



Small Stream Modification in Taranaki

An assessment of the ecological and hydrological values of small streams, the cumulative extent and ecological effects of modification, and implications for policy and practice.

Small Stream Modification in Taranaki

An assessment of the ecological and hydrological values of small streams, the cumulative extent and ecological effects of modification, and implications for policy and practice

Taranaki Regional Council
Private Bag 713
Stratford

April 2010

#537059

Executive summary

Taranaki has a very dense drainage network, the natural consequence of its frequent and plentiful rainfall and of gravity's effects upon water driving it downhill to the sea. Stream flows become the habitat of freshwater ecology and gain value for their in-stream uses and benefits. In Taranaki as in other parts of New Zealand, land clearance and associated drainage have been an essential part of land development and utilisation. Drainage has been encouraged as a means of extending pastoralism and improving farm productivity and profitability. The Taranaki Regional Council and the regional community has recognised the positive consequences of land drainage, and that in some circumstances new or significantly modified or improved drainage may be appropriate. However, the Council and community also recognise that land drainage may result in adverse effects upon the environment or on other users and uses of freshwater, and these effects should be avoided, remedied or mitigated. The *Regional Freshwater Plan for Taranaki (2001)* contains a suite of policies, objectives, and methods of implementation around land drainage and stream diversion. As pressures and activities develop and change it is important to ensure that existing policies and methods remain appropriate and adequate to address existing and emerging issues.

Small streams (first or second order streams that comprise the headwaters and upper reaches of catchments) make up 75% of all streams in Taranaki, and are a significant component of the Taranaki landscape. Of the nearly 20,000 km of streams in Taranaki, 11,500 km drain the ring plain where the most intensive farming (and therefore greatest pressure in terms of stream modification) occurs in the region. On average there are nearly 6 km of stream per dairy farm, many of which are small in size, and subject to considerable modification, in particular stream realignment and piping for land improvement purposes.

Anecdotal evidence and observations by Council staff, as well as an increase in the number of resource consent applications received by the Council for stream modification work, has indicated an increase in the rate of stream modification in recent years, certainly since consideration and adoption of the RFWP in 2001. Therefore, the purpose of this report has been to quantify the extent and effects of land drainage and stream modification, specifically through the piping or realignment of streams, in light of the Council's current policies relating to both stream modification and the instream values of small streams, to ascertain whether there is any need to review the existing provisions for the management of land uses.

Intact small streams provide habitat for rare and diverse stream-life and perform hydrologic functions such as the provision of natural flood attenuation, the buffering of summer low-flows and the recharging of groundwater. The riparian zone of such streams (and the stream channel itself) provides important functions such as trapping sediments, recycling nutrients and filtering pollution from fertilisers and animal waste. Analysis of relevant literature, and the fish and macroinvertebrate data available on the Councils database, indicate that in Taranaki, small streams provide important fish habitat, and higher altitude small streams that are mountain fed, support a particularly high diversity of macroinvertebrates.

When small streams are modified, the diversity of habitat for stream life is often lost, meanders and riparian vegetation are often removed, barriers to fish passage created, with an associated loss of upstream habitat to migrating fish, and the natural flood control functions and capacity of the catchment are diminished.

Establishing the extent of stream modification in Taranaki was considered key to determining if stream modification was becoming a significant issue (in terms of loss of small streams). Since 1995, the Council issued 267 consents for stream modifications including piping, culverting, stream diversions and realignments, involving 43.6 km of stream. During

the period 2006-2008 consent application rates for stream modification work almost doubled, confirming that particularly piping streams for land improvement purposes has become increasingly popular. This could reflect the relative 'boom' period that the dairy industry was experiencing at this time, with increased money available to invest in land intensification; as well as the increased presence of Council officers throughout the region, promoting riparian planting and advice on resource consent requirements for stream modification work.

In addition to consented stream modification, permitted and historical (pre RFWP) modification was also investigated. The extent of stream modification was calculated by comparing the two sets of aerial photographs for the Taranaki ring plain taken in 2001 and 2007. The results indicated a much higher rate of small stream modification than that indicated by records of consent applications, an estimated 96 km of small stream modifications (including some consented works) during this six year period alone were mapped (an increase of 15% compared to all modification conducted prior to 2001). Comparison of the mapped data with the consents database indicated that a significant amount of small stream modification may have been undertaken under the permitted activity rules, but a proportion of the works may also have been undertaken without the necessary consents.

Overall, 5.5% of the total stream length on the ring plain has been modified. Most of this modification is historical (particularly stream realignments), but piping streams for land improvement purposes is becoming more popular in recent years with most of this occurring in South Taranaki (nearly 1% of total stream length between 2001 and 2007). The increased rate (15% increase in six years) of piping streams (as opposed to realignment) is of particular concern as this results in a total loss of habitat. Therefore, on one hand, small streams comprise a vast network in the region, and even after some 170 years are still largely intact; on the other, the rate of modification has been increasing and as a region there has been little debate on acceptable rates and absolute limits to small stream modification, within catchments and from a regional perspective.

In terms of the proportion of their total stream length lost, the most affected catchments include many of the small unnamed coastal catchments in southern ring plain dairying areas, as well as the Mangatoromiro, Rawa, Ouwe, Mangati, Opuhi and Taikatu Streams (excluding the Mangati Stream, all located on the south-west ring plain between Pihama-Te Kiri and Otakeho-Awatuna). However, when the total distance is considered, the greatest modification occurred in larger catchments like the Kaupokonui, Waingongoro and Patea rivers.

The '*Regional Policy Statement for Taranaki*' and the '*Regional Freshwater Plan for Taranaki*' (RFWP) recognise the values of small streams, but also the positive effect of increasing the productivity of Taranaki's farmland through land drainage. Policies were reviewed in light of findings in this report and three key issues have emerged:

- While the values of all streams are recognised in policy documents, there is a lack of well targeted, comprehensive policies and procedures in relation to small streams and their modification.
- There has been a recent up-surge of stream modification. However, the question still remains as to whether this will be a long term trend, and therefore a new, emerging issue in Taranaki, which should be considered in the review of the RFWP in 2011.
- There is evidence that much of the stream modification undertaken since 2001 may have been illegal.

As a result of this project:

- Council staff have implemented improvements to the consents database, and administration that have resulted in better consistency and efficiency when processing consents relating to stream modification. Consideration of mitigation measures has been highlighted as a requirement of consents, to offset stream habitat loss.
- The Council's GIS system has had an 'extent' layer developed, and a 'stock-take' of stream modification was undertaken for the first time. This will provide a valuable resource for consents officers when assessing the cumulative effects of new applications.
- There are some procedures and information management systems that the Council has already improved.
- There are some deficiencies in current policy definitions and rules identified, and these can be addressed in the RFWP review.
- There are some policy decisions that need to be made and that the next two years should illuminate i.e. the Clean Streams Accord driver and the high dairy payout productivity driver.
- There needs to be further investigations undertaken prior to the RFWP review i.e. to determine effects of stream modification (in particular cumulative effects) and 'trigger levels' of acceptable modification in catchments, and quantifying the regional benefits of increased production capacity.

The limitations of this report in its scope and considerations should be noted. It has focused primarily on ecological and hydrological aspects of small streams. But the Resource Management Act requires a broader consideration, such as the added economic value of enhanced productivity for individual farmers and cumulatively for the region. This study has identified an acceleration in stream modification. It has not investigated in depth whether this is a new emerging long term trend, or a 'blip' driven by very specific and short term factors, and most likely to dissipate. Further work is needed within these and other areas, for the Council and the regional community to make fully informed and well considered decisions on policies, objectives and targets around small stream modification.

Table of contents

1.	Introduction	1
1.1	Background	1
1.2	The purpose of this report	2
1.3	Defining small streams	3
1.4	Defining small stream modification	4
1.5	The structure of this report	4
2.	Values of small streams	5
2.1	A review of the literature on values of small streams	5
2.1.1	Ecological and biodiversity values	5
2.1.2	Hydrological values	7
2.2	Ecological values of small streams in Taranaki	7
2.2.1	Macroinvertebrates	7
2.2.2	Fish	8
3.	Effects of stream modification	16
3.1	A review of literature on the effects of stream modification	16
3.2	Ecological effects of stream modification in Taranaki	19
3.2.1	The effects of stream straightening or realignment	19
3.2.2	The effects of stream piping	23
3.2.3	Climate change and the effects of small stream modification	27
3.2.4	Stream piping – a cost-benefit analysis	27
4.	Extent of stream modification	28
4.1	Consented stream modification	28
4.2	An assessment of the true extent of stream modification	32
4.2.1	Methods	32
4.2.2	Results	35
5.	Policy framework	44
5.1	Resource Management Act	44
5.2	Regional Policy Statement	44
5.3	Regional Fresh Water Plan	45
5.3.1	Stream definitions	45
5.3.2	Relevant objectives and policies	46
5.3.3	When consents are required for stream modification under the Fresh Water Plan	48
5.3.4	Addressing cumulative effects of stream modification	49
5.3.5	Mitigating loss of habitat	51
5.3.6	Summary	53
5.4	Approach undertaken by other councils	54
5.4.1	Stream definition	54
5.4.2	Permitted activities	54
5.4.3	Culverts	55
5.4.4	Land drainage	55
5.4.5	Stream realignments	56
5.4.6	Mitigation	56
6.	Council's response	58
6.1	Non-statutory methods	58
6.1.1	Sustainable land management programme	58

6.1.2	Development of a GIS method for recording ongoing small stream modification	58
6.1.3	Provision of information	59
6.1.4	The Dairying and Clean-Stream Accord	59
6.2	Statutory methods	60
6.2.1	Processing consents	60
6.2.2	Improvements to the consenting process	61
6.2.3	Compliance and enforcement	62
7.	Summary and conclusions	64
8.	Recommendations	67
9.	References	70

List of tables

Table 1	Results of electric fishing and spotlighting surveys carried out in the Mangahewa Stream	13
Table 2	Consented stream modification between 1995 and April 2009	29
Table 3	Summary of catchments with consented stream modification greater than 1 km (includes culverted, piped and realigned modification)	29
Table 4	Stream modifications detected through examination and comparison of 2001 and 2007 aerial photographs	35
Table 5	Stream modification expressed as a proportion of total stream length on the ring plain and in the larger two districts	35
Table 6	Permitted stream modification activities	54
Table 7	Types of modification to be recorded as a GIS shape file with their own distinguishable status to allow calculation of total lengths of stream lost in each category	59
Table 8	Range of stream sizes within each of the REC Network Position categories	75
Table 9	Number of macroinvertebrate samples from control sites within each of the stream width categories	76
Table 10	Number of macroinvertebrate samples from control sites within each stream width and riparian shade category	78
Table 11	Number of macroinvertebrate samples within each of the eco-regions for different stream widths	79
Table 12	Number of macroinvertebrate samples within each of the eco-regions and riparian shade groups for different stream widths	81
Table 13	Summary of fish survey results undertaken in Taranaki by the Taranaki Regional Council	87

List of figures

Figure 1	Number of consents issued for stream modification since 1995	31
Figure 2	Total stream length modified per year for consents issued for small stream modification since 1995	31
Figure 3	Three aerial views of the same location from the ArcView computer programme where three sections of stream have been piped between the 2001 photo (upper) and 2007 photo (middle). The lower photo shows the editable layer	33

Figure 4	Three views of the same location from ArcView showing the 2001 photo (top) and the 2007 photo (middle) with the edited stream layer overlaid (below) showing sections of stream that have been straightened and piped	34
Figure 5	Estimated stream length modified from aerial comparison survey, including pre 2001 modifications	36
Figure 6	Estimated stream length modified between 2001-2007 from aerial comparison survey	36
Figure 7	Estimated percentage of 1 st and 2 nd order stream length that was modified between 2001 and 2007. Catchments have been ranked and graph shows only those catchments with the greatest proportion of stream modification between these two dates	38
Figure 8	Mapped extent of stream modification in the Kaupokonui River catchment	39
Figure 9	Mapped extent of stream modification in the Taikatu Stream catchment	40
Figure 10	Mapped extent of stream modification in the Mangatoromiro Stream catchment	41
Figure 11	Mapped extent of stream modification in the Rawa Stream catchment	42
Figure 12	Mean number of taxa (left) and MCI values in streams of different width groupings. Error bars are 95% Confidence interval (CI)	76
Figure 13	Location of monitoring sites with macroinvertebrate data in relation to the REC stream order classes (Data source: TRC ESAM database)	77
Figure 14	Mean number of taxa (left) and MCI values in streams of different width groups and riparian shade. Error bars are 95% CI	78
Figure 15	Mean number of taxa (left) and MCI values in streams of different width groupings for different eco-regions. Error bars are 95% CI	80
Figure 16	Mean number of taxa (left) and MCI values for ring plain streams of different width, rising inside the National Park, with differing riparian vegetation. Error bars are 95% CI	81
Figure 17	Mean number of taxa (left) and MCI values for ring plain streams of different width, rising outside the National Park with differing riparian vegetation. Error bars are 95% CI	82
Figure 18	Mean number of taxa and MCI values for lowland coastal streams of different width, with differing riparian vegetation. Error bars are 95% CI	82
Figure 19	Location of monitoring sites with fish data in relation to the REC stream order classes	85
Figure 20	Number of species recorded in samples taken in small (<2 m), medium (2-8 m) and large (>8 m) width Taranaki streams	86

List of photos

Photo 1	Recontoured paddock after the realignment of the Mangawhero stream	1
Photo 2	A well designed culvert that will provide for fish passage	2
Photo 3	Inaha stream diversion	3
Photo 4	Examples of longfin eel community streams	9
Photo 5	Aerial photo showing contributing catchment to the Mangahewa tributary	10
Photo 6	Examples of shortfin eel community streams	10
Photo 7	Examples of typical banded kokopu community streams	11
Photo 8	Lake Rotokare tributary where banded kokopu were found in abundance	11
Photo 9	Examples of inanga community streams	12

Photo 10	Aerial photo showing the contributing catchment area which drains to the Mangahewa Stream site	13
Photo 11	Subsample of crayfish captured from unnamed tributary of Mangawhero Stream	14
Photo 12	Stream where crayfish were captured	14
Photo 13	Undercut bank, and the trout that was using it as cover (inset)	20
Photo 14	Part of the original channel, with a pool which had an undercut bank along the true right hand bank	21
Photo 15	The new channel, 17 months after the stream was diverted (13 May 2009)	21
Photo 16	New channel on 4 January 2008 (above) and 2 September 2008 (below)	22
Photo 17	Dead animals recovered from the original stream channel	22
Photo 18	Typical streams in Taranaki which are commonly piped for land improvement purposes	24
Photo 19	The headwaters of the Rawa Stream	24
Photo 20	Aerial photo of a piped stream upstream of the road and riparian planted section downstream	25
Photo 21	Piped stream at Westown Golf Course	26

1. Introduction

1.1 Background

Taranaki has a history of small stream modification with streams and wet areas being channelised and realigned to improve the drainage and hence the economic productivity of agricultural land. Similarly, the installation of culverts and drainage pipes in small tributaries is not a new issue. However, to date the effect and extent of these works on instream ecology has not been investigated in detail in Taranaki, nor has there been consideration of these changes in the context of the region's total network of small streams.

Structures such as piping (for land improvement) and farm dams continue to be installed in order to increase the effective land area or increase the certainty of water supply. There is anecdotal evidence to suggest that the piping of small streams in relation to land reclamation in some cases is undertaken to avoid fencing and planting riparian margins in order to meet the Dairying and Clean Streams Accord target of 90% of riparian plans to be implemented by 2015 (i.e. fenced and planted). This piping increases the effective land area which can have a measurable pay back (Photo 1).

The disappearance of these small headwater streams is made difficult to quantify due to the fact that these streams are often unnamed and do not appear on topographic maps. The extent of these small stream networks in Taranaki, is most accurately quantified based on the Land Management (LM) rivers GIS layer which is edited by Council's Land Management Officers through ground-proofing, in the process of developing riparian management plans for land owners.

In the past it has been considered that small streams on farm land have generally had relatively low ecological values, particularly where there is very little riparian vegetation. However, this has not really been quantified in a manner that considers all aspects of a stream's services and values (including aquatic ecology, hydrology, riparian vegetation and water quality). Furthermore, with increasing emphasis on biodiversity values, the loss of significant lengths of streams (i.e., the cumulative effects of many reaches of stream being piped and reclaimed) may have significant impacts on biodiversity values even when streams have been previously modified.



Photo 1 Recontoured paddock after the realignment of the Mangawhero Stream

In 2008 the Council prepared the *'Biodiversity Strategy: An operational strategy to guide biodiversity actions of the Taranaki Regional Council'*. This identified that one of the threats to freshwater biodiversity was habitat modification such as the drainage of wetlands or wet areas, or the channelising or piping of streams. It included several actions relating to this issue: one was the development of guidelines for applicants and consenting officers outlining information to be provided by the applicant when applying for a consent to undertake consent modification, the stakeholders to involve and matters to be considered in processing such applications. The second relevant action is the assessment of the cumulative effect of piping small streams and land drainage in relation to potential loss of freshwater biodiversity (this study).

Anecdotal evidence and observations by Council staff, as well as an increase in the number of resource consent applications received by the Council for stream modification work, has indicated an increase in the rate of stream modification in recent years. This has raised concerns that cumulative modification may be an emerging issue for Taranaki. There has been no way to determine the actual extent of modification to date. Therefore, the purpose of this report has been to quantify the extent and effects of land drainage and stream modification, specifically through the piping or realignment of streams, in light of the Council's policies relating to both stream modification and the instream values of small streams.

1.2 The purpose of this report

The four primary objectives of this study have been to assess:

- the values of small stream habitat in terms of biodiversity and other ecosystem services;
- the effects of stream modification on these values;
- the extent of the cumulative loss or modification of small streams in Taranaki; using data in the existing consents database and comparison of aerial photos; and
- relevant policy appropriateness and effectiveness in relation to the findings in the three points above.

It is important to note that this study does not encompass an assessment of all benefits and costs of small stream modification, and does not propose that instream values are the only factor that are to be considered when assessing consent applications for stream modification, or possible policies or objectives for land and surface water management. Likewise, this study does not endorse a strict 'zero effects' approach to modifications of small streams. Further work is needed in these additional areas if the Council and regional community is to make well informed and fully considered decisions on



Photo 2 A well designed culvert that will provide for fish passage

policies and actions going forward. The report is intended to clarify the consequences for in-stream values of small stream modifications, and the extent of the issue in Taranaki, as input into the decision-making process.

In order to progress the study objectives, a method has been developed for assessing the cumulative extent of piping and realignment in any catchment and an approach has been developed to use this information in the consenting process. Systems have also been improved for recording information about small stream modification gained during Council officer's site visits.

The current *Regional Freshwater Plan for Taranaki* [RFP] (TRC, 2001) sets out objectives, policies and methods in relation to the management of rivers, wetlands and land drainage. These are examined in this report in light of the issue of stream modification as revealed by this study. Aspects that could be examined in the review of the Plan in 2011 are highlighted in this report. In addition, systems for processing consent applications are discussed, including suggestions for the use of mitigation measures in instances where consent is granted and habitat loss is required to be off-set.

1.3 Defining small streams

For the purpose of this report, small streams are generally permanently flowing streams that are less than 2 m wide. They are invariably either first or second order¹ streams with defined stream channels. They include seeps and the very headwater of streams which are not constantly flowing. Modified 'farm drains' are also considered small streams where they have water flow and were originally a natural stream.

The various definitions of small streams used by other councils and as interpreted in the RFP are discussed elsewhere in this report.

¹ A stream with no tributaries is considered a first order stream. A stream segment downstream of the confluence of two first order streams is a second order stream.



Photo 3 Inaha Stream diversion; above - April 2007, below – September 2009



1.4 Defining small stream modification

There are a number of activities undertaken that will be discussed in this report as 'stream modification'. These include the following:

- Stream straightening or realignment – this involves the removal of meanders in a stream, and is generally undertaken to prevent further erosion of land, or in order to 'reclaim' the land over which the river flows, increasing the amount of productive land. Straightening a stream removes habitat complexity within the modified stream channel and reduces the length of stream originally present.
- Stream piping – this involves burying the stream in a pipe for the purpose of reclaiming the open stream channel for land improvement purposes. The piped sections are often longer than 100m, and the main ongoing environmental effect is the complete loss of stream habitat.
- Drain maintenance – small streams or 'drains' are often dug out periodically to increase their ability to transport flood water more efficiently away from intensively farmed pasture areas. This activity disturbs and can destroy instream habitat and riparian vegetation. Over time, habitat can re-establish naturally.
- Removal of riparian vegetation – stream bank vegetation is often removed as part of the types of modification discussed above. This reduces the biodiversity values of affected areas and reduces the capacity to buffer the stream against nutrient inputs and extremes in temperature.

1.5 The structure of this report

This report is divided into eight sections as follows:

Section one gives a background to the issue of small stream modification in Taranaki. It also outlines the purpose of the report and provides a definition for small streams and small stream modification.

Section two reviews the current literature base relating to the ecological and hydrological values of small streams.

Section three discusses the effects of stream modification from a review of the literature, and includes specific case studies of stream modification in Taranaki.

Section four details the investigation into the current extent of the modification of small streams in the Taranaki region using aerial photos, and information from the consents database.

Section five outlines the current policy framework in relation to small stream issues in Taranaki.

Section six outlines the Council's response to managing and mitigating the effects of small stream modification both through statutory and non-statutory methods.

Section seven sets out conclusions, pulling together the issues raised in the previous sections.

Section eight lists recommendations and outlines possible further work.

2. Values of small streams

2.1 A review of the literature on values of small streams

Historically, the value of small streams (including both intermittent and permanently flowing) has been considered poor, particularly where these streams have already been highly modified by intensive farming. This has often been reflected in regional policy, allowing stream modification in streams with small headwater catchments, cross-sectional areas and intermittent flow. However, research has highlighted the importance of small streams and their contribution to the overall catchment (Meyer et al, 2007a & b).

Small streams are important for a variety of stream functions. Meyer et. al. (2007a) state that the special physical and biological characteristics of intact, undisturbed small streams and wetlands provide natural flood control, recharge groundwater, trap sediments and pollution from fertilisers, recycle nutrients, create and maintain biological diversity, and sustain the biological productivity of downstream rivers, lakes and estuaries. Even modified streams retain some of these characteristics which activities such as piping and realignment could reduce further.

Internationally, the value of small streams has been recognised for some time. In America, 'daylighting' projects have been undertaken since the early 1980s. These projects identify streams that have been buried, and aim to restore them to a more natural state by recreating open channels. *Daylighting: New life for buried streams*, published by the Rocky Mountain Institute (Pinkham, 2000), reports on 18 projects that have daylighted over 4.2 km of perennial (streams that flow all year round) and ephemeral streams (flow briefly in response to a rainfall event) in the United States. While the specific ecology of streams and regulatory requirements internationally may not be directly applicable to New Zealand, the overall functions of streams can certainly be compared and discussed in the New Zealand context.

The limited knowledge of the distribution of headwater streams, poor recognition of the biological values, and limited understanding of the ecological processes sustaining their biological communities are currently hampering efforts to conserve and manage such streams both overseas and in New Zealand (Storey and Quinn, 2008; and references therein).

2.1.1 Ecological and biodiversity values

Headwater streams are probably the most varied of all running-water habitats and as such offer an enormous array of habitats for plant, animal and microbial life (Meyer et. al., 2007a & b). Small streams support diverse macroinvertebrate and fish populations. Meyer et. al. (2007a) noted that in America, a review found that small headwater streams that do not appear on most maps can support over 290 taxa, some of which are unique to headwaters, thus emphasising the significant contribution of small streams to the biodiversity of entire river networks.

Research into the ecology and biodiversity of small streams in New Zealand is limited. However, Auckland Regional Council have recently conducted significant investigations into the value of small headwater streams (ARC, 2006), focusing both

on streams that flow all year round (perennial) and those that flow intermittently (ephemeral). In terms of natural character it was found that both perennial and ephemeral streams had similar aquatic macroinvertebrate communities with respect to dominant taxa and relative abundances of taxa types; however communities in ephemeral streams recorded a significant proportion of rare taxa not present downstream. This study highlighted the significance of these intermittently flowing stream habitats for maintaining biodiversity particularly when they have riparian vegetation. However, in relation to fish habitat, intermittent (particularly ephemeral) streams may be less important for fish which would require water all year round in most cases.

Environment Waikato also recently commissioned a NIWA report which concluded that small (non-perennial) streams in native forest catchments harbour elements of indigenous biodiversity not found in perennial streams and warrant consideration in catchment management and policy development where biodiversity objectives are of interest (Parkyn et. al., 2006).

Headwater streams can also provide rich feeding grounds in terms of organic matter input, algal growth, and macroinvertebrates as sources of food. Many species also use headwaters for spawning sites, nursery areas, feeding areas and travel corridors, as well as refuge from higher flows, extreme temperatures, predators, competitors and exotic species (Meyer et. al., 2007a).

Small streams and wetlands provide a crucial link between aquatic and terrestrial ecosystems. The Auckland Regional Council (2006) found that riparian vegetation on small Auckland streams resulted in macroinvertebrate communities which were similar to those draining native forest catchments. The benefits of intact riparian margins have long been acknowledged and are particularly beneficial in small streams, where the beneficial influence of the riparian vegetation on instream habitat is high (i.e. shade and associated benefits for periphyton growth and water temperature regulation, organic matter input and stream edge habitats, and the interception of sediment and nutrients in surface runoff).

The hyporheic zone (the water-land interface beside and beneath a small stream channel) is also a particularly important and ecologically dynamic area. It is in this zone where much of a stream's cleansing action and nutrient processing occurs. Up to 90% can occur in headwater wetlands (Sukias and Nagels, 2006). Ecological processes that occur within these zones have strong effects on stream water quality. Recent scientific findings are highlighting the need to maintain the connectivity between these zones. When human impacts, such as the piping of streams, break these connections, the result is poorer water quality and degraded fish habitat downstream (Meyer et al, 2007a).

Small pasture streams may provide important habitat for native fish with some streams known to support high numbers of eels. Small streams with good riparian cover are also known to support banded kokopu. While little monitoring of fish communities has been conducted in small streams in Taranaki, many other fish species are also likely to be present (Hudson and Harding, 2004), particularly in streams close to the sea. Further it should be noted that most New Zealand indigenous freshwater fish prefer small stream habitats (McDowell, 2000; NIWA, 2008).

In addition to instream habitat, small streams also provide important habitats for birds, particularly where some vegetative cover is retained. These areas can be used for nesting and brood rearing (e.g., Mallard duck). The loss of such areas of habitat can result in reduced population levels of a variety of birdlife. It has been noted that the South Taranaki ring plain contains a very sparse bird life, owing to the lack of habitat (Fish and Game, 2006).

2.1.2 Hydrological values

Intact small streams and wetlands provide natural flood control, absorbing significant amounts of rain water and runoff before saturation and consequent flooding occurs. Natural stream channels tend to meander and provide a variety of substrate types which slow the flow and energy of water, aiding seepage into a stream's natural water storage system and recharge to groundwater. Slower moving water also has less power to erode stream banks and carry sediment and debris downstream (Meyer et. al., 2007a).

Headwater streams also play a crucial role in ensuring a continuous flow of water to downstream freshwater ecosystems. The recharge process that occurs in unaltered headwater streams and wetlands both moderates downstream flooding in times of high water and maintains stream flow during dry seasons. These smallest upstream components of a river network have the largest surface area of soil in contact with available water, thereby producing the greatest opportunity for recharge of groundwater (Meyer et. al., 2007a).

2.2 Ecological values of small streams in Taranaki

Small streams make up at least 75% of all streams in the Taranaki region (based on the River Environment Classification (REC) Network Position layer). There has been no specific monitoring of the ecological communities of these small streams in Taranaki and the ecological values have not been documented.

The Taranaki Regional Council has undertaken significant monitoring of streams in the region for both macroinvertebrates and fish. This historical data is reviewed in the following section in relation to the values of small streams in Taranaki, to ascertain whether existing data can identify the ecological values of small streams, or whether further surveys are required to better characterise the state of the region's small streams.

2.2.1 Macroinvertebrates

Macroinvertebrate data from the Taranaki Regional Council's database (ESAM) was reviewed to ascertain the diversity and ecological health of small streams (<2 m wide) in comparison to medium (2-8 m wide) and larger sized streams (>8 m). The analysis of this data is presented in Appendix 1 and is summarised below.

The nature of the macroinvertebrate data means that there is a lot of 'noise' in the data which makes it difficult to determine whether there are significant differences in the macroinvertebrate communities within the different stream width groups. Other factors (catchment and reach landuse, geology, presence of riparian vegetation and

altitude) are likely to have a strong influence on macroinvertebrate communities and their habitat. In particular, the data indicates strongly that increased riparian shading increases diversity and stream ecosystem health regardless of stream width, and that small streams can certainly be as diverse and healthy as larger streams given equivalent riparian management.

Regionally, it appears that in general, there was no difference in macroinvertebrate diversity between different stream width groups but that ecological health may increase as stream width increases. However, when the different eco-regions and the presence of riparian vegetation are also considered, several important points emerge:

- When the stream and riparian ecosystem is intact (i.e. there is intact riparian vegetation and little of the upstream catchment in developed farmland), small streams (<2 m) have higher diversity and ecosystem health than moderate to large streams;
- While lowland coastal stream health was generally poorer than streams draining the ring plain, small lowland coastal streams (<2 m) also appear to have higher diversity and ecosystem health compared to medium sized lowland coastal streams; and
- Ring plain streams rising outside the National Park showed little difference in macroinvertebrate communities between different stream width groups, however the lack of small streams sampled with intact riparian vegetation highlights that streams within this eco-region in a “reference” condition are under-represented, therefore differences in diversity may be difficult to establish.

These conclusions are consistent with the literature (refer to section 2.1), where it has been found both in NZ and internationally, that ‘intact’ small streams offer high diversity and ecological health as well as a number of other ecological benefits for catchments as a whole. Further, considering that first and second order streams in Taranaki make up more than 75% of the streams in the region, improvement of ecological health in the whole catchment could be significant if these streams in catchment headwaters are protected and enhanced. This certainly supports the Council’s riparian planting initiatives where the resultant riparian planting of all streams in Taranaki is eventually likely to provide benefits (in terms of ecosystem health) for the whole catchment as a result of riparian planting in the headwaters.

2.2.2 Fish

This section of the report discusses the distribution and diversity of fish in Taranaki with respect to stream size, with particular reference to threatened freshwater fish and the habitat requirements of small stream fish.

The threat status is classified in Hitchmough, Bull, and Cromarty (2007). Three classifications which apply to Taranaki small stream species discussed below are:

- Gradual Decline – Chronically threatened, face extinction, but are buffered slightly by either a large total population, or a slow decline rate;
- Sparse – At risk, with very small, widely scattered populations;
- Not threatened – Taxa that are assessed and do not fit any of the Threatened categories.

The Taranaki freshwater biota with the most threatened classification, 'gradual decline', include the brown mudfish, the longfin eel, the giant kokopu, the freshwater crayfish (koura) and freshwater mussel (kakahi). Shortjaw kokopu and lamprey are classified as 'sparse' (Molloy et al, 2002).

A number of agencies have surveyed the freshwater fish populations of Taranaki, with their data usually submitted to the New Zealand Freshwater Fish database, administered by NIWA. This fish data was analysed in relation to stream size, and the results are presented and discussed in Appendix II.

In summary, the results indicate that:

- Streams less than two metres wide are under-represented in the database, with only just over 22.7% of all fish samples being undertaken in such streams.
- There are statistically significantly fewer species recorded in small streams than medium and large streams, although this is a difference of only one fish species and therefore unlikely to be ecologically significant (particularly considering the lower proportion of samples within the small stream group).

The Department of Conservation has undertaken monitoring of brown mudfish distributions in Taranaki and has found Taranaki populations existing in remnant wetlands, predominantly around the Ngaere swampland and in South Taranaki. There are also populations present in the creeks and drains created when the swampland was drained, with the highest frequency of brown mudfish records being in streams less than two metres wide (Appendix II). This species has become endangered primarily through habitat loss, as the wetlands it commonly inhabits have been drained.

The high recorded occurrence of longfin eels in small stream samples (relative to other species) indicates that small streams provide important habitat for longfin eels. This is also the case for shortfin eels. Habitats preferred by eels include deep, slow water i.e. pools, during the day. They also use large substrate and undercut banks as cover (Photos 4 and 6). At night they are probably found foraging for food in shallower and swifter water. Jowett and Richardson (2008) noted one particular record of 68 longfin eels in a 5 m² area, where they were found under an undercut bank. This illustrates well the importance of such habitat.

Giant kokopu (in 'gradual decline') are usually nocturnal, and uses undercut banks and wooden debris for cover during the day. This is well illustrated in a later case study (Mangahewa Stream, Table 1). These species favour small to medium-sized streams



Photo 4 Examples of longfin eel community streams. Note the pool habitat with cover (logs, boulders, undercut banks). These sites are well inland at moderate elevations and there are no other fish species here.



(McDowall, 2000) and is considered to be a 'small stream fish'.

Case Study: Mangahewa Stream tributary

The landuse surrounding the catchment of this stream is predominantly dry stock farming. A fish survey undertaken at night using spotlights in this stream recorded 16 fish, including two banded kokopu, one shortjaw kokopu, one giant kokopu, and five redfin bully. There were also seven unidentified galaxiids. A number of the observed fish were of a significant size (>150 mm). The stream was sampled at an altitude of about 110 metres.

This stream was very small and overgrown, and there was good cover present within the stream, in the form of undercut banks and coarse wood debris.

Photo 5 Aerial photo showing contributing catchment to the Mangahewa tributary



Photo 6 Examples of shortfin eel community streams
Note the farmed catchments, low velocity water, and cover along the stream banks. The substrate is soft and made up of fine particles.

A number of the other species recorded in the Taranaki are more common in smaller streams, especially banded kokopu and shortfin eel, which is consistent with what is known about these species. Being a typically nocturnal fish, banded kokopu usually spend the day taking cover using instream debris, or undercut banks (Photo 7 and 8). During both day and night, the adults prefer a very low water velocity over a range of depths more than 0.2m deep. Again, this shows a preference for pools.

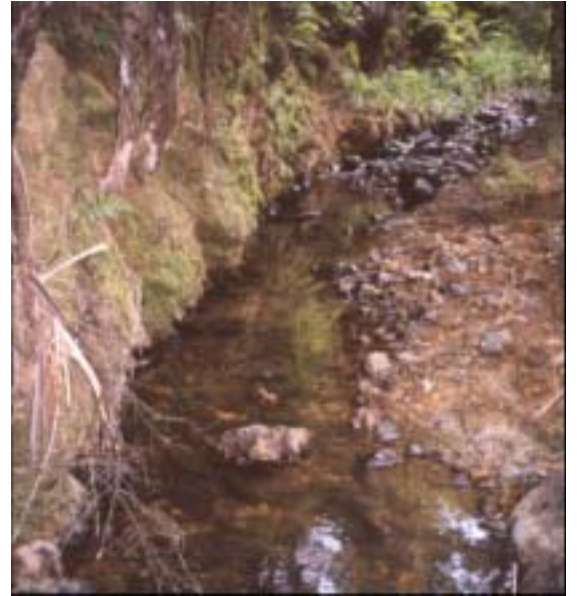


Photo 7 Examples of typical banded kokopu community streams
Note the small size of these streams, debris or undercut bank cover, overhead canopy, and pool habitat.



Photo 8 (left) Lake Rotokare tributary where banded kokopu were found in abundance (catchment area 17 ha) and (right) a banded kokopu living in the tributary

Inanga were recorded in all stream sizes, being slightly more frequent in small streams compared to medium and large streams. This species favours gently flowing and still waters (Photo 9). Because of their poor inland penetration, the majority of inanga are found near the coast, where the streams flow is typically slower. Low altitude stream modification would cause some reduction in inanga abundance, while there would be less of an impact at mid to high altitudes, due to their lower abundance at these altitudes. Loss of spawning habitat at low altitude sites should also be considered.



Photo 9 Examples of inanga community streams
Note the similarities to shortfin eel streams, although inanga community streams must have good access and be close (preferably less than 10 km) to the sea.

Case Study: Mangahewa Stream

This is a larger stream, with a catchment of approximately 228 hectares at an altitude of about 110 metres. The predominant landuse here is also dry stock farming, although this stream also receives a stormwater discharge from the McKee Production Station.

The stream has a slight meandering pattern, and at most bends contained a deep pool, often with depths in excess of one metre. There is also significant cover, with undercut banks that extend as far as 50 cm under the bank, and coarse wood debris. Two reaches were surveyed, one downstream of the McKee Production Station, which had relatively complete riparian cover (about 70% of stream banks), and stock were excluded, and the other upstream of the production station, where there was much less riparian cover and stock were not excluded. There were large areas of soft sediment within the stream, especially upstream, where stock access had caused slumping of the banks. It should be noted that there is a weir and fish pass situated between the two reaches. The results of electric fishing and spotlighting surveys undertaken in May 2009, are given in Table 1.

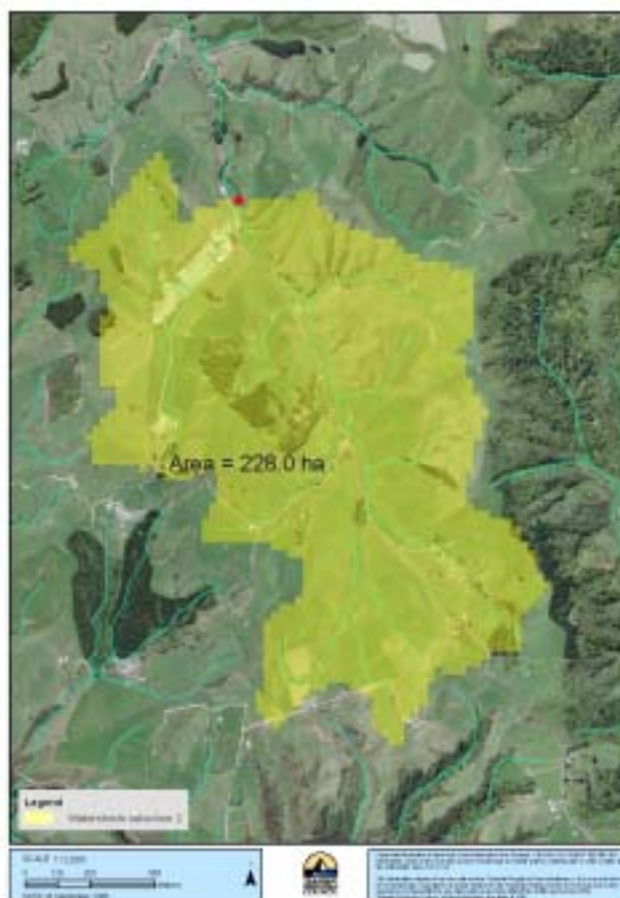
Table 1 Results of electric fishing and spotlighting surveys carried out in the Mangahewa Stream

Species	Downstream		Upstream		Previous Surveys
	Electric Fishing	Spotlighting	Electric Fishing	Spotlighting	
Longfin eel	4	-	3	2	✓
Shortfin eel	1	-	-	-	✓
Giant kokopu	-	3	-	5	✓
Shortjaw kokopu	-	-	-	-	✓
Banded kokopu	1	-	1	1	✓
Inanga	-	-	-	-	✓
Redfin bully	-	1	-	-	✓
Common bully	-	-	-	-	✓
Torrentfish	-	-	-	-	✓
UID Galaxiid	-	4	-	8	✓
UID eel	1		4	-	✓
Elver	12		5		✓
Abundance	19	8	13	16	
No. species *	3	2	2	3	9

*Does not include unidentified (UID) species

This stream is known to contain at least nine species of fish, with some in abundance. A notable result is the abundance of giant kokopu, which were present in the pools, and quickly escaped to the cover provided by the undercut banks. Giant kokopu were only present in ones or twos within the pools, a reflection of their territorial nature. This shows the importance of pool habitat for this species, considered to be in gradual decline.

Photo 10 Aerial photo showing the contributing catchment area which drains to the Mangahewa Stream site



Case Study: Small stream in the Ngaere swamp area

Some g-minnow traps were set in two small streams draining the Ngaere swamp area, where previous surveys by the Department of Conservation recorded the presence of brown mudfish. These streams form the headwaters of the Mangawhero Stream, a tributary of the Waingongoro River. Unfortunately no brown mudfish were recorded this time, although 59 freshwater crayfish (*Paranephrops planifrons*) were captured, a subsample of which is shown in Photo 11. Both brown mudfish and freshwater crayfish are species considered to be in gradual decline.

Photo 12 shows the type of stream in which this survey was undertaken. This type of stream, often referred to as a drain, is commonly considered by the general public as having little value, but it is clear that crayfish are able to thrive in such a habitat, probably due to the ample amount of food available in the form of watercress. This watercress is also assisting with improving water quality, which is a significant issue in this catchment, as further down the Mangawhero Stream, the South Taranaki District Council discharges the treated wastewater from the Eltham sewerage system. Watercress is considered to be a luxury feeder, in that it can absorb more nutrients than it needs to survive (NIWA, 2008). Note, this Mangawhero Stream is different to that discussed in the case study in Section 3, which is a tributary of the Kaupokonui River.

The presence of crayfish, brown mudfish, and significant amounts of watercress indicate that even farm 'drains' can contribute significant ecological value.



Photo 11 Subsample of crayfish captured from unnamed tributary of Mangawhero Stream



Photo 12 Stream where crayfish were captured

These examples show that native fish, including threatened native fish, are present within Taranaki's smaller streams. It is clear that even the smallest of streams, when they are in good condition, are able to support notable populations of fish.

There is certainly a lack of information on fish populations in many of the small stream 'types' in Taranaki (i.e. farm drains, streams with riparian planting in agricultural catchments, small headwater streams with intact riparian areas). Considering that literature confirms that small streams provide important habitat for New Zealand native fish, it would be useful to determine the state of fish populations in small streams in Taranaki. This would also have benefits for consent processing and undertaking the assessment of effects if more is known about fish populations and hence the ecological value of streams in Taranaki. As such it is recommended (refer to recommendation 5, section 8) that small streams are included in a State of the Environment fish monitoring programme to provide this 'state' data and also assess the changes in fish populations over time.

3. Effects of stream modification

3.1 A review of literature on the effects of stream modification

Throughout the world, river and stream ecosystems have been modified by human activity. Changes in the landscape due to deforestation, drainage of wetlands and farmland, grazing, water abstraction, impoundment and the introduction of exotic species have influenced river and stream catchments directly and indirectly in many countries for several millennia, and in New Zealand since human colonisation began. These changes, especially the loss of riparian vegetation and wetland drainage have had profound effects on rivers, streams and wetlands, and their ecologies. Some freshwater fish species seem ill-adapted to cope with these changes and as a result, about 25% of the native fauna in New Zealand is now a conservation concern (West Coast Regional Council, 2002).

Habitat modification or destruction

The most obvious effect of stream modification is habitat destruction or modification. Particularly for streams that have been piped, the effect on instream habitat is a total loss of what is a diverse habitat for instream and stream bank flora and fauna in naturally intact streams. While larger pipes may offer some ecological habitat, smaller pipes and long distances of piping will offer little habitat for macroinvertebrates or fish. Further, habitat loss to fish can extend further up the catchment above the piping (or culvert) if fish passage is restricted. Where streams have been straightened or channelised, “bends and meanders are altered to straight trenches; overhung banks where fish might shelter are lost; formerly diverse habitats with deep pools and shallow riffles, sand and gravel beds, slow and swift flows, etc., are replaced by uniform flows, depths and sediments” (McDowall, 1990). There is also a reduction in the availability of refuges from fast flow or appropriate cover, as well as a reduction in food retention and availability. Modification of stream habitat in the process of agricultural development has certainly lead to substantial declines in native fish populations in New Zealand (West Coast Regional Council, 2002, and references therein). Channelisation has been found to result in siltation and degraded substrate, in turn resulting in degraded habitat and also habitat loss, reducing benthic macroinvertebrate communities (Hudson and Harding, 2004).

Specialised headwater species can be particularly sensitive to habitat destruction because of their small geographic ranges. As the disruption of natural headwater systems is increased by human activities such as pollution, impoundment, and destruction of riparian zones, more populations of headwater specialists may be removed or completely destroyed, potentially resulting in the regional extinction of some species (Meyer et al, 2007a).

An investigation in the West Coast Region (West Coast Regional Council, 2002) found that highly disturbed streams had poor instream habitat in terms of cover and refugia for fish, siltation/embeddedness and sediment deposition. In this investigation, total fish abundance and diversity did not appear to be related to stream habitat disturbance, however sensitive native fish appeared to be considerably affected by it, with significantly higher population densities in streams with very little habitat disturbance. The quality of riparian vegetation, amount of instream woody debris, and whether there was stock access to streams, were the most significant factors

affecting sensitive native fish. This pattern is consistent with that found in other parts of New Zealand. It appears that stream reaches that have 80% or more of intact riparian vegetation are more likely to support greater numbers of sensitive native fish.

In the same investigation, stream habitat disturbance appeared to have limited effect on the abundance and species richness of macroinvertebrate communities, however it was noted that macroinvertebrate indices may not be a suitable indicator of stream habitat disturbance on the West Coast. Physical stream habitat disturbance can however cause long term and severe impacts on stream biodiversity (West Coast Regional Council, 2002, and references therein) even if this is not demonstrated by changes in macroinvertebrate indices.

Hydrology

Alteration of small streams and wetlands disrupts the quantity and availability of water in a stream (Meyer et al, 2007a). Straightened channels send water downstream more quickly, resulting in more enlarged and incised channels, and accelerated erosion of the stream bed and banks. Furthermore, the faster the water moves the less it can soak into (recharge) the stream bed and banks. The effect is then magnified downstream, because larger rivers receive water from multiple small headwater basins (Meyer et al, 2007a). This can result in more widespread and frequent flooding. Similarly, when larger smoother pipes substitute narrow, rough-bottomed stream channels, a similar effect of increased flood frequency occurs downstream through the acceleration of the speed with which water follows subsurface flow paths (Ward and Robinson, 2000). For example, three decades of growth in storm sewers and paved surfaces around Watts Branch Creek, Maryland, US (greater than half the stream network) more than tripled the number of floods and increased average annual flood size by 23% (Meyer et al, 2007a). Agricultural drainage increases the hydraulic gradient in the soil and lowers the water table more rapidly between storms than would otherwise occur. There is also less groundwater recharge from these faster-flowing streams which often results in less water in streams during drier seasons. As such low flows may become lower.

Based on this, the ongoing excavation, straightening and piping of small streams in Taranaki could in time potentially reduce the contribution from these small streams to downstream baseline flows during dry weather, and increase the frequency and intensity of flooding in wet weather. As a consequence of this, median and low flows in rivers may potentially be reduced, leaving less water available for allocation as well as for maintaining the ecological values of the catchment as a whole. While the bulk of base flow from ring plain streams originates from Mount Taranaki, the effect of piping large proportions of streams on groundwater levels and surface water flows in catchments where a number of contributing tributaries arise outside the National Park are unknown.

Water quality

Headwater streams can be source areas and provide transport pathways for sediment, faecal contamination and nutrients. The large contribution of small streams to a catchment means that the water quality of the whole catchment can be significantly affected by the water quality of small headwater streams. The water quality of the stream is often regulated by the presence of riparian vegetation by filtering surface runoff, providing suitable conditions for nutrient uptake or

transformations, stabilising stream bank morphology and moving sediment and nutrient generating activities away from streams (McKergow et al, 2005). The removal or absence of riparian vegetation can therefore reduce the water quality of small streams.

There has been little monitoring of water quality in pasture catchments less than 6 ha in New Zealand (McKergow et al, 2005). McKergow et al (2005) concluded in their study of small headwater streams in the Auckland region, that there would be continued export of sediments and faecal bacteria that will contribute to pollution and, in the case of sediment, cause accumulation downstream. With no riparian buffers on headwater streams, direct fertiliser additions, and open access to stock, exports of nitrogen and phosphorus will remain high. This suggests that there is likely to be greater degradation of water quality in modified streams where riparian vegetation is removed or does not exist. The implications for water quality in the whole catchment are therefore significant if modification of large areas of the catchment continues.

Healthy aquatic ecosystems can transform natural material like animal faeces and chemicals such as fertilisers into less harmful substances. Small streams and their associated wetlands play a key role in both storing and modifying potential pollutants, in ways that maintain downstream water quality (Meyer et al, 2007a). The straightening and piping of streams effectively reduces or, in the case of piping, removes much of this ability to attenuate pollutants once they enter the stream. Meyer et al (2007a) noted research on headwater streams has demonstrated that nitrate removed by headwater streams accounts for half of total nitrate removal in entire river catchments.

As such, if headwater streams and wetlands are degraded or filled, more pasture runoff reaches larger downstream rivers. Larger rivers process excess nutrients much more slowly than smaller streams. Losing the nutrient retention capacity of headwater streams could therefore cause downstream water bodies to carry higher concentrations of nitrogen and phosphorus (Meyer et al, 2007a), potentially resulting in increased periphyton growth (amongst other things).

A recent study of a small streams in Taranaki in relation to the attenuation of contaminants from a discharge of dairy pond effluent (TRC, 2008) indicated that overall, there was effective attenuation of the discharge within 120 metres for ammonia and dissolved reactive phosphorus, and within 450 metres for biological oxygen demand and faecal coliforms, and within 1.55 kilometres for total phosphorus and nitrate in this first order stream. The biological survey showed that the stretch of stream studied, was of very high ecological quality under preceding conditions of high wastes dilution. It was noted that this is of significance when considering the value of first-order streams. The effects of riparian vegetation were especially apparent at some of the sites, confirming the valuable contribution of riparian vegetation to enhancing in-stream ecosystems. This study highlights the benefits to water quality that can be attained with more 'intact' stream ecosystems.

Fish passage

Restriction of fish passage when a stream is re-channelled or straightened is rarely an issue, as although there is often an increase in water speed, there is usually enough variation in flow across such a channel to allow for fish passage.

However, when a stream is piped, there can be a number of factors which restrict fish passage. Gaining access to the pipe can be the first barrier, with the possibility of the outlet of the pipe having a free overhang (perched). However, once fish have entered the culvert, there is the question of water speed and depth, both of which can reduce or prevent fish passage, especially if the pipe is long, and doesn't contain rest areas and refugia (McDowall 1990). Similar effects are possible at access culverts when they are not installed or maintained properly (Boubee et al. 1999). The review of the fish data suggests that fewer fish species live in smaller streams which could be a reflection of the fact that streams narrower than two metres are more likely to have a barrier to fish passage downstream, due to the ease with which a culvert can be installed.

The above findings are not new. The following paragraph is taken directly from Quinn, J.M. (2000) and contains references published as far back as 1977.

“Land drainage and stream channelisation are also common features of agricultural development in lowland areas of New Zealand where excessive soil moisture has been a major factor limiting agricultural productivity of approximately two million hectares of land (Bowler 1980). Channel works, such as deepening and straightening to improve soil drainage, and simplify fencing and paddock management, typically increase stream gradient and reduce stream length and habitat diversity (Williamson et al. 1992). These practices have been applied extensively in both lowland and gently rolling country (Bowler 1980). The increased capability of straightened channels to erode sediment has sometimes led to extreme habitat degradation with marked impacts on benthic invertebrates (e.g., Quinn et al. 1992b). Artificial drainage (e.g. mole and tile drains) reduces water storage and increases quick flow to streams (Turner et al. 1977), contributing to the increased size and frequency of storm flows in some agricultural catchments (Fahey and Rowe 1992). These subsoil drains also bypass riparian areas where significant nutrient removal often occurs (Cooper 1990; Nguyen et al. 1999), and thus contribute to increased stream nutrient loads following agricultural development. “

3.2 Ecological effects of stream modification in Taranaki

3.2.1 The effects of stream straightening or realignment

It is characteristic of many lowland streams in Taranaki to meander. This is the natural and usually stable path that the streams have established, as a result of the relatively steep gradient in which they descend towards the sea. Meanders slow the flow of water by increasing the length of river, effectively reducing the river gradient. By slowing the water flow rate, the potential for erosion is reduced, and therefore such channel-paths can be relatively stable. Channel stability also depends on the geology through which the stream flows. For example, the Waiteika Stream near Opunake, flows through relatively sandy country, and its meanders are still eroding in places. The presence of meanders in a channel form allows for a wide diversity of habitat for stream life.

There are two main reasons why meanders are modified as part of landuse management; removal of meanders that are eroding on the outside bend, to prevent further erosion of land, and the removal of meanders in order to 'reclaim' the land over which the river flows, increasing the amount of productive land.

From an ecological perspective, there are often significant differences between the habitat provided by the original channel and the habitat provided by a modified straight channel. The following case study aims to illustrate these habitat differences.

Case Study – The effects of consented stream straightening on the Mangawhero Stream

The photos below are from the Mangawhero Stream, which had approximately 170 m of meander removed, and replaced by a new channel of approximately 45 m in December 2007. While this is a large scale example, and not necessarily typical of the majority of works being undertaken on the ring plain, it aids in the identification of specific habitat changes, and other associated effects.



Photo 13 Undercut bank, and the trout that was using it as cover (inset)

Meanders in Taranaki streams often contain deep pools, separated by areas of faster flow, known as runs and/or riffles. Pools and riffles differ markedly in the habitat provided. Pools provide cover for fish in the form of depth, and also refuge from floods, through the reduction in water speed. The margins of pools are shallow and slow, this type of habitat is heavily utilised at night by foraging bullies. Pools can also provide alternative feeding areas, such as weed beds.

In comparison, riffles and runs are usually much shallower, and have a faster flow. This type of habitat contains an abundant and diverse invertebrate community, and is

often the primary food source for the fish community. There is also some flood refuge available in this habitat, although it would only be effective during minor floods.

Pools, riffles and runs can also contain habitat in the form of undercut banks. This habitat is very important as cover for nocturnal species, and also adult trout. For example, the trout in Photo 13 was forced out from the undercut bank shown through electric fishing. This type of location provides both cover and food, with invertebrates drifting by in the current.

When a meander is removed, the pool-riffle-pool structure is replaced by a channel devoid of pools, and dominated (usually) by fast flowing riffles and runs due to the increased gradient down which the stream now flows. There is also a complete absence of undercut banks (Compare Photo 14 with Photo 15).



Photo 14 (left)

Part of the original channel, with a pool which had an undercut bank along the true right hand bank



Photo 15 The new channel, 17 months after the stream was diverted (13 May 2009)

An increased gradient also increases water speed, which in turn increases the erosive potential of the stream. In a worst case scenario this increased erosive potential could cause the stream to begin eroding a new meander, something that would require extensive repair works, and repeated disturbance of the stream bed. Other impacts of the erosion can be the re-grading of the stream bed, with degradation of the stream bed at the top of the new cutting and aggradation of the bed downstream, through the deposition of eroded material. Such erosion is amplified by steeper terrain, and is what caused the erosion upstream of the new channel shown in the photos below.



Photo 16 New channel on 4 January 2008 (above) and 2 September 2008 (below)



The fish salvage undertaken just prior to diverting the stream recovered four trout, 78 eels, three torrentfish and numerous redfin bully and koura. Many fish are likely to have been missed, due to the depth of water being fished, poor water clarity, and the small size of some of the fish, especially juvenile trout. A variety of stream life was recovered from the dry river bed (Photo 17).

Photo 17 Dead animals recovered from the original stream channel

As a result of the monitoring undertaken during the works authorised by the resource consent in the above case study, a greater understanding of the effects of diverting water (on fish populations and habitat, as well as potential for erosion) and the degree of fish diversity in such streams was gained. This led to an improvement in consent processing and the assessment of environmental effects with respect to stream realignment. Procedures have now been put in place to ensure that such effects are adequately considered in future applications (including an improved template for the officer report which includes assessments of the fish populations, standard consent conditions relating to fish salvage, and review of the officer report by a freshwater ecologist prior to granting of consent).

To obtain a better understanding of the fish populations in such streams, it is also recommended that more detailed ecological assessments be required for resource consent applications which involve significant lengths of modification and/or are within high value stream habitats (recommendation 16, section 8). Further monitoring of fish populations in small streams in Taranaki would also provide a better understanding of the distribution of fish and where high value stream habitat for fish is located. Including small streams in a state of the environment fish monitoring programme (recommendation 5) would go some way to providing this information.

3.2.2 The effects of stream piping

When a stream is buried, and its flow directed through pipes, the most obvious impact is the loss of habitat which was provided by the original channel.

The streams in Taranaki under most threat of piping are typically very small, and may even stop flowing during the drier months (Photo 18). However, a lot of the rain runoff from farmland initially passes through these small streams, before entering the main stems. The slower flow, and often high macrophyte biomass, especially watercress, helps improve water quality by retaining much suspended sediment, and by reducing bacteria and dissolved nutrients. Where this small stream also has a protected and planted riparian margin, the initial input of suspended sediment, bacteria and nutrients into the stream is even further reduced.

When a stream is piped, it no longer has a riparian margin to filter and reduce contaminant loadings. Instead, during periods of persistent rain, runoff will frequently flow overland, and directly into the pipes e.g. at inspection covers or holes, or into the stream once an open channel occurs below the pipe. In piped sections, the stream loses its capacity to lower suspended sediment, bacteria and dissolved nutrient concentrations, effectively transferring these contaminants to the main stem. This has the potential to exacerbate further the incidence of nuisance periphyton growth, bacteria counts and also the amount of sediment that settles on the streambed downstream. All of these factors reduce the recreational value of the main stems, and overall, lead to reduced water quality. Photos 19 and 20 demonstrate the dramatic changes to stream habitat that occur following piping work, while the potential changes to water quality are less visible once pipes are installed.



Photo 18 Typical flow paths (above) and streams (right) in Taranaki which are commonly piped for land improvement

In Taranaki a series of subsoil/novaflo pipes are commonly used for piping as they are cost effective. The small diameter of these pipes restricts fish passage. Therefore while these may be used at the very top of headwaters, they are less appropriate further downstream as such pipes will limit all fish habitat upstream of the pipe.



Photo 19 The headwaters of the Rawa Stream, upstream of Skeet Road (left) being piped (note remnant raupo swamp in background), and downstream of Skeet Rd (right) which has already been piped. Note manhole cover in foreground



Photo 20 Aerial photo (top left) of a piped stream upstream of the road (above) and riparian planted section downstream (bottom left)

The increase in contaminants reaching the main stem can be further exacerbated by the irrigation of dairy effluent directly over the piped stream. The resultant land is usually recontoured and can appear ideal for effluent irrigation. The path of the piped stream may often be unknown as this knowledge may not be transferred upon sale of the farm. This can make the management of this issue very difficult. On occasions Council officers in Taranaki have observed a stream flowing green following the irrigation of dairy effluent nearby in areas where novaflow pipe was present beneath the ground (TRC environmental incident register, 2009).

When a number of such stream burials occur within a catchment, the cumulative deterioration in water quality (as well as habitat loss) can be significant, but not always easy to trace back to a particular source, as it only accrues slowly down catchment. There have been no investigations undertaken in Taranaki in relation to effects of cumulative piping on stream water quality.

In addition to the potential deterioration in water quality, piping streams can also result in the creation of a barrier to fish passage. Either the outlet of the piped stream can be unsurpassable by fish, as in Photo 21 at the Westown Golf Course in the Te Henui Stream catchment, and/or the pipe itself is impassable due to steps within the pipe, water speeds and/or water depths. In addition, there is some debate internationally as to whether the darkness itself is a deterrent to some migrant fish,

although it appears to be less of a factor for fish indigenous to New Zealand (ARC 2000b, Boubee et al 1999). This restriction in fish passage would mean the use of upstream habitat by migrant fish is reduced, effectively adding to the habitat already lost through the destruction of the original piped stream length. The Te Henui Stream has reasonable fish diversity (13 fish species recorded in the TRC database) with good access to the sea for migratory species. Small unnamed tributaries such as that found at the Westown golf course (Photo 21), where there is some riparian vegetation intact, provide excellent habitat for native fish. The piping of this stream directly removes habitat where the pipes have replaced the stream, but also removes the 1 km of stream habitat available upstream of the piped sections by restricting passage of fish at the entry to the pipe (due to the high set pipe).

Photo 21 Piped stream at Westown Golf Course. Location of culvert below is marked by red star on map. Red lines indicate piped reaches.



Summary

In summary, the impacts of stream piping could include:

- loss of habitat;
- potential barrier for fish passage;
- runoff bypassing riparian areas where significant contaminant reduction and recycling often occurs;
- absence of instream macrophytes, which play a major role in removing contaminants from the water;
- increased drainage of land, negatively impacting the hydrological balance of the catchment; and
- increased discharge of nutrients, bacteria and suspended sediment to the stream.

In Taranaki, while the habitat lost due to piping streams for land improvement is obvious, the extent to which cumulative stream modification impacts on water quality and hydrology is unknown. It is recommended that further investigations into these issues be undertaken, possibly utilising the GIS maps showing the extent of stream modification to identify some areas in catchments where there are several piped sections on a stream in a small area (i.e. refer to Figure 11 in section 4.2). Recommendations to this effect are included in section 8 (Recommendations 7 and 11). This will provide valuable guidance for the next review of the RFWP.

3.2.3 Climate change and the effects of small stream modification

The piping and straightening of small streams both serve to speed the passage of water through catchments, causing heightened flood peaks and greater erosive potential, and extended low flow during dry periods. A NIWA report found that Taranaki is expected to become wetter overall with an increased frequency of extreme weather events (NIWA, 2007). A study into the region's rainfall between 1930 and 2004 (Griffiths, 2007), indicates that northern Taranaki has had an increase in the number of days of heavy rainfall and an increase in the amount of rain falling on the days of heaviest rain. For southern Taranaki, an area already prone to droughts in summer, indications are that things will get drier. These changing weather patterns, acting in combination with the impacts of small stream modification could cause problems with water availability for irrigation during long dry summers, and increased problems with stream channel erosion and flooding in winter.

3.2.4 Stream piping – a cost-benefit analysis

A desktop analysis was carried out as an attempt to quantify and compare the costs and benefits to farmers of piping a stream compared to planting and fencing its riparian margins. Through discussion with drainage contractors it has been estimated that it would cost approximately \$25 per metre to pipe the smallest streams with 100-150 mm novaflow piping and approximately \$100 per metre for larger 1-2 m wide streams. We can then calculate that for 200 m of piping, the project could cost from \$5,000 to \$20,000. The cost of consents would also have to be factored in.

If we assume that the farmer gains 0.2 ha for each 200 m of stream that has been piped instead of fenced and planted, and using a return on land of 850 kg of milk solids per hectare at \$5 per kg, then the farmer could gain \$850 per year as a return on the initial outlay, with a potential pay-back period possibly as short as six years, but up to 23 years for larger streams.

In contrast, fencing and planting would cost \$13 per metre, a total cost of only \$2,600 for the 200 m of stream, but maintenance costs must be factored in, and the farmer wouldn't get the ongoing return in productivity, as the land would be retired. Conversely the fenced and planted stream would give benefits to the farmer in terms of aesthetics (studies have also shown that farms with amenity plantings sell for more money given the aesthetic benefits), reduction in erosion (and loss of productive land), potential shelter for stock, prevention of stock losses within the stream and options such as water abstraction. Pasture near stream banks also often consist of low quality pasture which is easily disturbed by stock, and dominated by weeds. Fencing and planting can therefore improve weed management in these low productivity areas.

4. Extent of stream modification

To help establish the potential effects of stream modification in Taranaki, the current extent of modification needs to be known. Stream modification consists of both permitted activities and those requiring resource consents (refer to section 5.3.3). The Council maintains a database of consented activities which can give an indication of more significant modification, however prior to this project, the extent of permitted stream modification was unknown. With the use of aerial photography and GIS facilities, the Council now has the ability to determine the extent of permitted and historical stream modification for the first time. This section examines both the consented and permitted extent of stream modification in Taranaki.

4.1 Consented stream modification

Stream modification that does not meet the permitted rules and conditions in the RFWP (refer to section 5.3.3.) requires a resource consent. Consent applications for stream modification include information on the extent of proposed stream modification. Until recently this information has not been easily retrievable. As part of this small streams project, the Council's resource consent database (R2D2) was recently modified to allow this information to be entered into the database, and improve the ability to search for such data.

Three parameters were incorporated into the database to encompass the range of different types of stream modification commonly undertaken:

- Total culverted stream length² - The length of original stream lost due to installation of a culvert or culverts (usually equal to the length of the culvert).
- Total piped stream length - The length of original stream lost due to piping (normally more than the length of installed piping if a straight pipe replaces several meanders).
- Total realigned stream length lost - The length of original stream lost due to channelisation, straightening, realignment or diversion, this does not include stream habitat lost due to piping and culverting that would be represented in the above parameters – "Total culverted stream length" and "Total piped stream length".

These three parameters have now been created in the R2D2 resource consents database and populated with the relevant information from historical consents issued since 1995, related to stream modification. The parameters and their definitions have been built into the officers' report template so that the same standardised information is captured for each consent, as applications for new stream modifications are received by the Council.

² The distinction between a piped stream and a culverted stream for these purposes has been set as the following:

Culverted – primarily for access purposes, usually less than 50m long (main potential ongoing environmental effect as a disincentive or barrier to fish passage rather than a total removal of habitat).

Piped – primarily installed for land improvement purposes, often longer than 100m.

From this database the amount of consented stream modification work that has been undertaken can now be calculated. Table 2 shows that from 1995 to April 2009, consents had been issued to pipe over 25 km of stream, culvert 7km of stream and divert or realign 11.4 km of stream (43.6 km of stream modifications in total). These totals do not include historical work carried out prior to the Regional Freshwater Plan (2001). To put these totals into perspective, the total consented modification is a very small proportion (0.2%) of total stream length in Taranaki (nearly 20,000 km). While this is a very small proportion of Taranaki's streams overall, when only ring plain streams are included, consented modification becomes 0.4% of ring plain stream length.

Table 2 Consented stream modification between 1995 and April 2009

Parameter	Length of stream (km)
Total piped stream length	25.2
Total culverted stream length	7.0
Total realigned stream length lost	11.4
Total modified stream length	43.6

Catchments with more than 1 km of consented modified stream length are listed in Table 3. Of note is that nine of these 13 catchments are located in the South Taranaki District, where the most intensive farming is concentrated, and topography generally allows more feasible modification of streams (i.e. flatter land).

Eight of these thirteen modified catchments are listed in Appendix 1A of the RFWP as being catchments with high natural, ecological and amenity values. These eight include the Kaupokonui, Patea, Tangahoe, Waingongoro, Waiongana, Waitara and Waiwhakaiho rivers, and the Tapuae Stream.

Table 3 Summary of catchments with consented stream modification greater than 1 km (includes culverted, piped and realigned modification)

Catchment	km modified
Taikatu Stream	6.54
Patea River*	4.57
Waingongoro River*	4.07
Kaupokonui River*	2.92
Tangahoe River*	2.27
Otakeho Stream	1.77
Tapuae Stream*	1.67
Waiwhakaiho River*	1.65
Waipapa 3 (Waipapa) Stream	1.54
Waitara River*	1.35
Waiongana River*	1.32
Taungatara Stream	1.06
Unnamed catchment 28	1.01

* Listed in Appendix 1A of the RFWP

Figure 1 and Figure 2 illustrate the increasing level of stream modification that has occurred in recent years in terms of tracking the number of consents issued, and the length of stream that has been affected by consented works. The high number of consents issued for culverting work (for access purposes), particularly in the years 2006-2008 could be partly due to farms amalgamating or increasing in size and the

need to create access between what was once two farms separated by a stream. Further, the large numbers of culverts being installed in Taranaki streams reflects the large number of streams in the region and possibly farmers implementing Clean Streams Accord requirements. Under the Dairying and Clean Streams Accord (which came into effect in mid-2003), Taranaki has a target of 50% of regular crossing points to have bridges or culverts by 2007, and 90% by 2015. In the 2007/2008 Dairying and Clean Streams Accord Annual Report (TRC, 2008d), Taranaki have exceeded this target with 97% of regular crossing points adequately bridged and/or culverted. In terms of length of stream lost, culverts installed for access purposes generally do not result in large amounts of stream length lost cumulatively, so although the number of consents issued is higher for access culverts compared to realignment and piping works (Figure 1), the stream length lost is comparatively less (Figure 2).

Realignment works have also increased significantly since 2007 (Figure 1 and Figure 2). Both the number of consents issued for realignment work and the length of stream modified have increased; and particularly in 2008, the length of stream modified (6.3 km) was 3.5 times higher than the previous year.

Although the number of consents issued for piping work to be carried out for land improvement purposes has been fairly steady since 2004 (but was relatively low prior to this, Figure 1), the actual magnitude of works in terms of the amount of stream length affected has increased significantly and been particularly high from 2006-2008, indicating that piping for land improvement purposes has been a relatively recent phenomenon.

The generally high rate of consented work carried out on small streams during the 2006-2008 period (compared to previous years) could also be due to the 'boom' period of relatively high dairy payouts making it more attractive for farmers to invest in maximising useable land around small waterways through stream realignments and piping. It was also during this time that the Council's land management officers were undertaking 300 riparian or farm plans per year, mapping all the streams on these farms and putting significant effort into raising awareness in relation to resource consent requirements for stream modification work (amongst other things). Further, in 2000 instant fines were introduced, and there has been an increase in prosecutions in general terms, with some of these related to stream modification work (refer to section 6.2.3). This is likely to have had some effect on the awareness of farmers around the region in relation to resource consent requirements. Investigating officers have been out monitoring and their increased presence (along with land management officers) is likely to have contributed significantly to the increase in the number of consents being applied for over this time.

While the Clean Streams Accord promotes culverts and bridges as an environmentally preferable alternative to stream crossings, the Accord otherwise promotes riparian exclusion and planting. While in general, the significant uptake of riparian plans in Taranaki in recent years indicates that farmers are implementing the Accord as intended, the significant increases in the last few years in stream piping and realignment suggest that some farmers may be opting for piping streams rather than fencing and planting. The question remains: is this a short term phenomenon, or the start of what might become a widespread and ongoing land management practice?

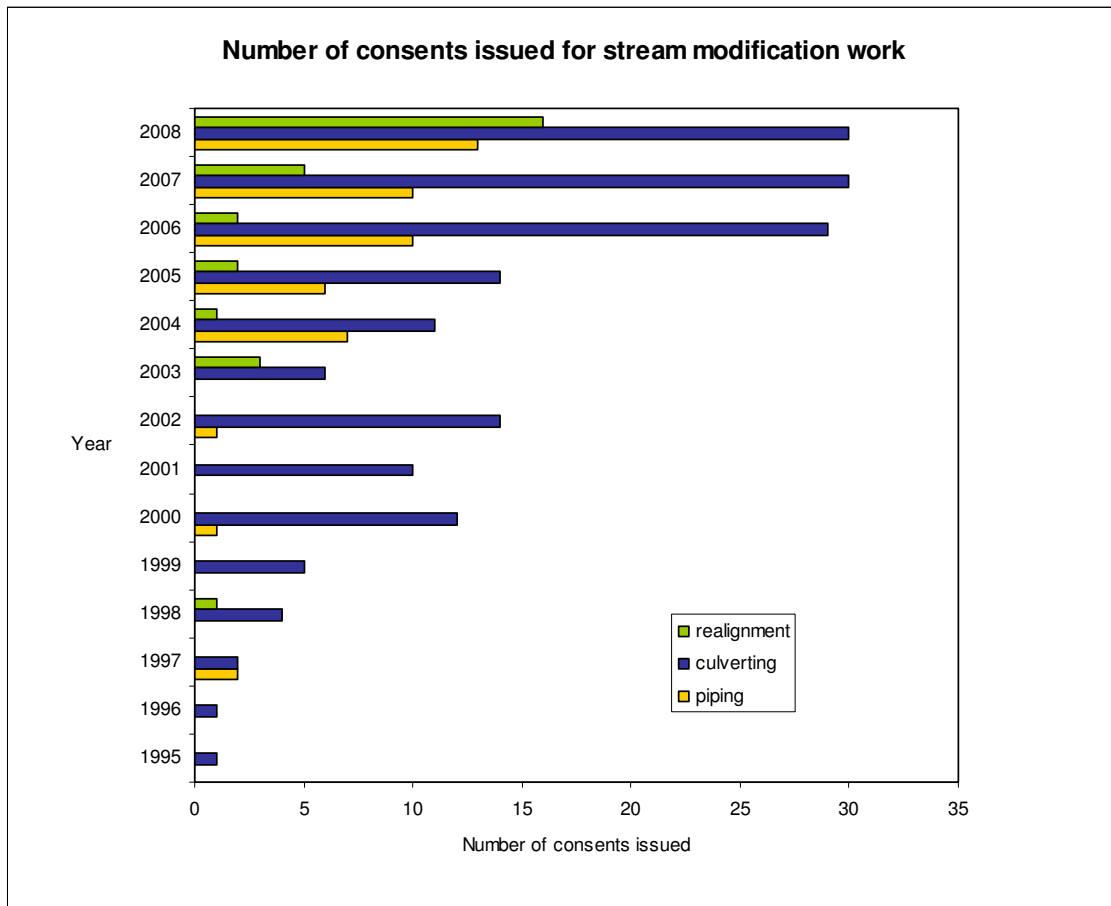


Figure 1 Number of consents issued for stream modification since 1995

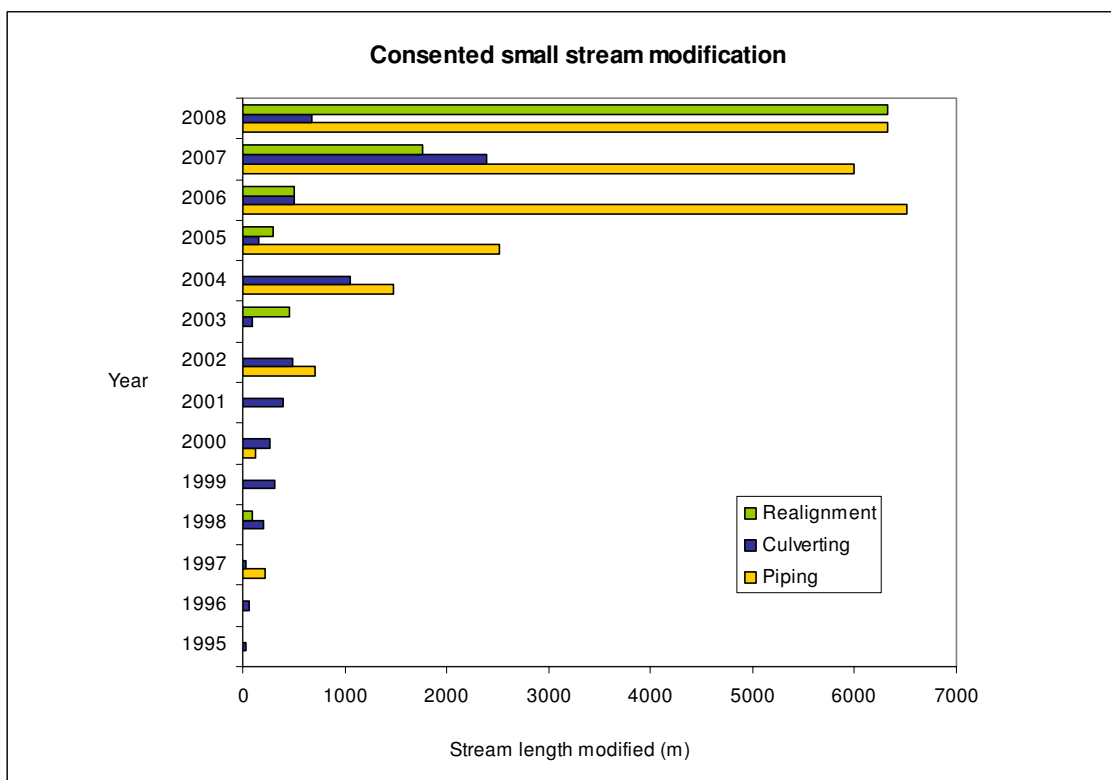


Figure 2 Total stream length modified per year for consents issued for small stream modification since 1995

4.2 An assessment of the true extent of stream modification

4.2.1 Methods

The increasing number of consents being applied for and granted in recent years (refer to section 4.1) has raised the question of whether there are significant cumulative effects on loss of habitat and other environmental effects as a result of small stream modification. However, there has been no way to date, to determine cumulative loss within a catchment taking into account consented, permitted, and historical stream modification.

Therefore, as part of this study, an investigation was made into the extent of small stream modification that had been undertaken prior to 2001, and between 2001 and 2007, using aerial photos flown in 2001 and 2007. Utilising the computer programme ArcView it was possible to overlay these two sets of photographs and detect changes in the layout of streams between these dates. As the later, 2007, set of aerial photos had better resolution, it was fairly easy to detect, with a reasonable level of certainty, streams that had disappeared in the later photo that were present in the earlier photo. A copy of the "Land Management (LM) Rivers" layer was created and edited with the stream modifications found through the comparison of the two sets of aerial photos. The computer program allowed for different types of stream modification to be given a distinct status to allow later quantification of the lengths of each type of modification. The area examined included the rural ring plain area, and excluded urban areas and the eastern hill country. Ground-truthing was undertaken with site visits to some areas where there was uncertainty.

The following categories were used:

- **Piped between 2001 and 2007:** where a stream that was visible in the earlier photo, was found to have disappeared in the later photo, it was assumed that it had been piped, and a line was drawn following the path of the stream before its loss.
- **Realigned between 2001 and 2007:** where the stream path had changed between the two photos, a line following the original path of the stream before realignment was drawn.
- **Piped before 2001** where a section of stream had obviously been piped before 2001 as there was open stream upstream and downstream of a section of flat open paddock. A straight line was drawn connecting the two open sections of stream to give a conservative estimate of the original stream length lost.
- **Realigned before 2001** – where stream paths followed an unnatural grid pattern aligned with paddock boundaries. Lines were drawn following the stream paths in their current form.

Figure 3 and Figure 4 show how the GIS and aerial photography were compared for both piping and realignment.

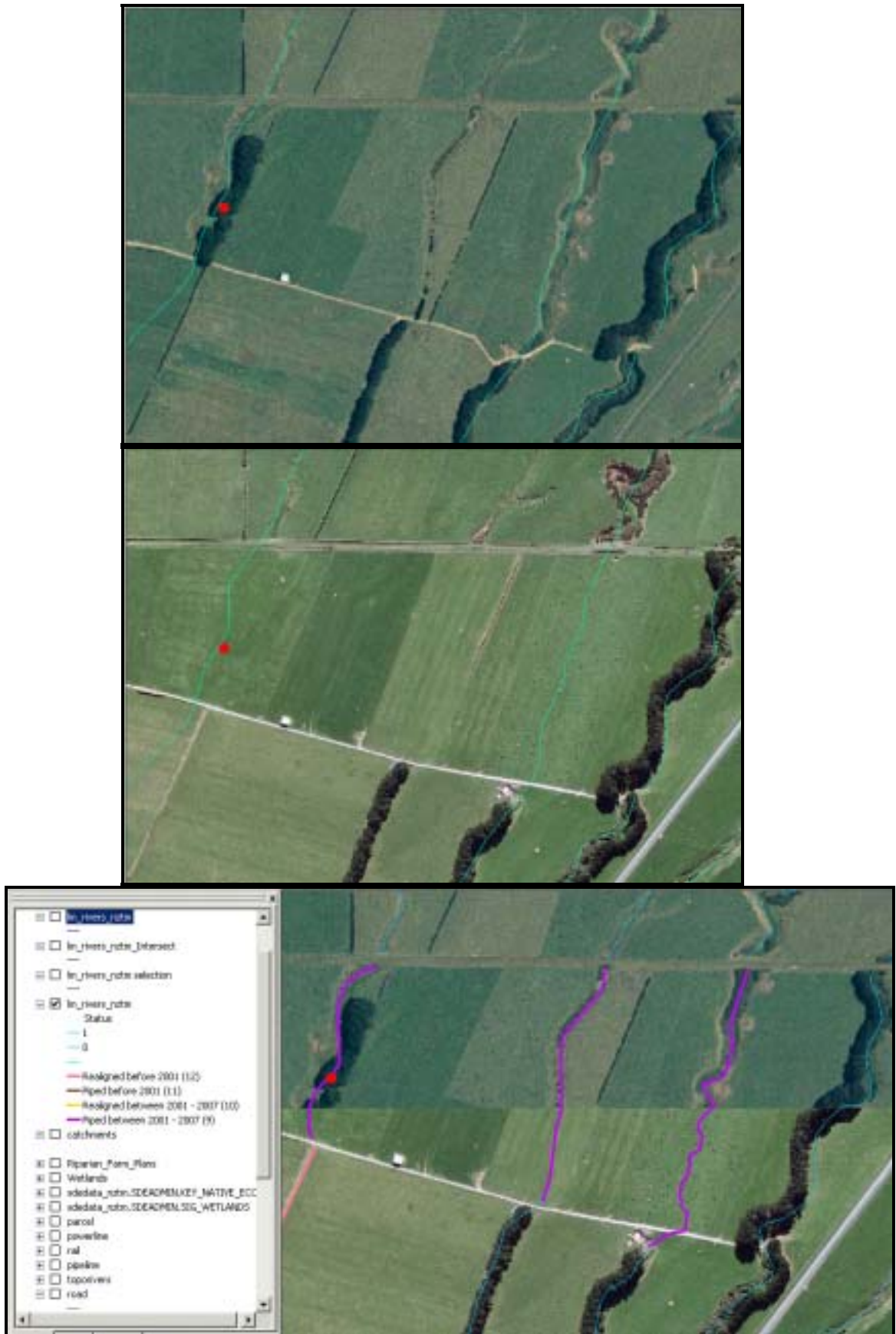


Figure 3 Three aerial views of the same location from the ArcView computer programme where three sections of stream have been piped between the 2001 photo (upper) and 2007 photo (middle). The lower photo shows the editable layer

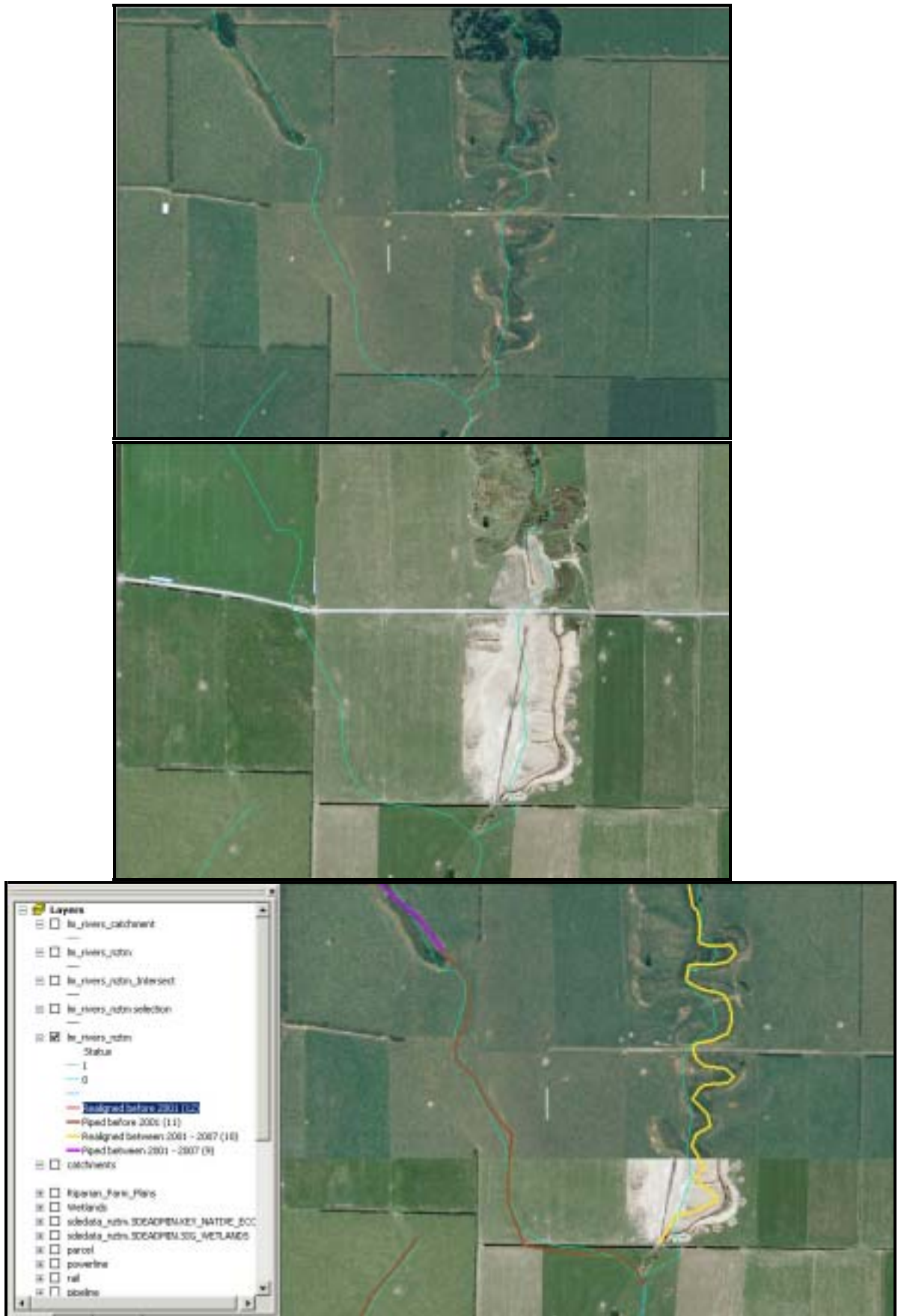


Figure 4 Three views of the same location from ArcView showing the 2001 photo (top) and the 2007 photo (middle) with the edited stream layer overlaid (below) showing sections of stream that have been straightened and piped

4.2.2 Results

From comparison of the aerial photos flown in 2001 and 2007 it was estimated that approximately 88.6 km of Taranaki streams on the ring plain were piped in the six years between these dates; 17.2 km of which was consented. Similarly 9.6 km of streams were realigned in the same period, of which 3.0 km was consented. This indicates that a significant amount of the stream modification work is either permitted, or has been undertaken illegally.

Sections of small stream that had obviously been realigned prior to 2001 due to their lack of meanders and alignment with paddock boundaries (i.e. in a grid pattern), or that had been piped prior to 2001, were estimated at 635.1 km of stream length (Table 4). As well as small stream modifications, this category would also include modified streams that are the remnants of larger wetlands that have historically been drained. This is likely to be a conservative estimate, as there is likely to have been modification historically that is not picked up in the aerial photos.

Of most concern is that the data in Table 4 also indicates that in the last six years (2001-2007) the total length of detectable modified streams in the region increased by nearly 15% compared to all modification prior to 2001. Further, most of this modification was streams which have been piped, where the length of stream lost has almost doubled in this six year period alone.

Table 4 Stream modifications detected through examination and comparison of 2001 and 2007 aerial photographs

	pre-2001	2001-2007	Total modification
Piped (km)	93.9	88.6	182.5
Realigned (km)	541.2	9.6	550.8
Total modification	635.1	98.2	733.3

At the regional scale, the total modification (including both historical and since 2001) shows that 5.5% of streams on the ring plain (the area that this exercise was limited to) have been modified (Table 5). Modification was highest in the South Taranaki District (7.2% of total stream length was modified), where the highest intensity farming occurs. By comparison, North Taranaki District (NPDC) had only 1.2% modification.

Table 5 Stream modification expressed as a proportion of total stream length on the ring plain and in the larger two districts

	Total modification		2001-2007 modification		Total stream length
	km	%	km	%	km
Ring plain	631.4	5.5	87.3	0.8	11503
STDC*	560.2	7.2	79.7	1.1	9105
NPDC*	56.5	1.2	11.6	0.3	7683

Note: Stratford District catchments were included in either STDC or NPDC depending on location of the majority of the catchment area. *District stream length totals include only streams that are on the ring plain.

Figure 5 shows the most-modified catchments (including all modifications) based on actual stream length modified. Stream modification was particularly high in the Waingongoro, Patea and Tangahoe rivers.

To get an indication of the catchments which have been under the most pressure from stream modification in recent years, the 20 most modified catchments were ranked (Figure 6) based on the actual stream length modified within each catchment over the period 2001-2007. While the Waingongoro, Patea and Kaupokonui rivers remain high on the ranking for more recent modification, there are a number of new catchments which appear to have greater modification since 2001 (Rawa, Waiokura, Mangatoromiro, Taungatara etc) compared to those where historic modification is also included.

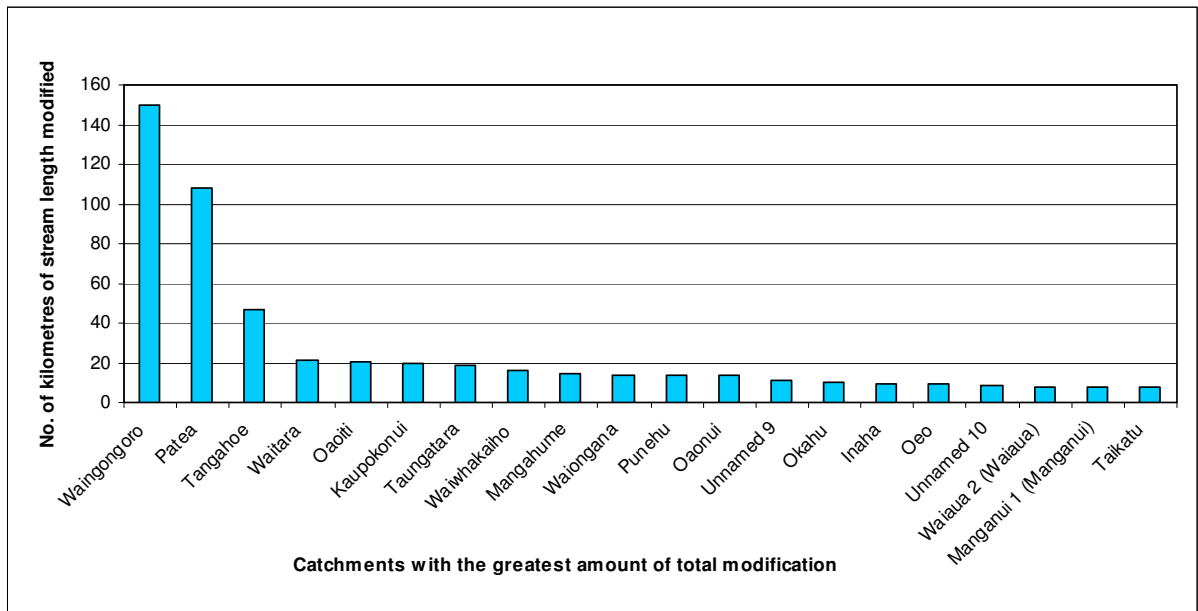


Figure 5 Estimated stream length modified from aerial comparison survey, including pre 2001 modifications

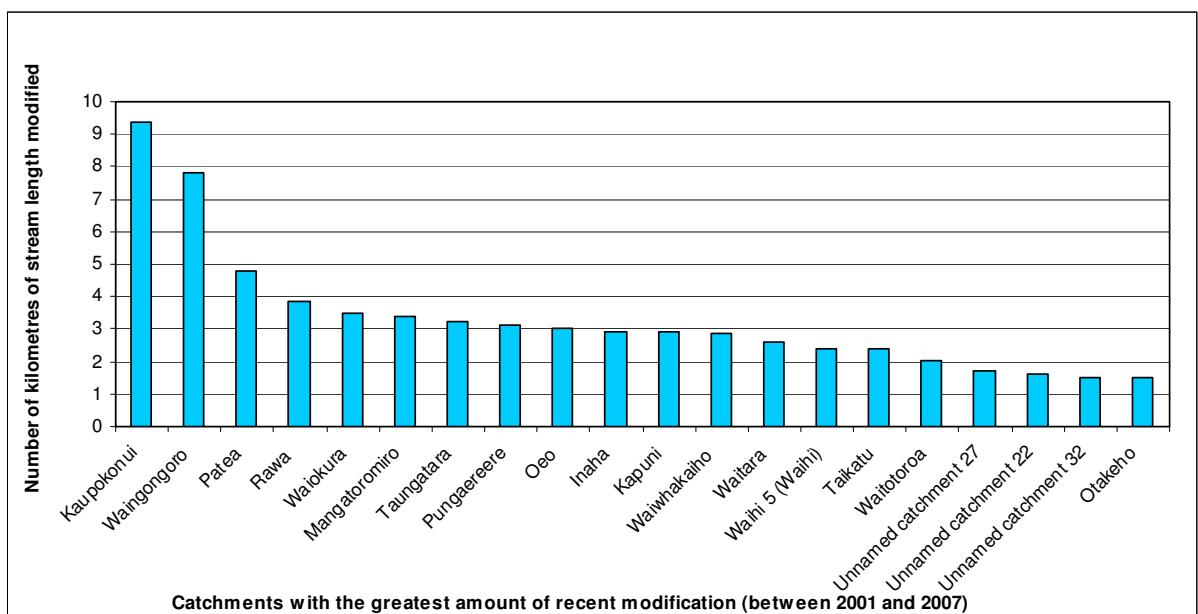


Figure 6 Estimated stream length modified between 2001-2007 from aerial comparison survey

Out of these catchments, of particular concern are the extent of modifications in the Rawa, Oeo, Inaha and Taikatu stream catchments. These catchments are generally small and originate below the National Park Boundary, so don't have a mountain-fed water source. Therefore their hydrology and ecology would be particularly sensitive

to small stream modification in their upper reaches. The Waiokura Stream catchment ranks highly in Figure 6 for level of stream modification. This catchment is included in Appendix 1B of the RFWP as being identified for enhancement of natural, ecological and amenity values, and life supporting capacity, and is also included in the NIWA research project into improved farm management and effects on water quality (Wilcock et al, 2009).

Six of the catchments identified in Figure 6 are also identified in Appendix 1A of the RFWP as having high natural, ecological and amenity values and life supporting capacity (Kaupokonui, Waingongoro, Patea, Kapuni, Waiwhakaiho and Waitara rivers).

To put the degree of modification into perspective, the data for the stream lengths modified within each catchment between 2001 and 2007 was then compared with the total length of just the 1st and 2nd order streams in that catchment using information from the River Environment Classification (REC) GIS layer. Only 1st and 2nd order streams were included as the maps indicated that these small streams were where the majority of modification was occurring and these were the streams of most concern in this report. This enabled an estimate of the percentage of 1st and 2nd order stream length already modified in each catchment to be obtained, and a ranking of catchments based on the proportion of their small streams that had been modified, this data is shown in Figure 7. The potential inaccuracy of this method needs to be acknowledged in that the stream lengths of the REC layer will not correspond absolutely with the streams in the Land Management Rivers GIS layer (which is updated as individual farm riparian plans are completed). However the method serves to give an accurate ranking of the catchments based on the proportion of small stream modifications that have taken place in them.

When the percentage of stream length modified is used for comparison, a lot of the larger catchments with the greatest length of modification present in Figure 5 and Figure 6 are no longer ranked highly. As such, modification is relatively small in these large catchments.

Highly represented in the group of more-modified catchments shown in Figure 7 are small (many unnamed) coastal catchments in southern ring plain dairying areas. While the 1st and 2nd order streams in these catchments are between 30 to 50% modified, some of the small coastal catchments are almost 100% piped or channelised when both historical and recent modification is considered.

Also ranked highly in Figure 7, is the Mangati Stream catchment (near Bell Block, North Taranaki). This is a small, highly industrialised/urbanised catchment, which is also identified for enhancement in Appendix 1B of the RFWP as a stream of very poor water quality. Just over 10% of its 1st and 2nd order streams have been modified since 2001 (and total modification is 9% of the whole catchment).

The Waiokura Stream is also listed in Appendix 1B of the RFWP, and in Figure 7. This catchment had 7% of first and second order streams modified between 2001 and 2007.

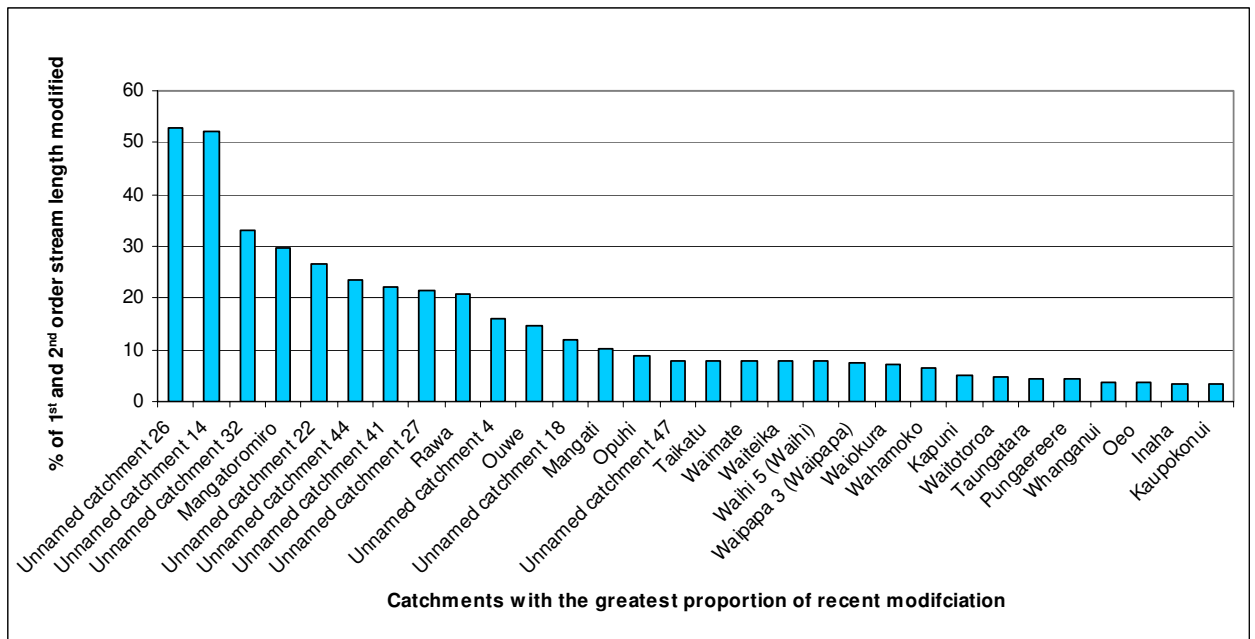


Figure 7 Estimated percentage of 1st and 2nd order stream length that was modified between 2001 and 2007. Catchments have been ranked and graph shows only those catchments with the greatest proportion of stream modification between these two dates

Figures 8-11 show some of these individual catchments with the different modification types mapped.

This analysis highlights that while larger catchments such as the Waingongoro, Patea and Kaupokonui rivers have had the most modification in terms of kilometres modified (historically and/or since 2001), when it is considered as a proportion of the whole catchment, it is generally the smaller catchments on the southern ring plain which are significantly affected by stream modifications. Figure 8 shows the extent of modification in the Kaupokonui River is a small proportion of the catchment as a whole, most of which occurs in small pockets throughout the catchment. At this level, the current extent of modification would be unlikely to exhibit significant cumulative effects from such modification.

Smaller catchments such as the Taikatū and Mangatoromiro streams are examples where stream modification is more likely to be at a level where cumulatively, effects could become significant. In the Taikatū Stream catchment (Figure 9) much of the modification has been historical, whereas in the Mangatoromiro Stream (Figure 10), most of the piping has been undertaken in recent years. The Rawa Stream catchment has had a significant concentration of modification in its headwaters (Figure 11).

These maps will be very useful for consents officers when assessing new applications for cumulative effects of stream modification. However, it is recommended that further ground-truthing of the GIS aerial photo comparison work be undertaken to confirm the accuracy of the GIS analysis (recommendation 4, section 8). Land management officers now record any stream modification work in the LM Rivers layer when they are developing new riparian plans or monitoring existing plans. Cross referencing this layer to the extent of modification will also increase the accuracy of the aerial photo comparison.

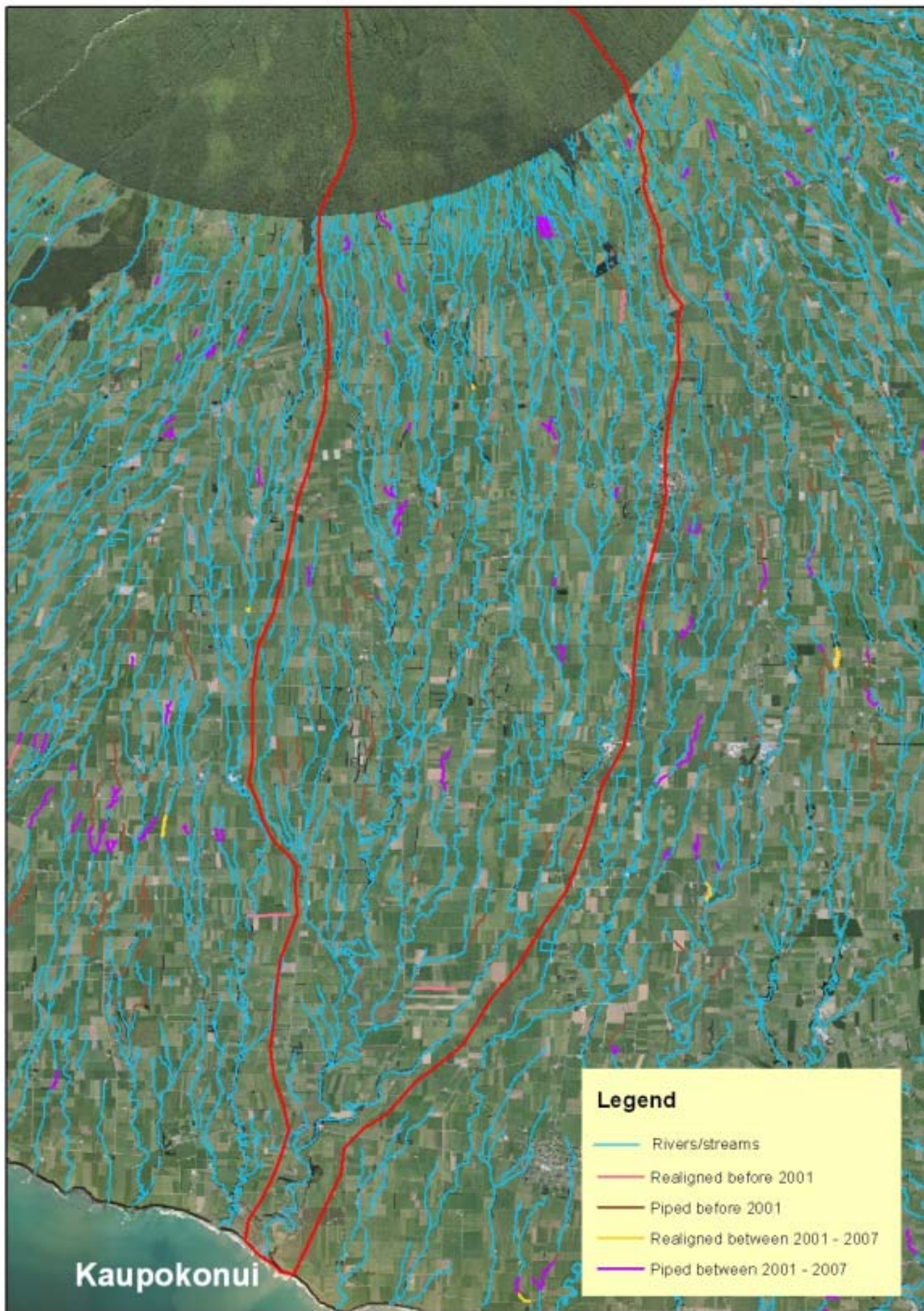


Figure 8 Mapped extent of stream modification in the Kaipokonui River catchment



Figure 9 Mapped extent of stream modification in the Taikatu Stream catchment

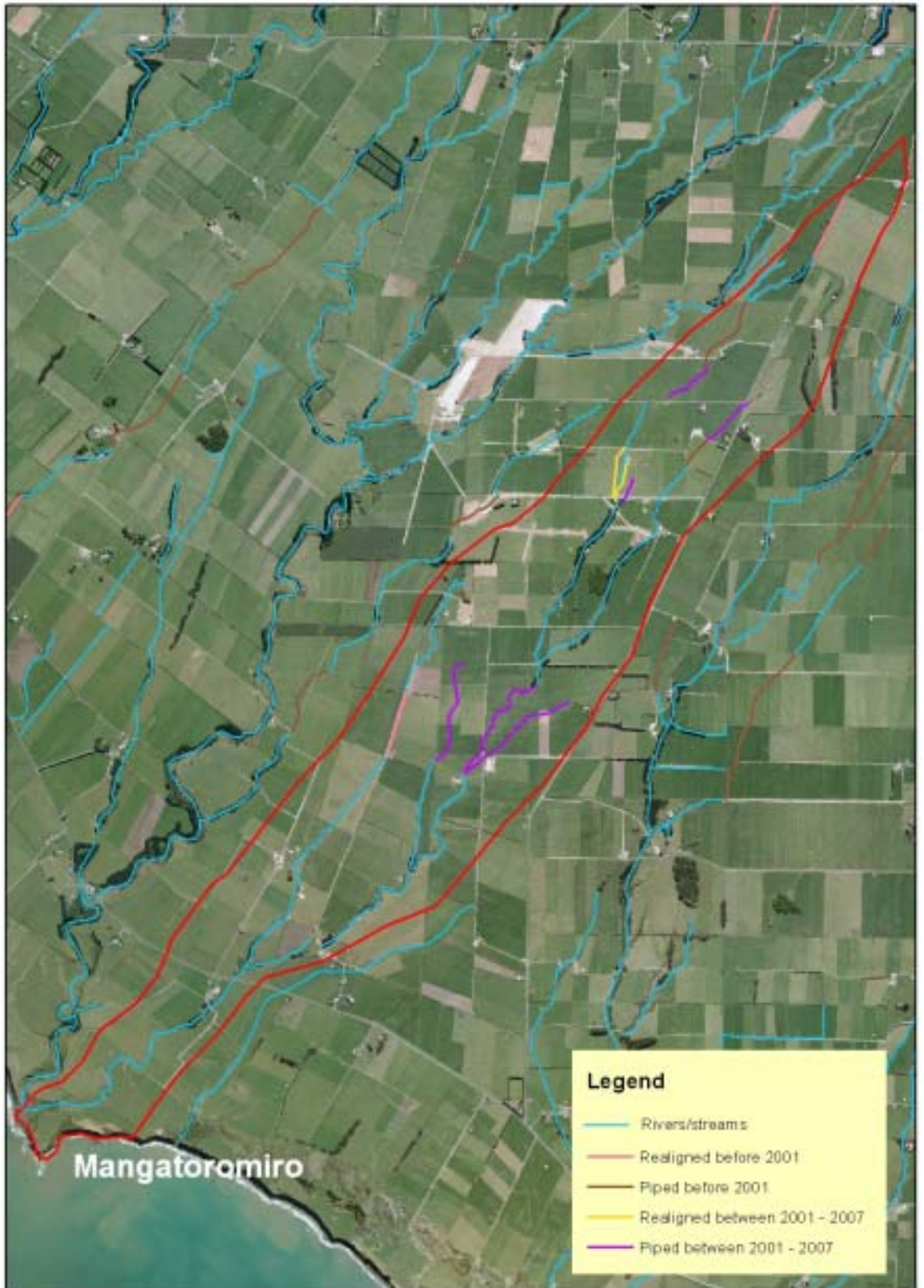


Figure 10 Mapped extent of stream modification in the Mangatoromiro Stream catchment

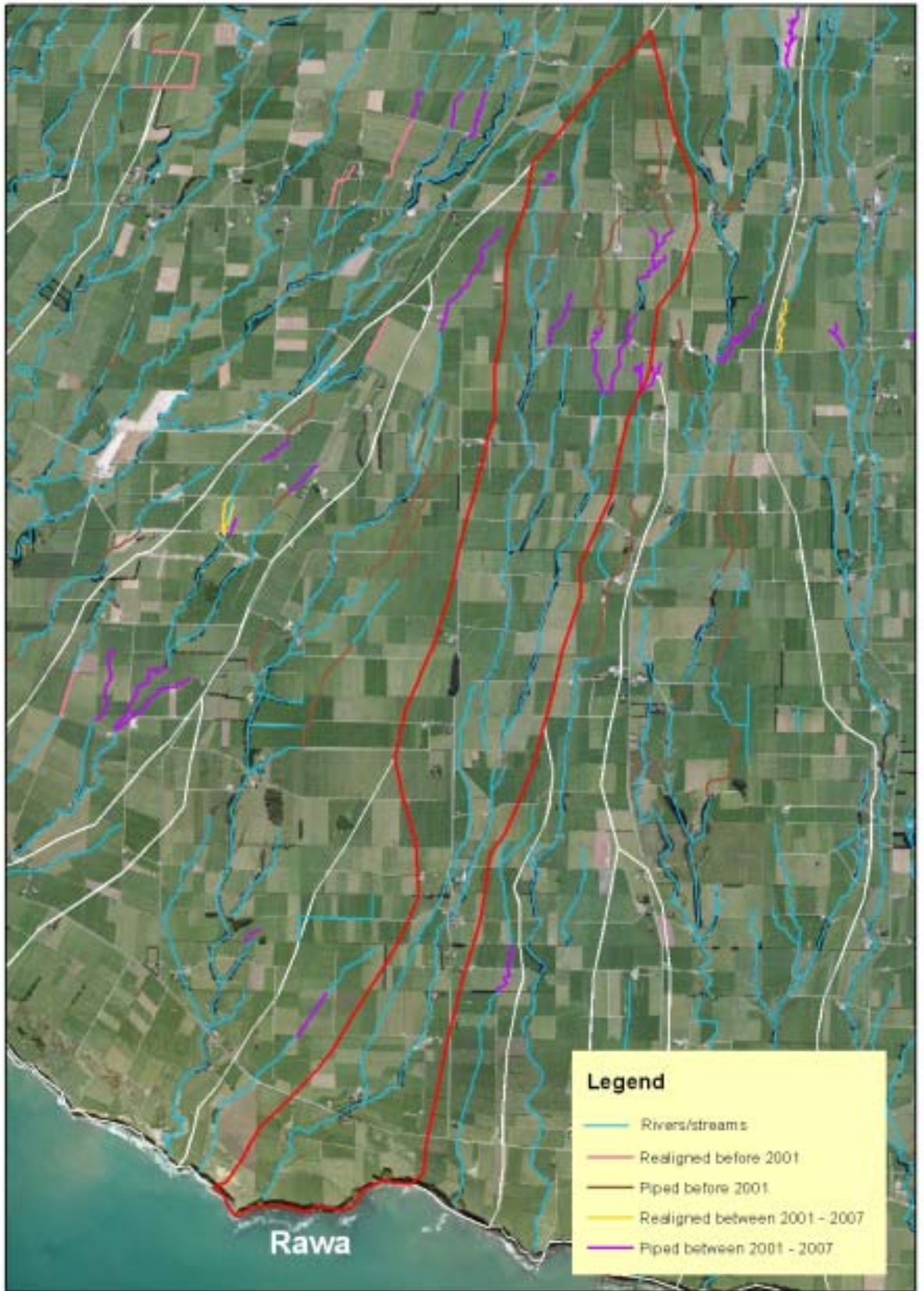


Figure 11 Mapped extent of stream modification in the Rawa Stream catchment

The RFWP allows some stream modification (and the associated loss of habitat) through its permitted activity rules. But, how much of the modification undertaken to date is actually permitted, considering there is a large proportion of modifications that do not have resource consents? A sample of 184 modifications found through aerial comparison (i.e. undertaken between 2001 and 2007) were further investigated with regard to the RFWP rules to determine their legality. Historical modification was not included as the RFWP only became operative in 2001.

Areas that had been piped were examined to determine whether the length of pipe was well over the allowable 25 m threshold set out under Rule 57 of the RFWP (this rule was used to eliminate structures associated with access from the analysis, as piping streams for land improvement is covered under Rule 64 which is discretionary and does not specify conditions on catchment area or length of pipe). This investigation indicated that approximately 15% of the stream piping (for land improvement) conducted between 2001 and 2007 had a resource consent and 25% was permitted under the RFWP (the area piped was determined a wet paddock (with no defined channel) rather than a stream). The remaining 60% of modifications did not have a consent, which, based on observations from aerial photography, makes them potentially illegal.

Stream sections that had been realigned were measured to determine whether the length modified was easily over 200 m or the upstream catchment was well over 25 ha as set out in Rule 74 of the RFWP. Ten percent of 18 stream realignments had resource consents, and a further 40% were permitted, leaving 50% of realignments undertaken between 2001 and 2007 as potentially illegally undertaken.

5. Policy framework

The Resource Management Act 1991, 'Regional Policy Statement for Taranaki' (TRC, 2008e) and 'Regional Freshwater Plan for Taranaki' (TRC, 2001) provide the framework for managing stream modification in Taranaki. These documents have been through the public notification process and as such, represent the management framework that the regional community have agreed is acceptable going forward. This section reviews the relevant policies and rules which relate to the management of small stream modification, and assesses the clarity and effectiveness of these policies and rules in relation to information gathered in this report.

5.1 Resource Management Act

Section 13 of the Resource Management Act 1991 places restrictions on certain uses of beds of lakes or rivers. No person may place any structure in the bed of a river unless it is expressly allowed by a rule in a regional plan or through a resource consent.

Reclaiming or draining the bed of a river or lake is similarly restricted by section 13 (1)(e) which states that no person may reclaim or drain the bed unless expressly allowed by a rule in a regional plan or through a resource consent. Piping a small stream and recontouring the land for land improvement purposes constitutes a reclamation.

5.2 Regional Policy Statement

The 'Regional Policy Statement' [RPS] includes an issue for managing the effects associated with the use and disturbances to river and lake beds (Issue 6.6). River and Lake Beds (RLB) OBJECTIVE 1 seeks to 'To enable appropriate use of and disturbance within river and lake beds in Taranaki while avoiding, mitigating or remedying any adverse effects of activities on the environment.' RLB Policy 1 sets out the potential adverse effects arising from the use or disturbance of river beds, such as the effects on natural character, ecological and amenity values, indigenous biodiversity values, effects on fish passage etc.

The RPS also addresses the issue of land drainage and associated diversion of water (Issue 6.5). The RPS acknowledges the positive effects of land drainage on the productivity of the land and so benefits to individual landowners as well as the regional and national economy. However, the RPS identifies the following potential adverse effects of land drainage:

- increased run-off of water from land producing higher peak flows, more rapid flow recessions and lower stream flows during dry periods;
- impacts on natural character, ecological and amenity values of water bodies;
- increased rates of bank erosion and sedimentation;
- degradation and loss of aquatic habitat;
- impacts on indigenous biodiversity values, fisheries values and habitat of trout; and
- unintended impacts on neighbouring properties and stormwater systems.

The RPS specifically notes that the piping of small streams and the maintenance of some existing drains can adversely affect Taranaki's remaining remnant wetlands by

reducing the quantity and quality of habitats available for wetland species, adversely affecting the natural character of wetlands, and make wetlands more vulnerable to the impacts of land management practices.

Land Drainage and Diversion (LDD) Objective 1 aims *'To recognise and provide for the land production and management benefits of appropriate land drainage and associated diversions of water from land in the Taranaki region while avoiding, remedying or mitigating any adverse effects on the environment.'*

LDD Policy 1 recognises and provides for the land production and land management benefits of land drainage and associated diversions of water while avoiding, remedying or mitigating any adverse effects on the natural character of rivers and wetlands, water quality, hydrology, ecological and amenity values, relationship of Tangata Whenua, flooding and erosion etc.

The methods in the RPS to achieve this objective and policy involve the maintenance of a regional plan with objectives, policies and methods of implementation addressing the effects of land drainage, the application of regional rules to control land drainage and diversions of water that have potential or actual adverse environmental effects, and the provision of advice, information and assistance on good land drainage practices including the protection of wetlands.

5.3 Regional Fresh Water Plan

5.3.1 Stream definitions

Rivers are defined in the RFWP (and in the Act) as a continually or intermittently flowing body of freshwater and *involves a stream and modified watercourse*, but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation and *farm drainage canal*). Policy 6.1.4 of the RFWP further defines a small stream as those with flows less than 500 L/s. This would include perennial, intermittent and ephemeral streams.

Thus small streams, either permanently or intermittently flowing, are considered rivers. However, small streams often start out much less clearly defined on the ground, and it is often difficult to determine when a seep area, or a 'flow path' becomes a stream. In such case the small stream may more closely resemble a wetland or swampy wet area.

Wetlands are defined in the RFWP as including 'permanently or intermittently wet areas, shallow water and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions' (the meaning adopted in the Act). The Plan notes (in Issue 6.8) that the essential features of wetlands are a terrestrial/aquatic boundary and the ecosystems that are adapted to living there. It goes on to note that the variety of water bodies and land forms that come within the definition of a wetland means that many wetlands also come within the definition of a river or lake.

Farm drainage canals where they have been artificially created are not considered a stream, unless the drain was created by straightening an existing small stream. Farm drainage canals are not defined in the RFWP and it is potentially difficult to

distinguish between a farm drainage canal, established through land drainage (i.e. an artificial watercourse), and 'drainage canals' which were originally a natural stream moved to the edge of a paddock and so would be considered a 'modified watercourse' and thus fall under the definition of a river.

A recent Environment Court case in Southland demonstrates the relevance of defining a 'farm drain' and confirms the definition given above (Invercargill District Court decision, March 2009). In this case a small waterway was diverted by directing its flow through two nova flow pipes for the purposes of land improvement. The sole issue in this case was whether the works carried out by the defendant were in relation to a bed of a river rather than in an artificial water course (a farm drainage canal). Evidence presented cited that a farm drainage canal indicated a small surface canal other than one that incorporates a natural occurring body of water. The judge found that the watercourse was a river for the purposes of section 13(1)(b) of the RMA, based in part on historical aerial photos demonstrating the 'drain' was historically a natural water course; and the defendants were found guilty of the offences charged.

5.3.2 Relevant objectives and policies

Given the definitions of small streams, and the difficulty of determining when a seep or wet area becomes a stream, the modification of small streams can potentially fall under a number of objectives and policies in the *Regional Fresh Water Plan for Taranaki* [RFWP]. These include ones that relate to the disturbance of beds of rivers, to land drainage and to wetlands as well as the general objectives relating to natural, ecological and amenity values.

This section discusses this suite of objectives and policies.

5.3.2.1 Natural, ecological and amenity values

Issue 3.1 of the RFWP includes objectives relating to maintaining and enhancing the natural character of all Taranaki's rivers and wetlands (OBJ 3.1.3), safeguarding the life-supporting capacity of water and aquatic ecosystems (OBJ 3.1.4) and promoting sustainable management of the environment by recognising the differences between rivers and streams (OBJ 3.1.6). Policies 3.1.2 and 3.1.3 outline a number of matters that will be regarded in managing potential adverse effects of activities on natural character, ecological and amenity values, and the life-supporting capacity of freshwater.

The RFWP recognises a number of catchments (in Appendix 1A of the Plan) that are river and stream catchments with high natural, ecological and amenity values. Policy 3.1.5 notes that the high natural, ecological and amenity values of those rivers and streams listed in Appendix 1A will be maintained and enhanced as far as practicable.

5.3.2.2 Adverse effects on the environment from uses of river and lake beds

Modification of small streams (straightening, realigning and piping) falls under Issue 6.6: Adverse effects on the environment from uses of river and lake beds. The Plan recognises that the excavation of the bed may divert river flows and change channel morphology, causing erosion of the bed and banks, disturbing habitat and creating

barriers to fish movement. The development of floodplain areas is also recognised to increase the risk and adverse effects of flooding and erosion hazards. The Plan contains objectives relating to the sustainable management of the beds of rivers and lakes, and the avoiding, remedying or mitigating the adverse effects of activities (OBJ 6.6.1 and OBJ 6.6.2). Policy 6.6.4 relates to the removal of vegetation and other material and temporary disturbances, Policy 6.6.5 prohibits the extraction of material from river beds, Policy 6.6.6 sets out times to avoid disturbing river beds and Policy 6.6.9 sets out matters the Council will consider when assessing resource consent applications for uses of river beds.

The RFWP does not specifically address the issue of reclamation.

Piping of small streams involves installing a length of pipe. This constitutes a structure in a waterway. Policy 6.6.1 sets out those matters that will be taken into consideration when placing a structure into a waterway, such as the need to avoid, remedy or mitigate the adverse effects on the habitat of aquatic and terrestrial flora and fauna, the effects of flooding and erosion and the adverse effects on water quality and aquatic life. Policy 6.6.2 reiterates the importance of providing for fish passage, and Policy 6.6.3, the need for structures to convey flood flows.

At the time of notification of the RFWP plan, the issue of stream modification (and in particular, stream piping for land improvement) was considered to be a low frequency activity. Thus whilst there are a number of relevant policies, the specific issue of stream piping is not mentioned in the RFWP.

5.3.2.3 Land drainage

Issue 6.7 of the RFWP addresses the adverse effects on the environment from land drainage. It is important to note that in definition, land drainage (increasing drainage flows to dry out pasture) is different from land reclamation (piping an open stream channel and over-filling to create new pasture). Land drainage is recognised as having a positive effect of increasing the productivity of the land and a significant factor in ensuring that Taranaki is a highly productive agricultural region. However, the Plan also goes on to note that land drainage may result in adverse effects on the environment, effects on hydrology, effects on water quality, and effects on remaining wetlands.

In considering submissions on the *Proposed Regional Fresh Water Plan* during its development, the Committee noted that remnant wetlands were not the target of land drainage in Taranaki, and that land drainage is directed towards improving pastoral production and maximising the production potential of pastoral land (TRC, 1999).

The objective relating to land drainage is OBJ 6.7.1 which aims *'To promote the sustainable management of land drainage while avoiding, remedying or mitigating actual or potential adverse effects on the environment.'* Policy 6.7.1 then set out those matters that will be considered in relation to land drainage activities, such as the 'natural character of rivers and wetlands, the natural, ecological and amenity values of any water body, and matters such as flooding and erosion'. This is to ensure that land drainage activities will be managed to avoid, remedy or mitigate adverse effects on the environment.

5.3.2.4 Wetlands

The RFWP contains objectives (6.8.1 and 6.8.2) relating to the protection of wetlands from inappropriate use and development or avoiding, remedying or mitigating the adverse effects of appropriate use. Policy 6.8.3 notes the Council's intention to promote the protection of all wetlands in the region from inappropriate use and from the adverse effects of appropriate use. Policy 6.8.4 sets out matters that will be considered when assessing resource consent applications for activities affecting wetlands. While small streams are not considered to be wetlands, the piping or realignment of streams could affect adjacent wetlands, therefore these policies have additional relevance in relation to stream modification.

5.3.3 When consents are required for stream modification under the Fresh Water Plan

The Resource Management Act restricts the activity of modifying the bed of a river, or installing a structure such as a pipe for piping a stream, unless such activities are specifically allowed for through a regional plan or through a consent.

For example, the RFWP specifically provides for the construction, placement and use of a culvert for access purposes (Rule 57). Rule 57 permits the construction, placement and use of a culvert in, on, under or over the bed of a river as long as (amongst other things):

- the cross sectional area of the river bed is no greater than 10 m²;
- the culvert is no greater than 1 m in diameter, with no more than 1 m of fill over the culvert;
- the culvert is no more than 25 m in length; and
- there shall be no significant adverse effects on aquatic life or instream habitat [note this provision includes cumulative effects as a result of a loss of habitat].

Generally landowners wishing to pipe a length of stream for the purposes of land improvement do not meet the permitted standards for Rule 57. The RFWP does not include a rule permitting the installation of a longer culvert or pipe into a stream, and thus this activity falls under the default rule, Rule 64 – the construction, placement and use of any structure that does not meet the standards, terms and conditions of rules 52-63. Therefore in cases where a landowner is piping a stream for the purpose of land improvement, a resource consent is required under Rule 64.

Other uses of rivers and lake beds are covered by Rules 69-76. The realignment or modification of a stream or river is addressed by Rule 74. This rule permits the realignment or modification of a stream or river as long as (amongst other things):

- the catchment area upstream is no more than 25 ha;
- the drainage channel shall be no greater than 4 m² in cross sectional area;
- the maximum length of stream that can be realigned or modified shall not exceed 200 metres³; and
- there shall be no significant adverse effects on aquatic life or instream habitat [note this provision includes cumulative effects as a result of a loss of habitat].

³ For the purpose of this rule the length of river or stream to be realigned or modified is defined as the length of river or stream on any particular property or contiguous property and includes any length of realignment or modification undertaken since the date the plan became operative.

Thus in cases where the landowner is modifying, straightening or channelling a stream, Rule 74 sets out the standards where it is a permitted activity, and if those standards can not be met, a resource consent is required under Rule 76 (the default discretionary rule where standards for a permitted activity can not be met).

If the activity involves the diversion of water for the purpose of land drainage, the activity is addressed by Rule 77. Rule 77 permits the diversion of water for the purpose of land drainage as long as (amongst other things):

- area of land drained shall be no greater than 10 ha;
- no wetland over 5 ha is to be drained;
- drainage shall not cause flooding;
- drainage channels are no greater than 300 mm in diameter or greater than 4 m²; and
- there shall be no significant adverse effects on aquatic life or instream habitat.

Activities that do not meet the permitted standards and conditions are required to obtain a resource consent under Rule 79, which is a discretionary activity.

The diversion of water for the purpose of land drainage (Rule 77) notes that for the purpose of a condition to that rule, the term 'wetland' does not include artificially created wetlands or wet pasture comprising exotic or juncus rushes.

Council staff have experienced some challenges when determining which rule applies for the activity of piping a stream for land improvement purposes, i.e. whether the activity relates to land drainage (Rule 77) or stream modification (Rule 74) or installing a structure, or pipe (Rule 64). This is largely due to the difficulty of applying the definitions on the ground, and the difficulty of determining when a seep becomes a flow path. It is recommended that the next review of the RFWP could clarify the definitions, consider including a rule relating to the activity of reclaiming a stream through piping it, and clarifying which rules apply to the various land improvement type situations. Then the different rules apply to different activities (recommendations 9 and 10, section 8).

In the interim, an information sheet could also be produced for Council staff and applicants to help clarify what rules apply in what situations, utilising photos to show the various types of streams/flow paths which would require resource consent. This is encompassed in recommendation 13 in section 8.

5.3.4 Addressing cumulative effects of stream modification

Small stream modification, whether permitted or consented, is the type of activity where there is the potential for effects to be cumulative. The term 'Effect' in both the RFWP and the Act includes 'any cumulative effect which arises over time or in combination with other effects, regardless of the scale, intensity, duration or frequency of the effect'. The definition of integrated management involves recognising that effects may occur immediately, may be delayed or may be cumulative. The Plan recognises the potential for cumulative effects of point-source discharges, and proposes methods to deal with them. Cumulative effects of water abstraction are addressed through the adoption of an approach that requires water

abstractors to leave sufficient water in a river to sustain two thirds of the habitat that would be found at the mean annual low flow.

Consideration of the potential cumulative effects of stream modification is not discussed specifically in the RFWP, although as noted above, is a key component in the definition of 'effects', and therefore does need to be considered.

The concept of cumulative effects has been described in case law (*Gargiulo v Christchurch City Council*, C137/00) as '...any one incremental change is insignificant in itself, but at some point in time or space the accumulation of insignificant effects becomes significant.' (cited in Milne, 2008). Another case (*Outstanding Landscape Protection Society Inc v Hastings District Council*, WO24/07) noted that 'If a consent authority could never refuse consent on the basis that the current proposal is...the straw that will break the camel's back, sustainable management is immediately imperilled.'

Milne (2008), in his paper referenced below concluded that the scope and meaning of cumulative effects is not settled. However, he did conclude that:

- Cumulative effects can and must be considered when determining a resource consent application.
- Cumulative effects include the effects that would result if the activity for which consent is sought is approved, in combination with the effects of other existing activities.
- Cumulative effects require consideration on a case-by-case basis and there are circumstances where such cumulative effects warrant the declining of consent.
- 'Precedent effects' are not cumulative effects, but are a relevant consideration.
- Cumulative effects include the additive effects of other possible but not yet occurring permitted activities and the effects of granted but not yet implemented consents.

This suggests that in considering consents to modify small streams, that the amount of consented, or permitted land drainage and stream realignment undertaken, or able to be done through the permitted rules, are matters to be considered. In the past, this has been difficult in Taranaki as the extent of existing stream modification has been unknown. However, now that the extent has been mapped for the ring plain, Council staff can be better informed of the potential for cumulative effects. GIS allows this information to be easily extracted for any catchment or sub catchment, making assessment of resource consent applications easier. It is therefore recommended that Council staff should utilise this GIS layer as standard practice (refer to recommendation 14 in section 8) when assessing resource consent applications.

Milne then discusses how to determine when enough is enough, i.e. determining the point in time or space where the accumulation of insignificant effects becomes significant. He identifies that there are three tasks which are discussed in light of the small stream modification issue:

- Identifying the resource – where, what and how much: Taranaki is well endowed with small streams as a region;
- Identifying the value based components of resources: these include the biodiversity values, hydrologic values which are discussed in this report, but also the economic values of undertaking the land development, and the current and

potentially changing community perceptions of the relative weight of these values;
and

- Determining the sustainable limits of the resource: while the region as a whole may be well endowed with small streams, individual catchments may be getting to a point where further stream modification may cause adverse effects that are at a 'tipping' point. Determining that 'tipping point' for individual catchments would need to take into consideration the values, alongside the extent of historic and current stream modification.

Considerable work has been recently undertaken to examine the 'tipping point' for terrestrial systems drawing on the species loss curves (which show that the rate of species loss markedly increases at a particular point of habitat loss) and habitat fragmentation. This has enabled the development of 'threatened environments' – i.e. those where there is now less than 10% of the original indigenous vegetation remaining are recognised as being at the greatest threat (Walker et al 2008). It may also be appropriate to identify such triggers for the loss of small stream habitat within a catchment. Taranaki has a significant number of small streams (75% of total stream length). The work undertaken in section 4 of this report demonstrates that stream modification work has been undertaken in 5.5% of ring plain streams, and smaller catchments, in particular, have been identified as being already highly modified, or vulnerable to significant modification. Many of these catchments are not considered to have high value (i.e. are not identified in Appendix 1A of the RFWP) and habitat intactness (in terms of riparian vegetation) has already been highly modified. Therefore assessing whether further modification of these catchments is acceptable is covered under the all encompassing policies 3.1.2 and 3.1.3 in relation to effects on natural character, ecological and amenity values, and life supporting capacity. As such, recognising the value of small streams as discussed in this report will be important to assess resource consent applications under these policies.

Consideration of a 'trigger level' in these catchments could be a useful tool for assessing resource consent applications. As the cumulative extent of modification can now be assessed with relative ease, a cut off point parallel to that used for water allocation (i.e. 2/3 habitat retention) could be applied assessing existing modification upstream of the point of the proposed modification (refer to section 5.3.4). Literature on trigger levels is sparse and it would be worth conducting further investigations into an appropriate loss of habitat (considering much of the small stream habitat is highly modified from its 'reference' condition). As such it is recommended (through recommendation 3 in section 8) that further investigations are conducted to determine if a trigger level approach is appropriate. Based on this, draft guidelines can be developed for Council consideration.

5.3.5 Mitigating loss of habitat

The RFWP for Taranaki recognises that adverse effects need to be avoided as far as practicable, or remedied or *mitigated* (Policy 3.1.4). The Council regularly requires off-set mitigation (primarily in the form of completion of riparian planting within a certain time frame) for other activities such as water abstraction, and increasingly this approach is also being applied to resource consent applications for stream modification work.

The RFWP includes a method that notes that the Council will promote the retirement, establishment of planting or riparian margins as an appropriate method for avoiding, remedying or mitigating the adverse effects of erosion on the banks of rivers and lakes. Thus where streams are realigned, there is a clear indication in the RFWP that riparian planting will be used to mitigate adverse effects of bank erosion. Policy 6.6.9 states that when assessing resource consent applications for uses of river and lake beds the Council will consider possible mitigation measures and Policy 6.6.1 notes that the placement of structures will be managed to mitigate adverse effects on water quality and aquatic life.

Policy 6.3.2 and 6.3.3 noted that existing riparian vegetation will be protected and enhanced for the purpose of maintaining the effective functioning of riparian zones, and that the Council will promote the restoration of riparian margins where riparian vegetation will provide net water quality benefits.

Therefore there is strong policy support for requiring off-set riparian enhancement to mitigate the effects of stream modification consents.

However, as these applications are often considered 'minor' or small scale works, determining the amount of mitigation required can be difficult. The pragmatic approach adopted to date by consenting officers has been to require applicants to restore the same amount of riparian planting elsewhere on their properties to mirror the amount of stream habitat being lost. This approach works when the applicant has a riparian plan, and when other streams on their property are in need of enhancement work. For example, standard consents for piping applications include the following:

1. **<if a riparian plan already exists>**The consent holder shall undertake and maintain fencing and riparian planting in accordance with the Riparian Management Plan for the property [RMP xxx] within three years of the granting of this consent along XX metres of stream bank [i.e. (XX metres/2) on each side of the bank]; **or**
2. **<if no riparian plan exists>**Within three months of the issue of this consent the consent holder shall make contact with the Taranaki Regional Council and request that it prepare a riparian management plan for the property. The Riparian Management Plan shall include the establishment and maintenance of fencing and planting along XX metres of stream bank within X years of the granting of this consent.

However, encouraging 1:1 mitigation may not consider if the restoration will achieve the appropriate mitigation (i.e. no net loss of habitat) and does not take into account time lags between the loss of habitat, and the gain which may not be attained until some years after initial planting. The Auckland Regional Council has developed and implemented a Stream Ecological Valuation (SEV – see section 5.4.6) which assesses the value of the stream and allows the calculation of a mitigation ratio. It is recommended (through recommendation 15) that this technique be assessed for implementation in Taranaki to enable more appropriate mitigation. Further, information on the ecological value of a stream submitted with a consent application can, at present, be limited (as there is usually none available at a particular site). Requiring an SEV to be undertaken as part of an application for stream modification work would also provide valuable ecological data which can be used when assessing

the effects of the application. This report has highlighted that small streams can have high ecological values and this will help to assess this (recommendation 16).

Another mitigation measure for stream piping could include installing wetlands at the end of tile drains to help remove nutrients that have bypassed the riparian verge (Tanner and Sukias, 2009). This may reduce the heightened level of nutrients that can potentially enter these streams.

5.3.6 Summary

A review of the RFWP is due to occur in 2011/2012. An analysis of the policies in the RFWP in relation to stream modification has highlighted that while stream modification is encompassed in the policies in general, there is a lack of well-targeted and comprehensive policies and procedures in relation to stream modification. The following conclusions were made while considering the findings in sections 2-4 of this report:

- There is currently a difficulty of applying existing definitions (where they exist) for streams, farm drains, wetlands and land drainage on the ground. Improving these definitions is recommended as part of the RFWP review to improve interpretation of the rules in relation to stream modification (recommendation 10). In the interim, an information sheet could be prepared to clarify what rules apply in different situations and stream types (recommendation 13).
- The RFWP does not specifically address the issue of reclamation (i.e. piping a stream for land improvement). At the time of the notification of the plan, the issue of stream modification was considered to be a low frequency activity, but has now become significantly more common in Taranaki. Whether this is a short term peak or a long term trend, is difficult to determine. However, the increase is such that it is recommended (through recommendation 9) that the appropriateness of specific rules for reclamation be investigated to encompass piping streams for land improvement to strengthen the management of stream modification in Taranaki.
- While cumulative effects of stream modification are not specifically addressed in the RFWP, cumulative effects must be considered in any resource consent application (through the definition of 'effects'). The current extent of stream modification have been difficult to assess in the past but can now be more easily considered with the GIS layer that has been developed as part of this project. It is recommended that Council staff utilise this GIS layer as standard practice when processing resource consent applications (recommendation 14) and that the accuracy of the layer continues to be improved and updated (recommendation 4).
- The development of a 'trigger level' (like that used for water allocation) above which further modification (or habitat loss) would be deemed a significant cumulative effect, could be a useful tool for assessing resource consent applications. It would be worth conducting further investigations into an appropriate level of habitat loss (recommendation 3) that could be used as a trigger level.
- There is strong policy support for requiring off-set riparian enhancement to mitigate the effects of stream modification through the resource consent process. However, determining the amount of mitigation required can be difficult. It is

recommended that techniques for determining appropriate mitigation (i.e. the SEV) be investigated for Taranaki (recommendation 15).

5.4 Approach undertaken by other councils

5.4.1 Stream definition

As noted in section 5.3, defining streams can be difficult. A review of the definition of streams and rivers in the regional plans of four other regional councils indicated some inconsistencies.

For example:

- Auckland Regional Council (ARC) has defined an intermittent stream and permanent river or stream in their Proposed Air, Land and Water Regional Plan.
- Environment Bay of Plenty Regional Council (EBOP) define an ephemeral flow path and intermittent water course, and note that the definition of a river (under the RMA) includes intermittent water courses but excludes ephemeral flow paths.
- Greater Wellington Regional Council (GW) defines intermittently (which by default also captures ephemeral) flowing streams. A stream fed wetland is also considered to be a 'River', as defined in the RMA.
- Environment Waikato Regional Council (EW) defines ephemeral and perennial streams.

5.4.2 Permitted activities

The activity status for placing a culvert, realigning a stream and draining land was reviewed for each of the four councils listed above. As outlined in section 5.3.3 above, these three activities are permitted within the RFWP for Taranaki if certain conditions are met.

The following table lists those activities which are permitted as well as the key restrictions or requirements in meeting that permitted rule. Common restrictions which apply to all four councils were not listed for that reason but included no effect on fish passage or no sedimentation effects. A brief discussion of the three activities (culverting, stream realignment and land drainage) in relation to activity statuses follows below the table.

Table 6 Permitted stream modification activities

Stream class	Activity permitted	Summary of key restrictions of the permitted rule (not incl. conditions)
ARC Regional Air, Land and Water Plan (proposed)		
Intermittent	Placement of any structure	<ul style="list-style-type: none"> • No flooding effects on neighbouring properties
Permanent (excluding certain streams, lakes and wetlands)	Placement of any structure (incl. a culvert and a reconstructed channel)	<ul style="list-style-type: none"> • Design criteria • Total length of structure (\leq 30 m) with limits on incremental increases • No flooding effects
N/A	Land drainage	<ul style="list-style-type: none"> • No effects on water level regime or direction of groundwater flow • No effects on structures from settlement

EBOP Regional Water and Land Plan (operative 2008)

All (excluding wetlands)	Culverts	<ul style="list-style-type: none"> • Location (not in an urban area and >1 km upstream of an urban area) • No more than 1 culvert per crossing of an appropriate length • Design criteria • No flooding effects
All	Take, diversion and discharge of water from existing farm drains (into surface water)	<ul style="list-style-type: none"> • Drains/canals were existing as of 19 February 2009 • No water quality effects in receiving waters • No erosion effects
N/A	Discharge of water to water between artificial watercourses	<ul style="list-style-type: none"> • No erosion effects • No flooding or ponding effects on neighbouring properties

GW Regional Freshwater Plan (operative 1999)

Intermittent	River crossings (e.g. culverts)	<ul style="list-style-type: none"> • Only allowed to be of a width necessary for the crossing (past s42A reports have determined this to be approx. 3.5m) • Catchment area upstream (\geq 50 ha or \geq 200 ha depending on location) • No flooding effects
N/A	Land drainage	<ul style="list-style-type: none"> • No flooding effects on neighbouring properties • No lowering of water levels within any river, lake or wetland • No lowering of groundwater levels on any neighbouring property

EW Regional Plan (operative 2007)

Ephemeral	Culverts	<ul style="list-style-type: none"> • Catchment area upstream (\leq 5 ha) • No flooding effects on neighbouring properties • Design criteria
All	Culverts	<ul style="list-style-type: none"> • Catchment area upstream (\leq 100 ha) • No flooding effects on neighbouring properties • Design criteria
N/A	Diversions and discharges in artificial watercourses and drainage systems	<ul style="list-style-type: none"> • Drains were existing at time the plan was notified • Catchment area (\leq 2 ha) • No flooding effects on neighbouring properties

5.4.3 Culverts

ARC, EBOP and EW all permit the placement of culverts within any stream class, provided that specified requirements and conditions are met (including fish passage provision, and avoidance of sedimentation, erosion and scouring, and flooding effects), while GW only permits the placement of a culvert within an intermittently flowing stream.

Out of the four councils assessed, only ARC and EBOP have explicitly limited incremental increases in the length of pipe within their permitted rule.

5.4.4 Land drainage

ARC and GW expressly allow land drainage. EW only permits drains which were existing at the time that their plan was notified. EPOB only permits drains which discharge into surface water which were existing as of 19 February 2009 whereas drains which do not discharge into surface water are a permitted activity.

Resource consent is required from EPOB and EW to divert water from a wetland. GW permits water to be diverted from a wetland which is fed by an intermittently flowing stream (apart from some exclusion areas). Worthy of mention is that the definition of wetland in EPOB's plan excludes wetted pasture and pasture with patches of rushes. As such, a resource consent may not be required for draining such areas.

5.4.5 Stream realignments

EBOP, GW and EW do not have rules specifically relating to stream realignments or modifications. However, in this case, the status of activities which are associated with stream realignments, such as water diversions and reclamations, can be assessed because there are rules relating to these activities.

For EBOP and EW, a resource consent is required for all surface water diversions and streambed reclamations, regardless of stream class.

GW permits water diversions in intermittently flowing streams, provided certain requirements are met. However, there are no rules which expressly allow reclamation.

The proposed ARC plan permits the reconstruction of stream channels, up to 30 m in length, in all stream classes. However, this permitted rule maybe restricted as it is only a permitted activity to reclaim an intermittently flowing stream. As such, it appears that a resource consent would be required for stream realignments within permanently flowing streams (to cater for the reclamation component of the activity).

5.4.6 Mitigation

ARC has a formal calculation called the Stream Ecological Valuation (SEV) (ARC, 2006) method (developed in corporation with NIWA) which they apply to all resource consent applications to quantify appropriate environmental compensation for the loss or degradation of stream environments.

The SEV is successfully applied and accepted in the Auckland region and works by providing an environmental compensation ration (ECR) to ensure that there is no net loss in ecological value. For example, if a restored stream would result in a stream with only a third of the ecological value of the degraded stream, then a theoretical ECR of 3:1 (or 3 units of stream are to be restored for every unit of stream degraded) might be appropriate. Other factors, such as the time delay in the benefits of mitigation being derived (e.g. through riparian planting becoming established), can also increase the ECR.

Recently GW has been applying ARC's SEV model to consent applications for activities that may result in more than minor adverse effects on stream ecosystems. As the model is tailored specifically for Auckland streams, GW has been applying it on a conceptual basis. Although the majority of cases where it has been applied have resulted in suitable mitigation being undertaken, the appropriateness of the model has always been questioned as using the model is somewhat arbitrary with it not being developed for the Wellington region. As such, GW is now engaging NIWA to develop a SEV model for the Wellington region.

EPOB anticipate to apply ARC's SEV model on a conceptual basis in line with GW. This will most likely be applied to piping applications which result in adverse effects which are more than minor. Such applications are rare for EPOB.

EW require mitigation to be undertaken in stream environments which are determined to be of high quality. Mitigation usually involves undertaking riparian planting along another area of the stream within the applicant's property, or if this is not achievable, by planting in another catchment or providing a sum of money for planting to be undertaken. EW expect at least a 1:1 or 1:1.5 ratio of stream restoration, meaning that for every 1 m of stream that is degraded, at least 1-1.5 m of stream needs to be restored to offset the adverse effects.

6. Council's response

6.1 Non-statutory methods

6.1.1 Sustainable land management programme

The Council has largely adopted non-statutory methods for promoting the sustainable management of wetlands and small streams through its sustainable land management programme. This involves the preparation of property plans and the making of recommendations for lengths of stream bank to be fenced, retired or planted. Riparian management plans are prepared at no cost to landowners, and riparian plants are supplied at cost price. The Council can also assist with organising planting contractors. This programme relies on a philosophy of voluntary cooperation, and ongoing commitment from landowners to riparian management.

6.1.2 Development of a GIS method for recording ongoing small stream modification

Prior to 2003, when Land Management Officers (LMO's) noticed that sections of small streams have been piped or realigned during plan preparation and monitoring of progress against farm plans, these were removed from the shape file within the LM Rivers GIS layer and the file showed the section of stream in its new incarnation. After the section of stream has been edited, there was no record kept of the original path of the stream or the path of the new piped drain.

To prevent the loss of this information and create an efficient way for LMO's to record the valuable information on small stream modification that they collect during on-farm monitoring against riparian management plans, an addition to the existing LM Rivers layer has been created. This allows the locations of small streams that are modified or piped to be recorded. Table 7 outlines the information that is captured.

What can we do with the information collected?

The layer should allow the following information to be extracted:

- By adding the length of 'status 1' segments (see Table 7) of stream lengths piped to the length of streams in the LM Rivers layer we could calculate more accurately the total original length of stream in the catchments covered by RMPs and an approximate proportion of stream length lost in any catchment.
- We could also compare the length or proportion piped with the length or proportion of stream length fenced or planted within any catchment.
- Investigating officers could access the layer so they know the location of subsurface drains that should be avoided when assessing appropriate land application of effluent.

Table 7 Types of modification to be recorded as a GIS shape file with their own distinguishable status to allow calculation of total lengths of stream lost in each category

Status	Category	Definition	Represented by	Information out
1	Stream length piped	Original path of stream piped for land improvement or drainage	A line following the path of the original unmodified stream	Location and original path and length of stream before modification known
2	Pipe	Path of pipe that replaces stream	A line following the path of the pipe	Location of pipe known so it can be flagged as a risk for contaminants
3	Stream length modified	Original path of stream that has been diverted straightened or realigned	A line following the path of the original unmodified stream	Original length and path of stream before modification known
4	Modified stream path	New path of stream that has been diverted, straightened or realigned	A line following the new path of the stream	Would allow comparison with 'stream length modified' category for average reduction.

6.1.3 Provision of information

The Council has produced a fact sheet (Sustainable Land Management no. 19) outlining the rules which affect farm activities in riverbeds including realignment, drainage and the placement of access culverts. Factsheets have also been developed outlining the general principles and practices of riparian management (SLM no. 23) and the importance of riparian management (SLM no. 21) which outlines support the Council can provide to landowners undertaking riparian retirement. It is recommended that a fact sheet be prepared which incorporates stream definitions (when is it stream or a flow path?) to help clarify when a resource consent is required (recommendation 13, section 8).

Additionally, on a regular basis, local earthworks contractors are invited to a workshop at the council offices to improve their understanding of the rules regarding small stream modification and sediment control.

6.1.4 The Dairying and Clean-Stream Accord

The Dairying and Clean Streams Accord was signed on 26 May 2003 by representatives of Fonterra Co-operative Group, Ministry of Agriculture, Ministry for the Environment and regional councils.

The purpose of the Accord is to promote sustainable dairy farming in New Zealand and focuses on reducing the impacts of dairying on the quality of streams, rivers, lakes, groundwater and wetlands. While the Accord is not legally binding on Fonterra's shareholders it is anticipated that an industry self-management approach will more effectively achieve positive environmental outcomes than sole reliance on

regulation. It is anticipated however that the policies and targets of the Accord will be incorporated into Fonterra supply contracts in the future.

A Regional Action Plan for Taranaki was prepared by local representatives of the Fonterra Co-operative Group, Federated Farmers, and the Taranaki Regional Council. The Plan adapts the actions outlined in the Dairying and Clean Streams Accord to Taranaki conditions and is reported on annually.

The Regional Action Plan sets targets for the percentage of property plans that have been implemented. The goal is that 90% of property plans will be implemented by 2015. Property plans set out recommendations for riparian retirement, fencing and planting.

Anecdotally, it is claimed that one unanticipated consequence of the Action Plan is that landowners, in some instances, are seeking opportunities for increasing productivity of their properties, and opting for piping or realigning small streams rather than fencing and planting them. This has been particularly so with high dairy pay-outs making such stream work more economic than previously. The high number of consents issued in the 2005-2008 period for piping and realignment work tends to support this theory (refer to section 3.3). However, the recent increase in the number of consents could also be as a result of farmers complying with the Accord, and also the presence of Land Management Officers in the field in recent years, mapping streams and providing information to farmers on resource consent requirements through the riparian plans that have been developed by the Council.

Nationally, streams large enough to be covered by the 'Accord' are defined as those larger than a stride and deeper than a red-band gumboot. However, the definition in the Taranaki Regional Action Plan supersedes this and in the first instance, is guided by streams identified on the 1:50,000 topographic map; and also individual property inspection and discussion with the land owner. As such, in Taranaki, streams that are smaller than the national threshold are covered. This includes many small streams with potentially high ecological value from protection or enhancement under the Accord.

6.2 Statutory methods

6.2.1 Processing consents

The Council has a developed document entitled '*Resource Consent Procedure Document*' [2007] that provides guidelines in relation to the resource consents process and the procedures adopted by the Council. Consents Officers are required to adhere to these guidelines in the processing of consents.

Council Consents Officers refer to Section 104 of the Act and the relevant policies, rules and standards in the RFWP, however, currently there are no explicit guidelines or procedures in place to assist Consent Officers in assessing stream modification applications. This may lead to some minor variation in the assessment of applications between Consents Officers. Consideration is being given to the development of such procedures in an attempt to provide more consistency in the assessment process.

A set of standard consent conditions has recently been developed for piping, stream re-alignments, and installation and maintenance of culverts in stream or river beds. A brief summary of mitigation measures adopted in these standard conditions are outlined below.

The standard conditions for piping include provision for the consent holder to undertake riparian planting and fencing as mitigation for the effects of the activity especially in respect to the loss of aquatic habitat. When an applicant holds a riparian management plan for the property in which the proposed activity is to be undertaken, they will be required to maintain fencing and planting in accordance with this plan within three years of the granting of the consent. The consent holder is required to plant and fence off a section of stream including both banks to the equivalent length that is proposed to be piped. In instances where an applicant does not hold a riparian plan, then under the standard conditions they will be required to gain one and undertake the necessary planting and fencing. As discussed in section 5.3.5, it is recommended that the SEV (ARC, 2006) and ecological assessment requirements for new applications be further investigated for Taranaki conditions.

In terms of stream re-alignments or diversions, the standard conditions focus on ensuring that the modified or new stream channel is developed in a way that minimises the potential for erosion or scouring, and sediment runoff from surrounding works becoming entrained in the stream. However, on occasion, provision has been made for the consent holder [usually by way of Council officers] to undertake a fish salvage in the section of stream channel before the water is diverted into the new channel as a mitigation measure for potential fish strandings as a consequence of the diversion. A condition requiring fish salvage (e.g. by electric fishing or trapping) tends to only be imposed on consents for stream re-alignments or piping on streams and rivers that are considered to provide important habitat for native fish species or trout. However, a general condition is applied to all stream modification consents where water is diverted from the channel, which requires the relocation of any fish that are observed as stranded as a result of the work.

6.2.2 Improvements to the consenting process

The *'Biodiversity Strategy: An operational strategy to guide biodiversity actions of the Taranaki Regional Council'* (May 2008) notes that one of the threats to freshwater biodiversity in Taranaki is the channelising or piping of streams. The Strategy identifies one action proposed as the development of guidelines for both applicants and consenting officers in terms of information they need to gather for applications for small stream modification, stakeholders they need to involve and matters that should be considered in processing such applications.

Changes are being made to streamline and improve the Council's approach to processing landuse consents relating to stream modification, they include the following:

- Consent application forms are being developed to encourage the provision of more information to better identify and assess the environmental effects of the works and to encourage best practice in environmental mitigation of small stream modifications.

- Standard information is now recorded for each consent as parameters in the consents database (R2D2) to enable the cumulative extent of all consented works in a catchment to be calculated.
- A new section has been developed in the officer's report template for small streams consents which includes the parameters to be recorded in the R2D2 database to enable the efficient extraction of these parameters by consents administrators for inclusion into the database.
- A review of the standard consent conditions for piping consents has been undertaken which includes a condition requiring the implementation of a riparian management plan for remaining stream margins. These conditions do need to be monitored to ensure conditions are complied with in specified timeframes. At present, monitoring is undertaken during initial instream works, but may not be continued once work has been completed. It is recommended that a tailored monitoring programme be developed which specifically monitors the progress towards riparian planting consent conditions (and other mitigation measures if specified) to ensure that these are implemented as required (recommendation 6).
- The new GIS layer which maps the extent of stream modification can be used for assessing the cumulative effects of stream modifications proposed in new consent applications. This method would use historic data which is now available from both the consents and GIS databases, and is a relatively quick and efficient method for processing staff.

Mitigation requirements through riparian planting are currently based on a 1:1 approach, i.e. the same length of stream bank needs to be planted as that which is lost through the modification work. Other councils have adopted a more quantitative approach which takes into consideration the existing value of the stream habitat and environment, and whether any further restoration work will achieve desired results at the proposed site of the mitigation work. This utilises the Stream Ecological Valuation method developed by NIWA for Auckland Regional Council (ARC, 2006). It is recommended that methods such as the SEV be investigated for application in Taranaki (recommendation 15).

6.2.3 Compliance and enforcement

The Council has received relatively few complaints from members of the public regarding illegal small stream modification. Over the last five years only 33 such complaints have been registered on the Council's incident database. This could well reflect that only those works observed from roads would be reported (and are only the 'tip of the iceberg'). These complaints are always followed up with investigation, site visits, and then further enforcement action when warranted. A total of 11 abatement notices and four environmental infringement notices (\$300 each) have been issued for illegal small stream modifications in the last five years. One incident resulted in prosecution action being undertaken by Council against the parties involved.

However, the aerial mapping exercise undertaken as part of this project has identified that there has been significant illegal activity occurring in relation to stream modification. It is recommended that illegal works identified as part of this project through aerial photo comparisons between 2001 and 2007 be followed up with

monitoring to confirm if such works were undertaken without the necessary consents. Where non-compliant work is identified, further riparian planting could be initiated on remaining intact reaches of small streams on the property through riparian management plans, to offset the loss of habitat from the modified reach. A recommendation to this effect is included in section 8 (recommendation 18).

7. Summary and conclusions

Taranaki has many small streams (75% of all streams in Taranaki) and as such these small streams contribute significantly to a catchment as a whole (in terms of water quality, hydrology and biodiversity). The scientific literature and limited Taranaki data available suggest that small streams less than 2 m wide can have significant ecological, hydrological and biodiversity values, particularly where the riparian and instream habitat is relatively intact. While permanently flowing streams have values for both fish and macroinvertebrate populations, intermittently flowing streams have been found to be important for maintaining biodiversity particularly for rare macroinvertebrate taxa. Even farm 'drains' can support endangered species such as the koura (freshwater crayfish), longfin eels and brown mudfish. These small streams are being steadily modified at an increasing rate as illustrated by the increasing number of consents being issued for this type of work, and the amount of permitted and unauthorised work that has been undertaken based on examination of 2001 and 2007 aerial photos.

The effects of stream modification potentially include:

- habitat loss or degradation;
- degradation in localised reach and catchment water quality;
- changes in the hydrological regime (more frequent and intense floods, longer periods of low flow); and
- loss of biodiversity.

Limited data on the effects of stream modification on the ecology, water quality and hydrology on a whole catchment basis exists in Taranaki, and further information obtained through specific investigations in catchments with high proportions of modification could add significantly to future policy reviews and long term decisions on dealing with stream modification. There is particularly a lack of fish data in small streams, a gap which could be addressed as part of the development of a State of the Environment fish monitoring programme.

The proportion of stream modification on the ring plain is 5.5% of total stream length. Most of this modification is historical (particularly stream realignments), but piping streams for land improvement is becoming more popular in recent years. Much of this modification is occurring in South Taranaki, where dairy farming is more intensive. While this may seem a small proportion of Taranaki's streams, of greatest concern is the more recent increased rate of piping streams (a 15% increase in total modification in the last six years compared to all modification prior to 2001). This is of concern as piping for land improvement results in total loss of habitat for aquatic life, and associated potential effects on water quality and hydrology downstream.

Stream culverting, piping, diversions and realignments generally serve to increase the workable area of land available to farmers. The recent amount of this type of work being carried out on Taranaki farms suggests that despite the initial cost of carrying out stream piping work, it can be a more attractive proposition than fencing and planting a small stream in some cases. The way that these types of activities are changing the landscape of Taranaki's smaller streams, it is timely to consider how existing policy can be improved, or whether it remains appropriate, to minimise or mitigate stream habitat loss. Approaches such as "no net loss" of habitat, utilising mitigation and/or declining consents in catchments with high proportions of existing

modification could be considered, if further regulatory intervention is considered justified. It is still unknown whether this increase in stream modification is a short term 'blip' as a result of the economic climate during this time (i.e. increased dairy payouts) or a more long term emerging trend which needs to be considered in future policy reviews.

The GIS layer developed in this project is the first time the Council has been able to do a 'stock take' of stream modification in the region and will provide a valuable resource for future consent processing to consider cumulative effects of stream modification with relative ease, and also means that any policy review work will be much better informed than in the past. Further ground-truthing of the GIS layer in the field and updating by land management officers will be required to ensure that this resource remains up to date and useable. To enable the preservation of representative habitats from all catchments, identification of those catchments most at risk of modification would be useful. Additional investigation into setting an upper limit for the amount of modification that small streams in any catchment can be subjected to, before some threshold is tripped, and greater protection afforded to the remaining stream reaches, could provide significant guidance to consents officers when assessing the cumulative effects of new applications for stream modification.

The '*Regional Policy Statement for Taranaki*' and the '*Regional Freshwater Plan for Taranaki*' (RFPW) recognise the values of small streams, but also the positive effect of increasing the productivity of Taranaki's farmland through land drainage. Policies were reviewed in light of findings in this report and three key issues have emerged:

- While the values of streams are recognised in policy documents, there is a lack of well targeted, comprehensive policies and procedures in relation to small streams and their modification. The RFPW is due for review in 2011/2012. The review could include a consideration of whether the current extent of allowable small stream modification under the permitted activity rules is appropriate and fully provided for, given the increased rate of work that is being carried out and the high likelihood of cumulative effects in some catchments. There are no specific rules relating to the piping of streams for land improvement in the current RFPW and this could be discussed during the next review of the RFPW.
- There has been a recent up-surge of stream modification. However, the question still remains as to whether this will be a long term trend, and therefore a new, emerging issue in Taranaki, which should be considered in the review of the RFPW in 2011.
- There is evidence that some of the stream modification undertaken since 2001 could be illegal. As such, can policy be improved to better manage this modification?

As a result of this project:

- There are some procedures and information management that the Council has already improved. Consent processing improvements have been made during this project in relation to mitigation requirements, administration, standardising consent conditions in relation to piping and realignment consents, and improving consistency in the processing of consents. Further avenues which could be investigated include mitigation and ecological assessment requirements to improve the ability for an accurate assessment of effects to be made at the time of

an application. A Stream Ecological Valuation (ARC, 2006) approach could provide both an ecological assessment and determine appropriate mitigation (if required) for any piping or realignment work.

- There are some deficiencies in current policy definitions and rules identified and these can be addressed in the RFWP review. It is recommended that there is clarification of some definitions that relate to small streams, in particular the difference between a modified water course and a farm drain. Clarification is also needed regarding 'what is a stream?' and the status of a piped stream (in relation to activities such as discharges), as this allows an easier assessment of the activity against which of the current rules in the RFWP apply. An information sheet could aid in interpretation of the rules in this respect.
- There are some policy decisions that need to be made and that the next two years should illuminate, i.e. the Clean Streams Accord driver and the high dairy payout productivity driver.
- There needs to be further investigations undertaken prior to the RFWP review i.e. to determine effects of stream modification (in particular cumulative effects), and 'trigger levels' of acceptable modification in catchments, and quantifying the regional benefits of increased production capacity.

The limitations of this report in its scope and considerations should be noted. It has focused primarily on ecological and hydrological aspects of small streams. But the Resource Management Act requires a broader consideration and involves more than 'protection' of natural and physical resources (section 5 of the RMA). 'Use' and 'development' of such resources are important to people and communities to provide for their social, economic and cultural well being. The added economic value of enhanced productivity for individual farmers, and cumulatively for the region from land development needs to be recognised.

This study has identified an acceleration in stream modification. It has not investigated in depth whether this is a new emerging long term trend, or a 'blip' driven by very specific and short term factors, and most likely to dissipate. Further work is needed within these and other areas, for the Council and the regional community to make fully informed and well considered decisions on policies, objectives and targets around small stream modification.

8. Recommendations

Based on the conclusions of this report, the following recommendations are made:

1. That it is acknowledged that the rate of small stream modification is an emerging issue in Taranaki ring plain catchments, and that these small streams have value in buffering both flood and low flow events, contributing to the water quality of the catchment, providing habitat for threatened fish and invertebrate species, and maintaining biodiversity.

Cumulative effects

2. That this report has identified (a) catchments with a comparatively high level of modification and, (b) catchments at high risk of significant modification (i.e. the headwaters of catchments which arise on the ring plain below the national park boundary, particularly in South Taranaki) which consents staff should be aware of when assessing resource consent applications.

Dept responsible: Consents.

3. That staff explore the options for and usefulness of a 'trigger level' for the amount of stream modification allowed in a catchment (i.e. how much of a catchment can have habitat loss before the life-supporting capacity begins to be compromised) before further work should be more closely constrained, discouraged or prevented, or appropriate mitigation is undertaken.

Depts responsible: Technical Services & Policy.

4. That ground-truthing of the GIS extent shape files and cross-referencing with land management monitoring be continued to ensure accuracy and up to date data.

Dept responsible: Land Management.

Further monitoring and investigations

5. That a representative group of small streams be included as part of a new State of the Environment fish monitoring programme (already in preparation), so that the programme generates information on fish populations in a catchment or stream reach where stream modification has occurred.

Dept responsible: Technical Services.

6. That as per the Council's procedures for all new consents, a monitoring programme be developed and implemented for consents granted for stream modification work, to ensure consent conditions that require riparian planting are implemented within specified timeframes. This requires a job manager, and existing information from riparian plan monitoring.

Depts responsible: Technical Services & Land Management.

7. That the flow-sourcing study conducted across the ring plain in the 1980's be repeated for selected high-risk catchments identified in this report, to determine the effects of small stream modification on catchment water balance and hydrology.

Dept responsible: Technical Services.

8. That the Council investigate reasons for the increase in stream modification works in recent years, in particular economic drivers, to help determine if this increased

activity is a new, emerging long term trend or a short term occurrence driven by very specific factors.

Depts responsible: Technical Services & Policy.

Regional Fresh Water Plan review

9. That a review of the effectiveness of the current rules governing small stream modification considers investigation of specific rules for reclamation to encompass piping streams for land improvement.

Dept responsible: Policy.

10. This report has established that better definitions are needed for streams (including farm drains, wetlands and land drainage, and the status of a piped stream (with regard to discharges to such streams, either directly (i.e. through oxidation ponds), or indirectly (i.e. through spray irrigation)), and that these definitions affect interpretation of the rules for stream modification work and land drainage. Further, this report has raised the question of whether policies and methods of implementation are still adequate in relation to stream modification. It is therefore recommended that these matters are considered at the time of the RFWP review.

Dept responsible: Policy.

11. That the appropriateness of current rules in the RFWP in relation to permitted activities for stream modification (i.e. catchment size, stream cross-section) be investigated, utilising small catchments which have been identified as highly modified in this report.

Depts responsible: Policy & Technical Services.

Council processes

12. That a checklist be developed for use by consent applicants in preparation of Assessment of Environmental Effects, and consent officers when undertaking site visits, to assist with the assessment of the values of streams being considered for modification work.

Depts responsible: Consents & Technical Services.

13. That an information sheet is developed to aid in the interpretation of stream definitions in the field and identify / determine the appropriate RFWP rules to allow consistent information to be provided to the public by all Council departments.

Dept responsible: Consents (also Technical services, Land management, Inspectorate).

14. That consents officers utilise the GIS extent layer for stream modification within the assessment of all future stream modification resource consent applications, to ascertain cumulative and other effects.

Dept responsible: Consents.

15. That staff explore the options for, and usefulness of, a method to be used by the Council to determine the level of appropriate mitigation that should be carried out by consent holders wishing to undertake small stream modification works, in particular investigating the feasibility of implementing the SEV (ARC, 2006).

Depts responsible: Technical Services & Consents.

16. That ecological assessments be required for resource consent applications which involve significant lengths of piping and/or are within high value stream habitats, to better assist consents officers undertaking an assessment of the environmental effects, and the values of specific small streams.

Dept responsible: Consents.

Compliance and education

17. That drainage contractors continue to be reminded annually, through a TRC hosted workshop or other contact, of their responsibilities for compliance under the RMA and RFWP rules.

Dept responsible: Inspectorate.

18. That the possible illegal stream modification works found through the comparison of aerial photographs in this study are further investigated, with a view to considering options for remediation or mitigation as or if required.

Dept responsible: Inspectorate.

19. That awareness is raised within the rural and farming community of the value of small streams and farm drains.

Dept responsible: Public Information.

9. References

- ARC, 2006. *Stream Ecological Valuation (SEV): a method for scoring the ecological performance of Auckland streams and for quantifying mitigation*. ARC Technical publication No. 302.
- ARC, 2000. *Wairoa River catchment riparian margins first order stream ecology*. Prepared by Boffa Miskell Limited for the Auckland Regional Council.
- ARC, 2000. *Fish passage guidelines for the Auckland Region*. Auckland Regional Council Technical Publication no. 131.
- Blakely, T.J., Harding, J.S., 2005. Longitudinal patterns in benthic communities in an urban stream under restoration. *New Zealand Journal of Marine and Freshwater Research*, Vol. 39:17-28.
- Boffa Miskell Limited, 2000. *Urban streams Habitat Assessment 2000*. Prepared for North Shore City Council.
- Boubee et al 1999, *Fish passage at culverts: a review with possible solutions for New Zealand indigenous species*. Department of Conservation, Wellington.
- Bowler, D.G., 1980 *The drainage of wet soils*. Hodder & Stoughton, Auckland.
- Cooper, A.B., 1990. Nitrate depletion in the riparian zone and stream channel of a small headwater catchment. *Hydrobiologia* 202: 13-26.
- Dewson, Z.S., James, A.B.W., Death, R.G., 2007. Stream ecosystem functioning under reduced flow conditions. *Ecological Applications*, 17(6), pp1797-1808.
- Dewson, Z.S., James, A.B.W., Death, R.G., 2007. Invertebrate responses to short-term water abstraction in small New Zealand streams. *Freshwater Biology*, Volume 52, 357-369.
- Dewson, Z.S., James, A.B.W., Death, R.G., 2007. Invertebrate community responses to experimentally reduced discharge in small streams of different water quality. *Journal of the North American Benthological Society*, Volume 26(4): 754-766. .
- Fahey, B.D., Rowe, L.K., 1992. Land-use impacts. In: Mosley, M.P. ed. *Waters of New Zealand*. New Zealand Hydrological Society Inc., Wellington. Pp. 265-284.
- Griffiths, G.M., 2007. Changes in New Zealand Daily rainfall extremes 1930-2004. *Weather and Climate* 27: 47-66. New Zealand Meteorological Society.
- Herzonand, I., and Helenius, J., 2008. *Agricultural drainage ditches, their biological importance and functioning*. University of Helsinki
- Hitchmough, R.; Bull, L.; Cromarty, P. (comps) 2007: *New Zealand Threat Classification System lists—2005*. Department of Conservation, Wellington.

- Hudson, H.R. (ed), 2005. *Sustainable drainage management field guide*. New Zealand Water Environment Research Foundation.
- Hudson, H.R., (ed), 2005. *H2O-DS Hillslopes to Oceans: Decision Support System for sustainable drainage management*. New Zealand Water Environment Research Foundation.
- Hudson, H.R., Harding, J.S., 2004. *Drainage Management in New Zealand – a review of existing activities and alternative management practices*. *Science for Conservation* 235, Department of Conservation.
- Hudson, H.R., Byrom, A.E., Chadderton, L., 2003. *A critique of IFIM – Instream habitat simulation in the New Zealand context*. *Science for Conservation* 231. Department of Conservation.
- Invercargill district court decision, 4 March 2009: Between Southland Regional Council and Southern Pastoral Holdings Ltd and Sydney William Matthew Drummond. Oral Judgement of Judge J E Borthwick.
- Jowett, I.G. & Richardson, J. 2005. *Restoring streams for freshwater fish*. NIWA Science & Technology Series No. 53.
- Jowett, I.G. and Richardson, J. 2008. *Habitat use by New Zealand fish and habitat suitability models*. NIWA Science and Technology Series No.55 ISSN 1173-0382.
- McDowall, R.M. 2000. *The Reed Field Guide to New Zealand Freshwater Fishes*. Reed Publishing (NZ) Ltd, Auckland, New Zealand.
- McKergow, L., Parkyn, S., Collins, R., Pattinson, P., 2005. *Small headwater streams of the Auckland Region Volume 2: Hydrology and water quality*. Auckland Regional Council Technical Publication No. 312.
- Meyer J.L., Kaplan L.A., Newbold D, Strayer D.L., Woltemade C.J., Zedler J.B., Beilfuss R., Carpenter Q., Semlitsch R., Watzin M.C., and Zedler P.H. 2007a. *Where rivers are born: The scientific imperative for defending small streams and wetlands*. The American Rivers and Sierra Club 26p.
- Meyer J.L, Strayer D.L., Wallace J.B., Eggert S.L., Helfman G.S., and Leonard N.E. 2007b. The contribution of headwater streams to biodiversity in river networks. *Journal of the American Water Resources Association* Vol 47 (1):86-103.
- Milne, P., 2008. *When is enough, enough? Dealing with cumulative effects under the Resource Management Act*. Simpson Grierson.
- MfE, 2007. *Protecting our places – Information about the statement of National Priorities for Protecting Rare and Threatened Biodiversity on Private Land*.
- MfE, 2008 *Water Quality Case Study 5: Peat farming in the Waikato: striking a balance between production and the environment*.
- Molloy, J.; Bell, B.; Clout, M.; de Lange, P.; Gibbs, G.; Given, D.; Norton, D.; Smith, N.;

- Stephens, T. 2002: *Classifying species according to threat of extinction—a system for New Zealand*. Threatened Species Occasional Publication 22. Biodiversity Recovery Unit, Department of Conservation, Wellington. 26 p.
- Nguyen, L., Downes, M., Melhorn, M., Stroud, M. 1999. *Riparian wetland processing of nitrogen, phosphorus and suspended sediment inputs from a hill-country sheep-grazed catchment in New Zealand*. In: Rutherford, I., Bartley, T. eds. Proceedings of the second Australian stream management conference. CRC for Catchment Hydrology, Adelaide. Pp. 481-486.
- NIWA, 2008 *Watercress, one step to cleaner waterways?* National Centre for Water Resources Update No. 28.
- NIWA, 2007. *Climate change IPCC Fourth Assessment Report Leaflet* produced by the NIWA National Climate Centre in collaboration with the Royal Society of New Zealand.
- Parkyn, S., Phillips, N., Smith, B., 2006. *Aquatic Invertebrate biodiversity and spatial characterisation of non-perennial streams in native forest in the Waikato Region*. NIWA Report prepared for Environment Waikato 27p.
- Parkyn, S., Wilding, T.K., Croker, G., 2006. *Small Headwater Streams of the Auckland Region Volume 4: Natural Values*. Auckland Regional Council Technical Publication No. 310.
- Pinkham, R. 2000. *Daylighting: New life for buried streams*. Rocky Mountain Institute publication, Snowmass, Colorado.
- Quinn, J.M., Davies-Colley, R.J., Hickey, C.W., Viskers, M.L. Ryan, P.A. 1992. *Effects of clay discharges on stream. 2. Benthic Invertebrates*. Hydrobiologia 248:235-247.
- Quinn, J.M. (2000). Effects of pastoral development. In Collier, K.J. and Winterbourn, M.J. eds. *New Zealand stream invertebrates: Ecology and implications for management*. NZ Limnological Society, Christchurch.
- Richardson, J., Taylor, M.J., 2002. *A guide to restoring inanga habitat*. NIWA Science and Technology Series No. 50 (reprinted with minor revisions 2004)
- Stark JD, 1998. SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. *New Zealand Journal of Marine and Freshwater Research* 32(1): 55-66.
- Storey, R.G., and Quinn, J.M., 2008. Composition and temporal changes in macroinvertebrate communities of intermittent streams in Hawke's Bay, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, Volume 42:109-125.
- Sukias, J., Nagels, J., 2006. *Small headwater streams of the Auckland Region Volume 3: Nitrate & Phosphate Removal*. Auckland Regional Council Technical Publication No 311, 2006.

- Tanner C.C., Sukias J.P.S., 2009. *Reducing diffuse agricultural nitrogen loads with constructed wetlands – how large do they need to be?* Paper presented at New Zealand Freshwater Sciences Conference 2009.
- TRC, 1999. Report of the Policy and Planning Committee of the Taranaki Regional Council following the Hearing of Submissions to the Proposed Regional Fresh Water Plan for Taranaki.
- TRC, 2001. *Regional Fresh Water Plan for Taranaki*. October 2001. 299p.
- TRC, 2008a. *The assimilation and dilution of dairy shed effluent pond discharges in Taranaki. A study and discussion of in-stream environmental effects below a treatment pond system discharge*. Taranaki Regional Council Internal Report 209p.
- TRC, 2008b. *Freshwater contact recreational water quality at selected Taranaki sites State of the Environment Monitoring Report Summer 2007-2008*. Technical Report 2008-02.
- TRC, 2008c. *Freshwater Nuisance Periphyton Monitoring Programme State of the Environment Monitoring Report 2002-2006*. Technical Report 2006-69.
- TRC, 2008d. *Dairying and Clean Streams Accord Regional Action Plan for Taranaki. Annual Report 2007/2008*.
- TRC, 2008e. *Proposed Regional Policy Statement for Taranaki*. As amended following pre-hearing consultation. September 2008 213p.
- Taylor, D., 2005. *Rural Drainage Management – Decision Analysis for Best Practice*. ENNR 425 : Natural Resource Engineering Project. Thesis report.
- Walker, S., Price, R., Rutledge, D. 2008. *New Zealand's Remaining Indigenous Cover: Recent Changes and Biodiversity Protection Needs*. Science and Technical Publishing, Department of Conservation, Wellington.
- Ward, R. C., Robinson M., 2000: *Principles of Hydrology, Fourth Edition*. McGraw-Hill Publishing Company.
- West Coast Regional Council, 2002. *The Effects of Stream Habitat Modification on the Life-Supporting Capacity in the Farmland Streams on the West Coast*. WCRC ref:02003.
- Whitaker, G. A., McCuen, R.H., Brush, J. 2007. Channel modification and macroinvertebrate community diversity in small streams. *JAWRA Journal of the American Water Resources Association*. Volume 15 Issue 3 pp 874-879.
- Wilcock R.J., Betteridge K., Shearman D., Fowles C.R., Scarsbrook M.R., Thorrold B.S., and Costall D., 2009. Riparian protection and on-farm best management practices for restoration of a lowland stream in an intensive dairy farming catchment: a case study. *New Zealand Journal of Marine and Freshwater Research*, Vol 43: 803-818.

- Wilding, T.K., Parkyn, S., 2006. *Small Headwater Streams of the Auckland Region Volume 1: Spatial Extent*. Auckland Regional Council Technical Publication No. 313.
- Williamson, R.B., Smith, R.K., Quinn, J.M., 1992. Effects of riparian grazing and channelisation on streams in Southland, New Zealand. 1. Channel form and Stability. *New Zealand Journal of Marine and Freshwater Research* Vol. 26: 241-258.
- Winterbourn, M.J., Harding, J.S., and McIntosh, A.R., 2007. Response of the benthic fauna of an urban stream during six years of restoration. *New Zealand Natural Sciences* 32:1-12.

Appendix 1 Review of TRC macroinvertebrate data

Macroinvertebrate data from control sites (i.e. sites which are not potentially influenced by point source discharges) were extracted from the Taranaki Regional Council macroinvertebrate database (ESAM) along with relevant environmental data and site information. The location of these sites in relation to stream order is shown in Figure 13. The TRC database does not record accurate stream width data, so to separate data from small streams, initially the macroinvertebrate information was compared with the River Environment Classification (REC) GIS layer, in particular the stream order (referred to as the 'Network Position'), to provide a general indication of stream size.

Streams were grouped according to the following network positions:

REC Network Position	Stream order
Low order	0-2
Middle order	3-4
High order	>5

More recently established sites have had stream width recorded when the site was first established. A further analysis was conducted using this stream width data (not available for all sites), and it was found that within these three stream order categories, actual stream sizes varied significantly (Table 8).

Table 8 Range of stream sizes within each of the REC Network Position categories

	REC stream order		
	Low order	Middle order	High order
Number of samples	317	635	171
Mean stream width (m)	3	8	27
Minimum stream width (m)	0.3	1	3
Maximum stream width (m)	10	30	50

It should be noted that this stream width data uses a visual estimate of the wetted channel width at the time of sampling, which likely included flows ranging from very low to median flows (high flows are unlikely as most biological sampling is conducted during flow recession, i.e. at least seven days after a significant fresh).

For the analysis of macroinvertebrate data, several categories were developed based on stream width (rather than stream order), using the average widths derived from the REC stream order data in Table 10. The mean width for low order streams was 3 m. This was considered to encompass streams larger than were intended for small streams within this investigation (particularly considering permitted activity rules which specify cross-sectional areas). A width of less than 2 m was considered more appropriate for this study. The distinction between medium sized, and larger streams was based on the mean width (8 m) of 3-4th order streams (middle order in the REC network position). The number of macroinvertebrate samples (from control sites) within each of these stream width groups is summarised in Table 9. The samples under the 'No data' category had no information on stream width.

Table 9 Number of macroinvertebrate samples from control sites within each of the stream width categories

	Stream width			
	<2 m	≥2 m - ≤8	>8	No data
Number of samples	214	404	478	577
Percentage of samples	14	24	28	34

Based on the data from the TRC macroinvertebrate database, the taxonomic diversity (measured by the number of taxa) of control sites was significantly lower in small streams (<2 m wide) compared to medium (2-8 m wide) and large streams (>8 m wide) (Figure 12). However, the difference in diversity was not 'ecologically' significant with a difference of less than three taxa between the means of all stream width groups. It should be noted when interpreting this 'diversity' data, that the level of identification of these taxa was to the minimum required for undertaking MCI analysis. As such, most taxa are identified to the *Genus* level.

Similarly, MCI values were significantly lower in small streams. This difference was ecologically significant (as defined by Stark, 1998, as a difference of greater than 11 MCI units). This suggests that at a regional scale, smaller streams have lower ecosystem health compared to streams greater than 2 m wide (Figure 12). However, small streams tend to have a higher proportion of soft bottom habitats (compared to medium and large streams, and particularly on the ring plain). The MCI was originally developed for stony bottomed streams. These soft bottom habitats tend to support taxa with lower MCI scores, and as a result may indicate poorer ecosystem health when there is not. A soft bottomed MCI has more recently been developed but was not used in this analysis due to the large amount of historical data.

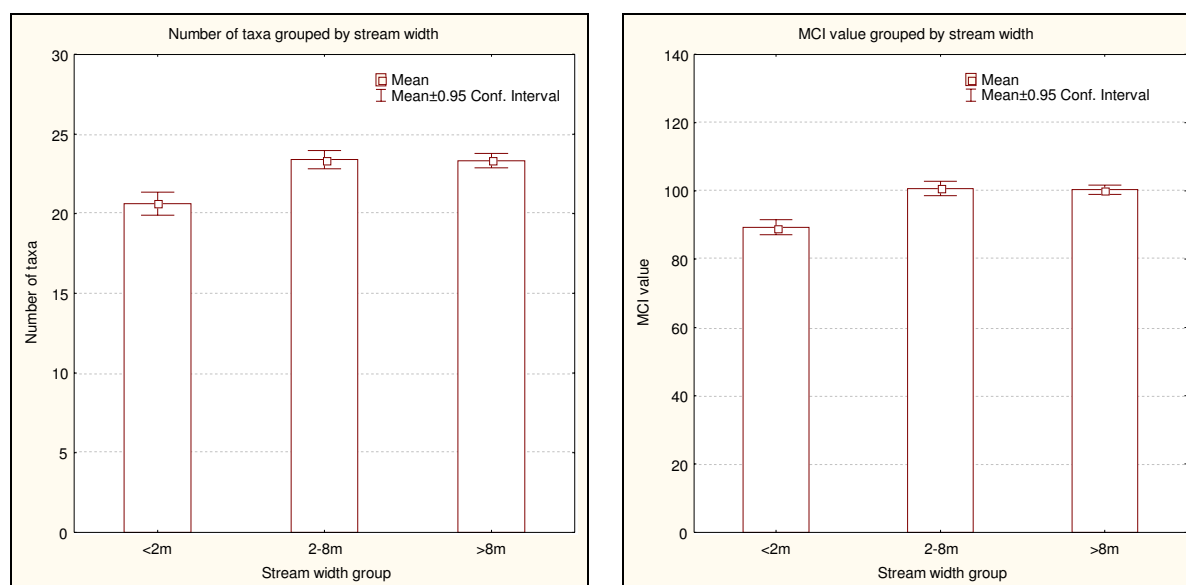


Figure 12 Mean number of taxa (left) and MCI values in streams of different width groupings. Error bars are 95% Confidence interval (CI)

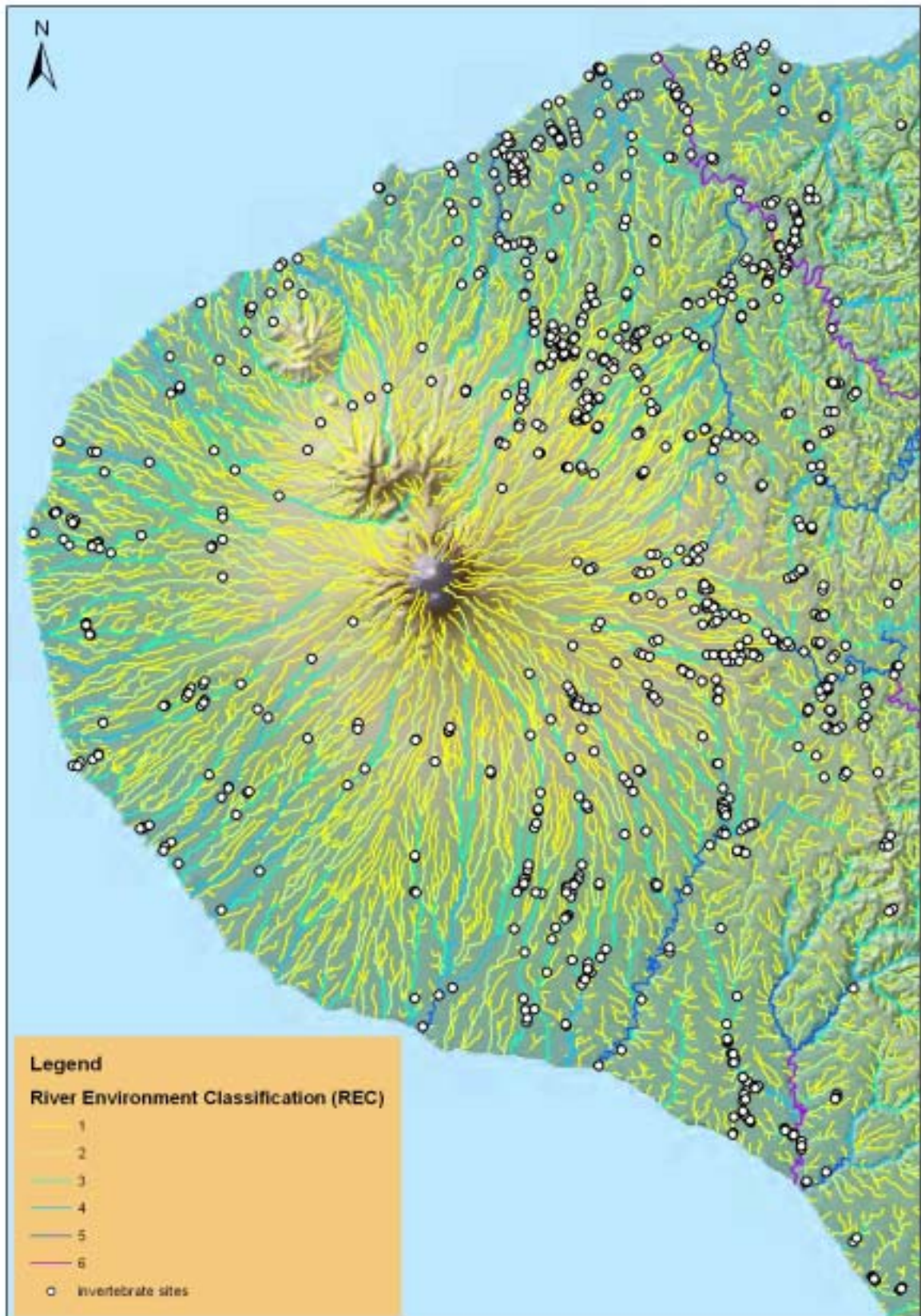


Figure 13 Location of monitoring sites with macroinvertebrate data in relation to the REC stream order classes (Data source: TRC ESAM database)

Intact riparian vegetation, particularly in small streams (where the benefits of shade and habitat are greater) will have a significant influence on instream habitat and ecosystem health, therefore macroinvertebrate diversity and MCI values in streams of different width with various degrees of riparian shading were also compared. This indicated that, at a regional scale, there were no significant differences in taxonomic diversity between stream width groups when riparian shade is also considered (Figure 14). MCI values tended to increase with increasing stream size groupings (Figure 14) although this was only significant for streams with no riparian shade and partial shade where small streams (<2 m) had significantly poorer MCI values compared to medium and large streams (>2 m wide). It should be noted that there were significantly fewer samples from completely shaded streams (Table 10).

Table 10 Number of macroinvertebrate samples from control sites within each stream width and riparian shade category

Stream width group (m)	No shade (<30%)	Partial shade (30-70%)	Complete shade (>70%)
<2	92	111	38
2-8	157	220	39
>8	332	132	2

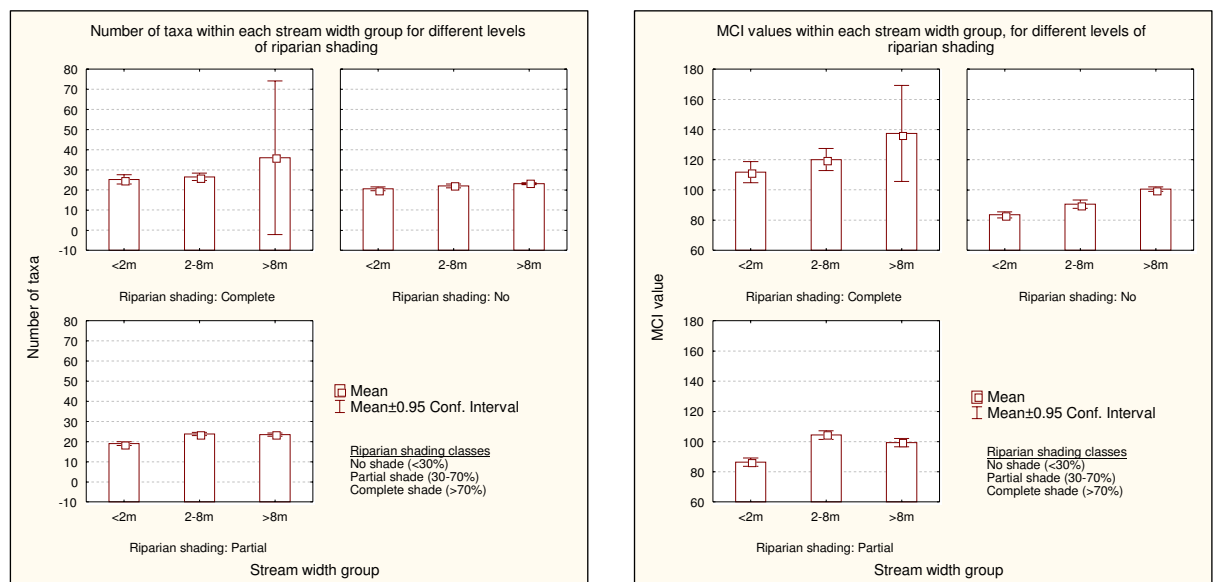


Figure 14 Mean number of taxa (left) and MCI values in streams of different width groups and riparian shade. Error bars are 95% CI

This small streams project focuses on those streams most likely to be affected by stream modification. Most habitat loss currently occurs on the ring plain and particularly in the more intensively farmed (dairy) areas. Based on this, the macroinvertebrate data was split into three different “eco-regions” on the ring plain based on the origin of the source of the stream (above the sampling site) (note eastern hill country streams were not included as stream modification is relatively low in this area). These eco-regions are:

- Ring plain streams originating inside the National Park;
- Ring plain streams originating outside the National Park; and
- Lowland coastal streams (not located on the ring plain).

Diversity in streams rising inside the National Park showed the opposite trend to the regional data as a whole (Figure 15). The number of taxa in small streams was highest compared to those greater than 2 m wide (and particularly those greater than 8 m wide). This also occurred to some extent in small lowland coastal streams (Figure 15), although this difference was not significant. Diversity was similar irrespective of stream width in ring plain streams originating outside the National Park (Figure 15).

MCI values also indicated that small and medium (2-8 m wide) sized streams originating within the National Park had better ecosystem health compared to large streams (>8 m wide), possibly as most small streams in this category will be in or near the National Park boundary and reflect the “reference condition” with intact native riparian vegetation and limited developed upstream catchment, whereas the wider stream sites are beyond the National Park boundary in open pastoral land (despite the source of the stream originating inside the National Park boundary). In other words, these differences are a function of riparian cover and landuse, rather than stream width *per se*.

Ring plain streams rising outside the National Park show a similar trend but not as significant with error bars overlapping and the range of MCI values being less than 11 MCI units (as per Stark (1998)). Lowland coastal streams also showed significantly higher ecological health in streams less than 2m wide (Figure 15), although MCI values were lower in all stream width groups compared to ring plain streams. Small streams were generally under represented in ring plain streams particularly those rising inside the National Park (Table 11).

Table 11 Number of macroinvertebrate samples within each of the eco-regions for different stream widths

Stream width group (m)	Ring plain streams rising inside the National Park	Ring plain streams rising outside the National Park	Lowland coastal streams
<2	25	76	50
2-8	182	137	23
>8	434	24	0

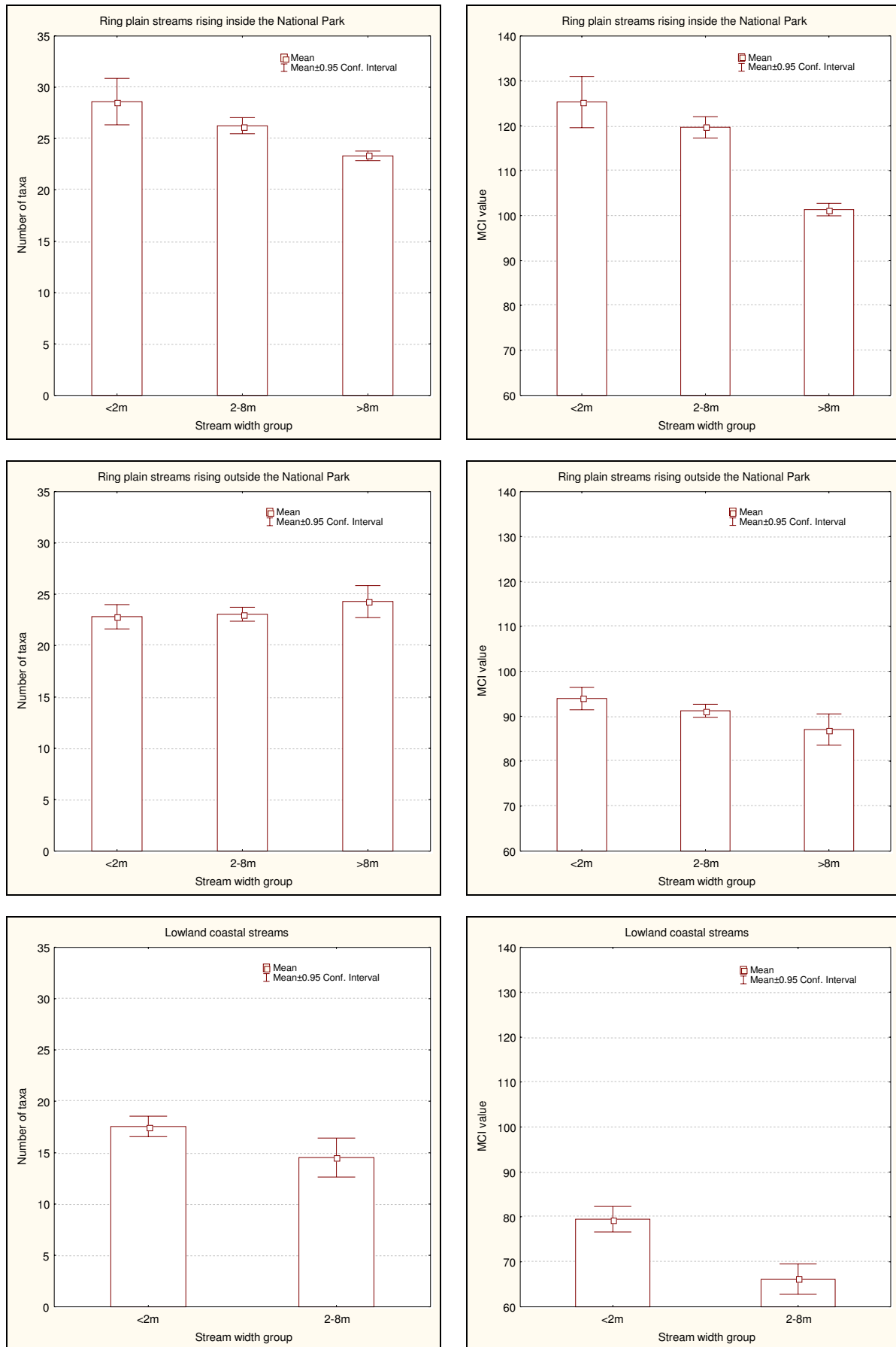


Figure 15 Mean number of taxa (left) and MCI values in streams of different width groupings for different eco-regions. Error bars are 95% CI

When the presence of riparian vegetation is considered, ring plain streams rising inside the National Park showed no differences in diversity between stream width groups (Figure 16), although diversity was high compared to other eco-regions (but note the small sample size for small unshaded and large completely shaded streams (Table 12)).

Table 12 Number of macroinvertebrate samples within each of the eco-regions and riparian shade groups for different stream widths

Stream width group (m)	Ring plain streams rising inside the National Park			Ring plain streams rising outside the National Park			Lowland coastal streams		
	No shade	Partial	Complete	No shade	Partial	Complete	No shade	Partial	Complete
<2	0	5	20	28	36	12	13	33	4
2-8	44	112	26	52	73	12	18	4	1
>8	316	116	2	8	16	0	0	0	0

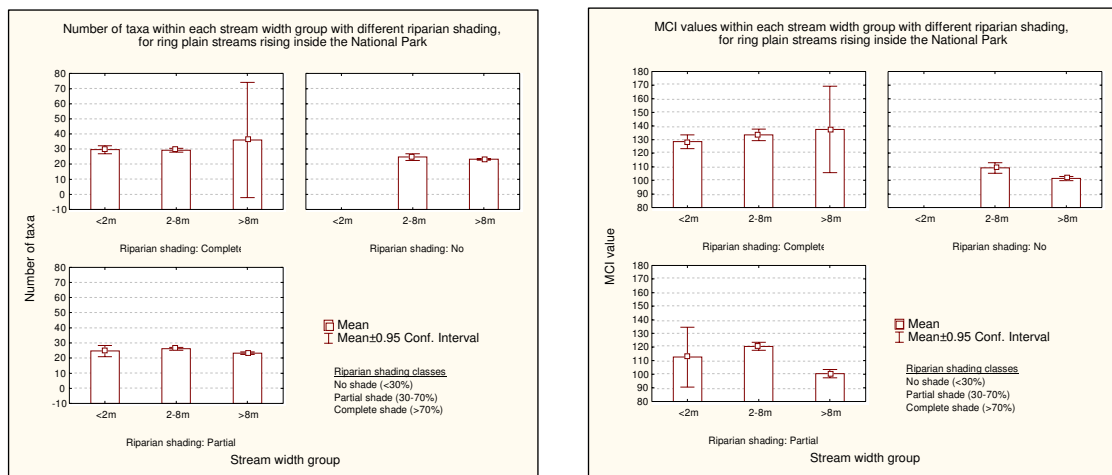


Figure 16 Mean number of taxa (left) and MCI values for ring plain streams of different width, rising inside the National Park, with differing riparian vegetation. Error bars are 95% CI

For ring plain streams rising outside the National Park, where there is likely to be significant potential for stream modification, there appeared to be little difference in diversity between stream width groups, when there was complete shade from riparian vegetation (but note the small sample size (Table 12)) or no riparian shade (Figure 17). Streams with partial shade indicated that diversity was significantly higher in larger rivers compared to small and medium sized streams, although this was a difference of only three taxa and unlikely to be ecologically significant. The small sample size within this eco-region highlights that there are few small streams with intact riparian vegetation on the ring plain below the National Park.

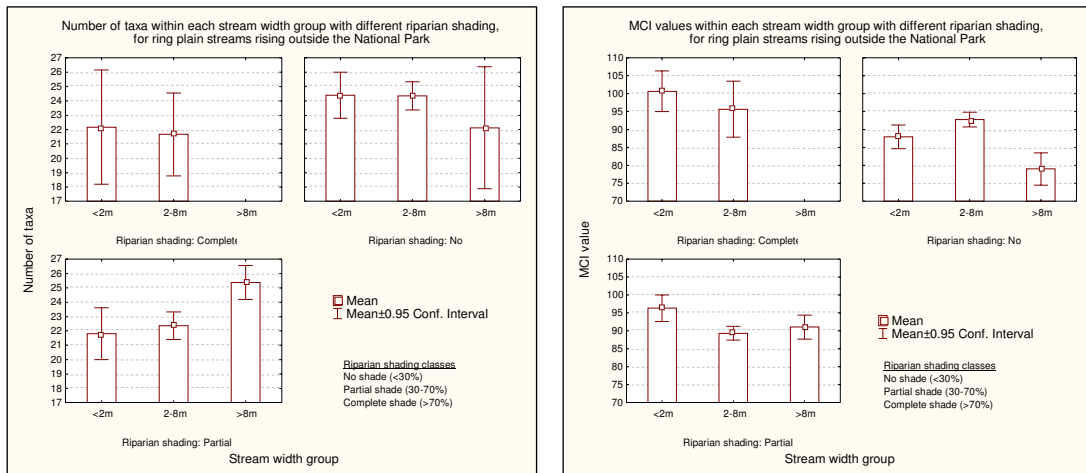


Figure 17 Mean number of taxa (left) and MCI values for ring plain streams of different width, rising outside the National Park with differing riparian vegetation. Error bars are 95% CI

Lowland coastal streams, also at high risk of modification (refer to section 4), showed higher diversity in smaller streams, more so under complete riparian shade (but note the small sample size (Table 12)) and no shade (Figure 18).

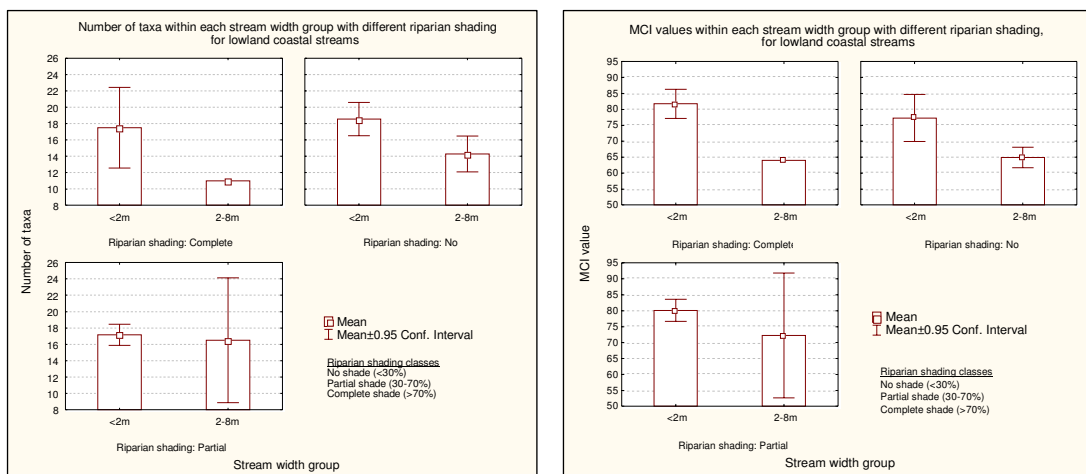


Figure 18 Mean number of taxa and MCI values for lowland coastal streams of different width, with differing riparian vegetation. Error bars are 95% CI

In ring plain streams rising inside the National Park, there was no significant difference in ecological health (as indicated by MCI values) with stream size if there was complete shade (Figure 16). Where there was partial shading, MCI values may be higher in small and medium sized streams (Figure 16), however only a low number of small streams have been sampled (Table 12).

Ecological health was lowest in larger ring plain streams rising outside the National Park which had no riparian shade compared to small and medium sized streams, which were similar (Figure 17). There were no significant differences in MCI values between stream width groups where streams were partially or completely shaded (Figure 17).

In lowland coastal streams, small streams had higher MCI values compared to medium sized streams, particularly where there was complete shade (but note the

small sample size (Table 12)) or no riparian vegetation (Figure 18). Partial shading also showed this trend although the small sample size in streams between 2-8 m wide means this is not significant. There would be few lowland coastal streams of medium to large size as these catchments comprise mainly of small unnamed coastal catchments which are very short and near the coast.

Appendix II Review of Taranaki fish data

Various organisations have surveyed the freshwater fish populations of Taranaki, and have usually submitted their data to the New Zealand Freshwater Fish database, which is administered by NIWA. Upon request, NIWA supplied this data to TRC, including environmental variables such as stream width. Those streams at greatest risk of piping are those less than two metres wide (small streams), while those at risk of straightening also include streams that are two to eight metres wide (medium streams). For this reason the fish data was categorised using these widths. The results of these analyses are given in Table 13, and the location of all sites with fish survey data in Taranaki (TRC data only) are shown in Figure 19 (source: TRC ESAM database).

The results indicate that streams less than two metres wide are under-represented in the database, with only just over 22.7% of all fish samples being undertaken in such streams. Although large rivers are even less represented, this is a function of their relative rarity in Taranaki. Streams less than two metres wide are under-represented due to less sampling effort. It should also be noted that most of these surveys have been undertaken by electric fishing, a technique known to produce an underrepresentation of the abundance of many native fish species, especially the kokopu species. Some of the electric fishing surveys undertaken are single pass, and therefore do not provide an accurate relative abundance for the species recorded (therefore only presence/absence data has been used in this report).

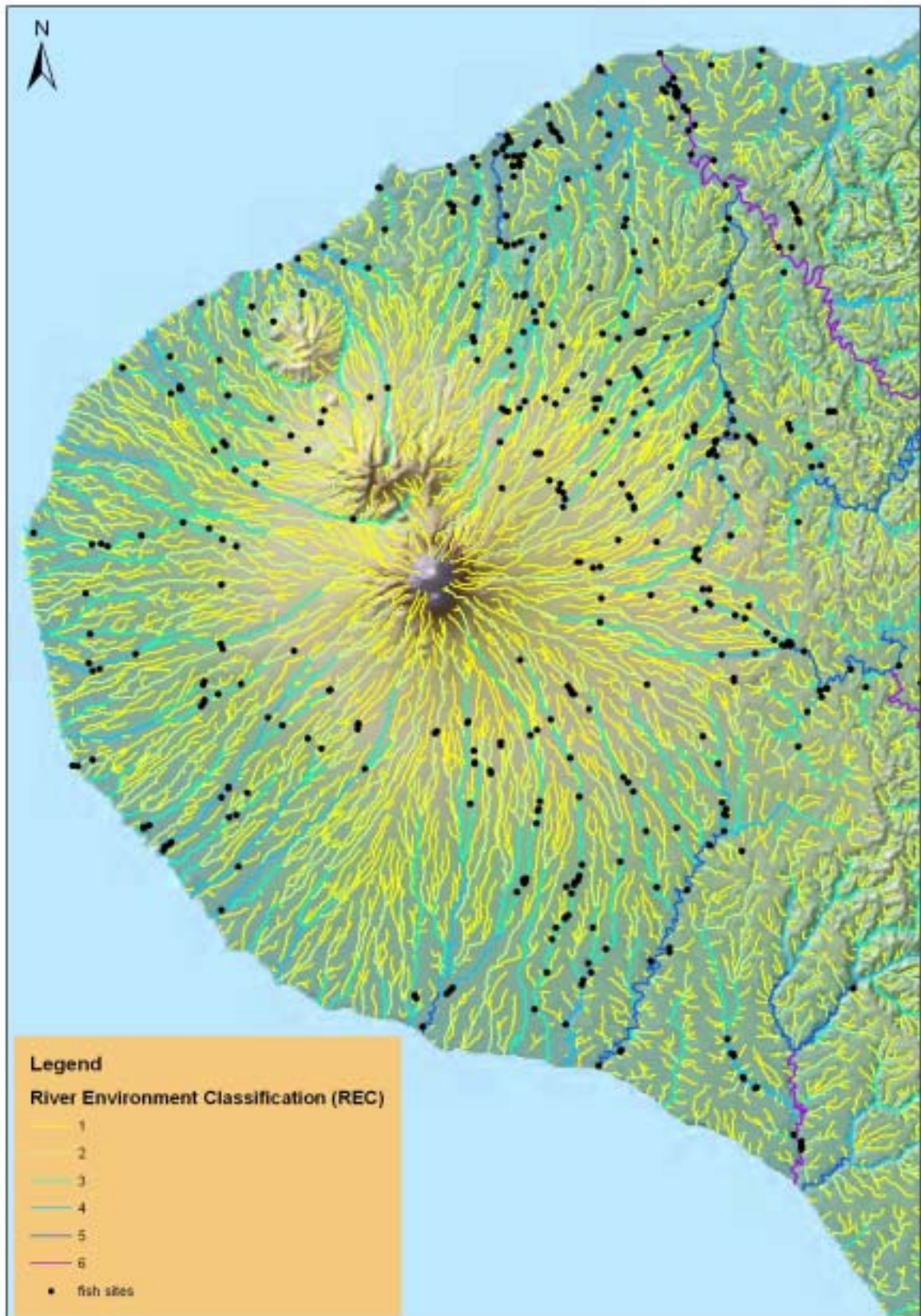


Figure 19 Location of monitoring sites with fish data in relation to the REC stream order classes

Figure 20 shows the variation in number of fish species recorded per survey, in small (<2 m wide), medium (2-8 m) and large (>8 m) streams. There are statistically significantly fewer species recorded in small streams than medium and large streams, although this is a difference of only one fish species and therefore unlikely to be ecologically significant.

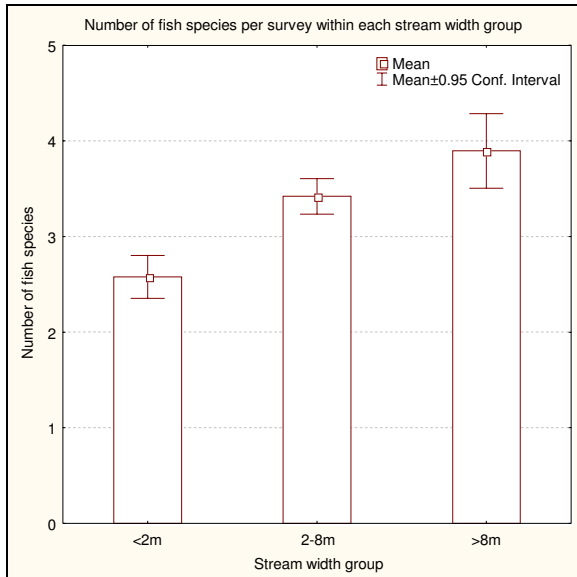


Figure 20 Number of species recorded in samples taken in small (<2 m), medium (2-8 m) and large (>8 m) width Taranaki streams

The total number of fish species recorded when all surveys (within each stream size category) were grouped together is similar across the three stream groups, with the exception of bluegill bully, which has not been recorded in small and medium streams, and common smelt which has not been recorded in small streams (Table 13).

The Department of Conservation has undertaken monitoring of brown mudfish distributions in Taranaki and found that Taranaki populations exist in remnant wetlands, predominantly around the Ngaere swampland and in South Taranaki. There are also populations present in the creeks and drains created when the swampland was drained, with the highest frequency of brown mudfish records being in streams less than two metres wide (11.1%, Table 13). This species has become endangered primarily through habitat loss, as the wetlands it commonly inhabits have been drained.

Table 13 Summary of fish survey results undertaken in Taranaki by the Taranaki Regional Council
Unbracketed number = number of occurrences
Bracketed number = number of occurrences as a percentage of all samples for that stream width

Species	No. of samples	Stream width			Total
		Small (<2m)	Medium (2-8m)	Large (>8m)	
		207	550	153	910
Longfin Eel (<i>Anguilla dieffenbachii</i>)		85 (41.1)	338 (61.5)	120 (78.4)	543 (59.7)
Giant Kokopu (<i>Galaxias argenteus</i>)		14 (6.8)	20 (3.6)	1 (0.7)	35 (3.8)
Brown Mudfish (<i>Neochanna apoda</i>)		23 (11.1)	16 (2.9)	-	39 (4.3)
Lamprey (<i>Geotria australis</i>)		-	9 (1.6)	7 (4.6)	16 (1.8)
Shortjaw Kokopu (<i>Galaxias postvectis</i>)		10 (4.8)	61 (11.1)	1 (0.7)	72 (7.9)
Redfin Bully (<i>Gobiomorphus huttoni</i>)		25 (12.1)	180 (32.7)	77 (50.3)	282 (31.0)
Shortfin Eel (<i>Anguilla australis</i>)		24 (11.6)	69 (12.5)	40 (26.1)	133 (14.6)
Common Bully (<i>Gobiomorphus cotidianus</i>)		9 (4.3)	35 (6.4)	25 (16.3)	69 (7.6)
Banded Kokopu (<i>Galaxias fasciatus</i>)		43 (20.8)	28 (5.1)	2 (1.3)	73 (8.0)
Inanga (<i>Galaxias maculatus</i>)		19 (9.2)	47 (8.5)	13 (8.5)	79 (8.7)
Koaro (<i>Galaxias brevipinnis</i>)		8 (3.9)	60 (10.9)	8 (5.2)	76 (8.4)
Torrentfish (<i>Cheimarrichthys fosteri</i>)		3 (1.4)	39 (7.1)	37 (24.2)	79 (8.7)
Crans Bully (<i>Gobiomorphus basalis</i>)		5 (2.4)	19 (3.5)	15 (9.8)	39 (4.3)
Common Smelt (<i>Retropinna retropinna</i>)		1 (0.5)	9 (1.6)	5 (3.3)	15 (1.6)
Giant Bully (<i>Gobiomorphus gobioides</i>)		-	7 (1.3)	-	7 (0.8)
Upland Bully (<i>Gobiomorphus breviceps</i>)		1 (0.5)	6 (1.1)	8 (5.2)	15 (1.6)
Bluegill Bully (<i>Gobiomorphus hubbsi</i>)		-	1 (0.2)	4 (2.6)	5 (0.5)
Unidentified adult Bully		10 (4.8)	41 (7.5)	9 (5.9)	60 (6.6)
Unidentified galaxiid		19 (9.2)	36 (6.5)	-	55 (6.0)
Unidentified eel		49 (23.7)	148 (26.9)	31 (20.3)	228 (25.1)
Brown Trout (<i>Salmo trutta</i>)		14 (6.8)	205 (37.3)	64 (41.8)	283 (31.1)
Rainbow Trout (<i>Oncorhynchus mykiss</i>)		-	3 (0.5)	2 (1.3)	5 (0.5)
Number of Species		19	24	21	24
Threat status =	Gradual Decline	Sparse	Not threatened	Unknown/Introduced	

On a positive note, just over 41% of the small stream samples and 61% of medium stream samples recorded the presence of longfin eel, which is another species classified as being in gradual decline. The reason for the decline of this species is considered to be 'human induced', which includes commercial fishing, but also habitat alteration and loss. The high recorded occurrence of this species (relative to other species) indicates that small streams provide important habitat for longfin eels but is also partly a reflection of the fact that eels are particularly susceptible to electric fishing, due to their length.

Giant kokopu, the third freshwater fish species in Taranaki that is considered to be in 'gradual decline', is usually nocturnal, and uses undercut banks and wooden debris for cover during the day. This is one of the reasons that this species is under-represented in the results, as it is very rarely recorded through electric fishing surveys. This is well illustrated in the case study in the Mangahewa Stream (Table 1). This species favours small to medium-sized streams (McDowall, 2000) and is considered to be a 'small stream fish'. This appears to be supported by the results, with 6.8% of small stream surveys and 3.6% of medium streams recording giant kokopu, compared with only 0.7% of large stream surveys.

The two species considered to be 'sparse', lamprey and shortjaw kokopu, have only been recorded in 16 and 72 surveys respectively, and this reflects their rare status. Shortjaw kokopu prefer similar habitat to giant kokopu, in that they are nocturnal and use undercut banks and wood debris as cover during the day, and hence are not often recorded during electric fishing surveys (but are more frequently recorded in night spotlighting surveys). They were recorded in 4.8% of small stream surveys and 11.1% of medium stream surveys, compared with only 0.7% of the large streams.

Lamprey are more susceptible to electric fishing, but are often tucked away under cover, and are therefore not always revealed in survey results. The juveniles, who live in softer sediment environments, are more often recorded, such as near the Huatoki Stream mouth, near the centre of New Plymouth.

The fact that lamprey have been recorded in 1.6% of medium stream surveys, suggests that they are not necessarily common within them. However, due to the specific habitat needs of these species, more targeted monitoring would be required before it could be concluded that small streams do not provide significant habitat for these two species. It should also be remembered that these species are classified as sparse, as they are considered to have very small and widely scattered populations, and so it shouldn't be a surprise for them to have a low incidence within the whole database.

The remaining 12 species listed in Table 13 are not considered to be threatened. However, it is clear from this table that a number of these species are more common in smaller streams, especially banded kokopu and shortfin eel, which is consistent with what is known about these species.

