	2	0	0	0	0
Pupae 1	0	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0	0
Chironomidae pupae	1	19	6	0	0	37
Sigara	0	0	0	0	0	0
Anisops wakefieldi	0	0	0	0	0	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	0	2	0	0	13	5
Medium Oligocheate	0	0	0	0	0	2

Species	Site 43	Site 45	Site 46	Site 47	Site 48	Site 49
Large Oligocheate	0	0	0	0	0	0
Xanthocnemis	0	0	0	0	1	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	0	0	0
Hygraula nitens	0	0	0	0	0	0
Archichauliodes	0	14	2	1	0	12
Terrestrial	12	12	8	49	6	21
Orthocladiinae sp.	5	22	4	6	0	89
Chironominae sp.	6	21	2	0	3	18
Diamesinae sp.	85	110	25	0	0	63
Podonominae sp.	75	93	78	1	1	113
Tanypodinae sp.	0	0	6	0	0	0

Species	Site 50	Site 51	Site 52	Site 53	Site 54	Site 55
Zephlebia versicolor	3	0	6	0	0	0
Nesameletus	0	1	0	0	0	1
Zephlebia borealis	0	0	0	0	0	0
Zephlebia dentata	0	77	0	0	0	0
Neozephlebia	0	0	0	0	0	0
Deleatidium	0	317	0	348	174	486
Coloburiscus	0	49	0	0	0	52
Acanthophlebia cruentata	0	0	0	0	2	3
Austroclima sepia	0	5	0	0	0	0
Oniscigaster distans	0	0	0	0	0	0
Stenoperla prasina	0	0	0	0	3	3
Spaniocerca	0	0	0	0	0	0
Zelandoperla agnetis	0	8	0	0	0	0
Zelandobius furcillatus	0	0	0	0	0	0
Acroperla spiniger	0	0	0	0	0	0
Acroperla trivacuata	0	23	0	0	0	0
Acroperla pupae	0	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	0	0
Zelandobius confusus	0	1	0	0	0	0
Zelandoperla decorata	0	13	0	0	0	0
Austroperla cyrene	0	0	0	0	0	0
Megaleptoperla grandis	0	0	0	0	0	0
Megalptoperla diminuta	0	0	0	1	3	2
Polycentopodidae sp.	0	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0	0
Neurochorema confusum	0	0	0	1	1	0
Olinga	0	31	0	1	87	87
Triplectides obsoleta/dolichos	0	0	2	0	0	0
Triplectides cephalotes	0	0	0	0	0	0
Pycnocentri funerea	0	0	0	0	0	0
Aoteapsyche	0	0	0	0	0	3
Orthopsyche	0	3	0	0	0	0
Hydrobosis (early instar)	9	6	8	0	20	8
Psilochorema mimicum	0	0	0	0	0	0
Psilochorema sp. A	0	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0	0
Hydrobosis parumbripennis	0	2	0	2	5	0
Oxyethira albiceps	1	0	151	0	0	0
Hydrobosis umbripennis	3	0	0	0	0	0
Paroxyethira	0	0	0	0	0	0
Beraeoptera roria	0	0	0	0	0	0
Hydrobosis clavigera	0	0	0	0	0	2
Hudsonema amabilis	0	0	1	0	0	0
Costachorema psaroptera	0	0	0	0	0	0
Costachorema xanthoptera	0	0	0	0	0	0
Costachorema callista	0	0	0	0	0	0
Costachorema brachyptera	0	0	0	0	0	0
Pycnocentrella eruensis	0	0	0	0	0	0
Helicopsyche	0	9	0	0	5	12

Species	Site 50	Site 51	Site 52	Site 53	Site 54	Site 55
Pycnocentrodes	0	59	0	0	0	3
Pycnocentrodes evecta	0	0	0	0	0	0
Psilochorema nemorale	0	1	0	0	0	0
Plectrocnemia maclachlani	0	0	0	0	0	0
Polyplectropus	0	0	0	0	1	0
Alloecentrella	0	0	0	0	0	0
Polycentropodidae sp.	0	0	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0	0
Trichopteran pupae 1	9	1	0	0	0	0
Trichopteran pupae 2	0	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0	0
Pycnocentria pupae	0	5	0	0	0	0
Rhantus pulverosus	0	0	0	0	0	0
Hydraenidae orchymontia	0	3	0	0	19	27
Elmidae	1	2	226	89	66	85
Ptilodactylidae	0	0	0	0	0	1
Hydraenidae homalaena	0	0	0	0	3	2
Elmidae adult	0	1	46	0	35	8
Berosus sp.	0	0	1	0	0	0
Liodessus plicatus	2	0	0	0	0	0
Hydraenidae podaena	0	0	0	0	0	0
Potamopyrgus	62	4	0	0	0	0
Physa	5	0	0	0	0	0
Gyraulus	0	0	0	0	0	0
Copepod	0	0	0	0	0	0
Pisidium casertanum	22	0	0	0	0	0
Ostracod	0	0	0	0	0	0
Amphipod	12	0	0	0	0	0
Eriopterini sp.	0	2	0	1	2	2
Mischoderus	0	0	0	0	0	0
Molophilus	0	0	0	0	0	0
Empididae (A)	0	0	0	0	0	0
Thaumaleidae	0	0	0	0	0	0
Psychodidae	1	0	0	0	1	0
Aphrophila neozelandica	3	11	1	6	2	5
Aphrophila pupae	0	0	0	1	0	0
Austrosimulium tillyardianum	10	8	21	0	8	2
Austrosimulium pupae	0	0	2	0	1	0
Paralimnophila skusei	0	0	0	0	0	0
Neoscatella vitithorax	0	0	0	0	0	0
Nothodixa campbelli	2	0	0	0	0	0
Dipteran pupae 1	0	0	0	0	0	0
Pupae 1	0	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0	0
Chironomidae pupae	0	0	98	0	6	2
Sigara	50	0	0	0	0	0
Anisops wakefieldi	1	0	0	0	0	0
Mniovelia kuscheli	0	0	0	0	0	0
Small Oligocheate	0	0	5	0	0	0
Medium Oligocheate	0	1	1	0	0	0

Species	Site 50	Site 51	Site 52	Site 53	Site 54	Site 55
Large Oligocheate	0	0	0	0	0	0
Xanthocnemis	0	0	0	0	0	0
Xanthocnemis pupae	0	0	0	0	0	0
Kempynus sp.	0	0	0	0	0	0
Hygraula nitens	0	0	0	0	0	0
Archichauliodes	1	6	0	0	3	8
Terrestrial	18	5	8	6	14	2
Orthocladiinae sp.	9	12	68	2	35	70
Chironominae sp.	13	2	29	0	5	1
Diamesinae sp.	2	0	79	0	51	45
Podonominae sp.	4	5	542	1	37	2
Tanypodinae sp.	0	0	0	0	0	0

Species	Site 56	Site 57	Site 58	Site 59	Site 60
Zephlebia versicolor	0	0	0	0	5
Nesameletus	0	0	1	0	0
Zephlebia borealis	0	0	0	0	0
Zephlebia dentata	0	0	0	3	0
Neozephlebia	0	0	0	0	0
Deleatidium	224	274	293	165	0
Coloburiscus	2	0	0	1	7
Acanthophlebia cruentata	1	0	2	0	0
Austroclima sepia	0	0	0	0	0
Oniscigaster distans	0	0	0	0	0
Stenoperla prasina	6	3	0	0	0
Spaniocerca	0	0	0	0	0
Zelandoperla agnetis	0	1	0	0	0
Zelandobius furcillatus	0	0	0	0	0
Acroperla spiniger	0	0	2	0	0
Acroperla trivacuata	0	0	0	1	0
Acroperla pupae	0	0	0	0	0
Zelandoperla fenestrata	0	0	0	0	0
Zelandobius confusus	0	0	4	0	0
Zelandoperla decorata	1	0	0	2	0
Austroperla cyrene	3	0	0	1	0
Megaleptoperla grandis	0	0	0	0	1
Megalptoperla diminuta	3	10	5	1	0
Polycentopodidae sp.	0	0	0	0	0
Hydrobiosidae larvae	0	0	0	0	0
Neurochorema confusum	0	1	0	1	0
Olinga	54	1	0	6	0
Triplectides obsoleta/dolichos	0	0	0	0	2
Triplectides cephalotes	0	0	0	0	0
Pycnocentri funerea	0	0	0	0	0
Aoteapsyche	0	0	0	0	0
Orthopsyche	0	0	0	0	0
Hydrobosis (early instar)	2	0	4	0	6
Psilochorema mimicum	0	0	0	0	0
Psilochorema sp. A	0	0	0	0	0
Psilochorema bidens	0	0	0	0	0
Hydrobosis parumbripennis	0	1	0	0	1
Oxyethira albiceps	0	0	0	0	0
Hydrobosis umbripennis	0	0	0	0	0
Paroxyethira	0	0	0	0	0
Beraeoptera roria	0	0	0	0	0
Hydrobosis clavigera	0	0	0	0	0
Hudsonema amabilis	0	0	0	0	0
Costachorema psaroptera	0	0	0	0	0
Costachorema xanthoptera	0	0	0	0	0
Costachorema callista	1	2	0	0	0
Costachorema brachyptera	0	0	0	0	0
Pycnocentrella eruensis	0	0	0	0	0
Helicopsyche	0	0	0	0	0

Species	Site 56	Site 57	Site 58	Site 59	Site 60
Pycnocentrodes	0	0	0	0	0
Pycnocentrodes evecta	0	0	0	0	0
Psilochorema nemorale	0	0	0	0	1
Plectrocnemia maclachlani	0	0	1	0	0
Polyplectropus	0	0	0	0	0
Alloecentrella	0	0	0	0	0
Polycentropodidae sp.	1	0	0	0	0
Hydrobiosella mixta	0	0	0	0	0
Trichopteran pupae 1	0	0	0	0	1
Trichopteran pupae 2	0	0	0	0	0
Trichopteran pupae 3	0	0	0	0	0
Pycnocentria pupae	0	0	0	0	0
Rhantus pulverosus	0	0	0	0	0
Hydraenidae orchymontia	12	2	0	1	0
Elmidae	32	12	3	1	3
Ptilodactylidae	0	0	0	0	0
Hydraenidae homalaena	0	0	0	0	0
Elmidae adult	7	0	3	0	30
Berosus sp.	0	0	0	0	0
Liodessus plicatus	0	0	0	0	0
Hydraenidae podaena	2	0	1	0	0
Potamopyrgus	0	0	0	0	33
Physa	0	0	0	0	2
Gyraulus	0	0	0	0	0
Copepod	0	0	0	0	0
Pisidium casertanum	0	0	0	0	0
Ostracod	0	0	0	0	0
Amphipod	0	0	0	0	0
Eriopterini sp.	0	0	0	0	0
Mischoderus	0	0	0	0	0
Molophilus	0	0	0	0	0
Empididae (A)	0	0	0	0	0
Thaumaleidae	0	0	0	0	0
Psychodidae	0	0	1	0	0
Aphrophila neozelandica	4	2	12	6	0
Aphrophila pupae	0	0	0	0	0
Austrosimulium tillyardianum	0	0	0	0	19
Austrosimulium pupae	0	0	0	0	0
Paralimnophila skusei	0	0	0	0	0
Neoscatella vitithorax	0	0	0	0	0
Nothodixa campbelli	0	0	0	0	0
Dipteran pupae 1	0	0	0	0	0
Pupae 1	0	0	0	0	0
Neocurupira hudsoni	0	0	0	0	0
Chironomidae pupae	0	0	0	0	5
Sigara	0	0	0	0	0
Anisops wakefieldi	0	0	0	0	0
Mniovelia kuscheli	0	0	0	0	0
Small Oligocheate	0	0	0	0	11
Medium Oligocheate	0	0	0	0	0

Species	Site 56	Site 57	Site 58	Site 59	Site 60
Large Oligocheate	0	0	0	0	0
Xanthocnemis	0	0	0	0	0
Xanthocnemis pupae	0	0	0	0	0
Kempynus sp.	0	0	0	0	0
Hygraula nitens	0	0	0	0	0
Archichauliodes	6	0	0	2	0
Terrestrial	1	10	16	0	4
Orthocladiinae sp.	7	7	15	29	6
Chironominae sp.	1	0	0	1	1
Diamesinae sp.	0	0	2	10	7
Podonominae sp.	6	1	0	7	209
Tanypodinae sp.	0	0	3	0	0