Environment Waikato Technical Report 2005/16

Middle Waikato Pilot Project

A Review of Soil Conservation Research and Catchment Environmental Monitoring

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Table of Contents

List of Figures

List of Tables

Executive Summary

The purpose of this paper is to provide a summary of existing soil conservation information that is relevant to the Middle Waikato Pilot Project.

Soil conservation work has been carried out in the Middle Waikato Zone before and following the implementation of Project Watershed. This report presents research and monitoring results available to date, to determine the environmental changes that have occurred or can be expected to occur in the Middle Waikato Zone. The findings will lend support to determining the benefit of soil conservation work in the Middle Waikato Zone. Primarily, only research and monitoring results directly relating to the Middle Waikato Zone or research in areas similar to the Middle Waikato Zone are included.

Hill country sustainable management research update – Whatawhata Research Station

Water quality

- pasture streams export more nutrients and sediment than native streams (2 x suspended sediment, 2 x total phosphorus, 4 x nitrogen)
- pasture > pine > native for nutrient outputs
- pine > native for sediment
- pasture > native for water temperature
- pasture highest runoff
- native highest baseflow
- Whatawhata nutrient exports high –high runoff and erosion

Pathogens

- Pasture stream pathogen counts > pine = native (3-4 times greater)
- Pathogen levels were highest in summer and lowest in spring - contact recreation risk during summer.
- Removal of stock and pest control reduced pathogen levels by an order of magnitude (~10x).
- All sites had pathogens and water was never suitable for human consumption.
- Pastoral streams almost always failed to meet stock drinking water guidelines (100/ml).

Stream ecology

- pastoral and native forest taxa numbers are similar
- pastoral and native forest taxa are different
- pastoral communities are less stable than native forest communities

Grazing and runoff

- pasture: winter sheep grazing in high intensity rainfall = 13-16x increase in sediment concentrations
- sediment and nutrient levels correlate with area of bare ground (e.g. pugging)
- recovery periods at least 6 weeks

Cattle behaviour

- cattle will spend time in stream (~10 minutes/day)
- provision of troughs reduces stream time
- better forage = less drinking

Terrestrial biodiversity

- grazed fragments have fewer native species, fewer emergents, smaller trees less understory and forest litter.
- sustained possum control is effective in forest fragments

Poplar planting

- monetary incentives are marginal - IRR of 5-6%
- pasture loss of 20-30% after 20 years at 50-100 stems per hectare
- estimated 36% subsidy for neutral NPV

Forecasting – the 30 year picture

Parameter		**Change***	**Amount**	**Timeframe**
Rainfall	interception	increase	10-12%	25-30 years
Stream temperature	maximum	decrease	5-6 °C	
	mean	decrease	2-3 °C	
Erosion		decrease	40%	
Nutrients	total P	decrease	35%	15-20 years
	particulate P	decrease	27%	
	soluble P	decrease	2%	
	NO_3-N	decrease	21%	
	TOC	decrease	30%	at 15 years
		increase	150%	at 20 years
		decrease	30%	at 30 years

* from baseline

Report for EW on Soil Conservation benefits

Pasture/stock management

- For cattle, sediment loss through runoff is reduced by up to 80% under a scenario of low treading damage.
- Runoff under sheep grazing contributes low proportion (~1%) of catchment sediment export.
- Controlled grazing, to maintain a dense sward reduces the area of bare ground by 20 to 100%
- Ungrazed strips in ephemeral watercourses and surficial watercourses reduce sediment entering waterways by 26 to 52%

Cultivation practices

- Well-timed cultivation, stubble-mulching and drainage avoids grain yield losses of 23 to 45%
- Fallow strips along surficial watercourses and drains reduce sediment entering waterways by 26 to 52%

Forest management

- Low-impact logging techniques reduce sheet erosion on dry soils of upper slopes, reduce pugging on wet soils of lower slopes and the area of bare ground is reduced by 70 to 100%
- Unharvested strips along ephemeral and surficial watercourses reduce rilling and gully initiation,
- trap sediment from clear-felled compartments up-slope and reduce sediment entering streams by 50 to 95%

Riparian fencing and planting

- Fenced riparian strips with no planting reduces faecal coliforms by 35% and buffer banks from erosion.
- Fenced riparian strips provide a sediment, pathogen, nutrient and pesticide filter;
  - sediment input to streams is reduced by 40 to 84%,
  - dissolved P input is reduced by 27 to 76%
  - dissolved N input is reduced very little,
  - particulate N input is reduced by 33 to 74%
- Keeping stock out of streams reduces channel disturbance and faecal coliforms are reduced, typically from 500+ per 100 ml to <50.
- Where wetlands border the channel and contain denitrifying bacteria they can remove 90%+ of dissolved N.
- Over 20-30 years sediment export predicted to drop by ~50%, total P by ~50%, nitrate by 40%
- After 15-20 years stream temperature predicted to drop by 2-3ºC (daily mean) or 5-6ºC (daily max) allowing sensitive insect re-colonisation
- The length of bank eroded is reduced from 3-7% down to <1% in a small flood and from 24-39% down to 5-8% in a big flood

Planting on hill slopes

- Where trees are planted on erodible soil on unstable slopes the area eroded by slips/earthflows/gullies is reduced from 1% to 0.2-0.5% in a small storm and from 10% to 2-5% in a big one
- The likely proportionate reductions in farm infrastructure damage costs resulting from this reduced erosion are:
  - fence repair, typically $6 to $44 a hectare (averaged over the farm)
  - track clearance, typically $1 to $26 a hectare
  - building repair, typically $1 to $11 a hectare
  - pasture re-sowing, typically $1 to $13 a hectare
  - general clean-up, typically $3 to $4 a hectare
- On stabilised slopes at typical planting densities (up to 100 stems per hectare), stock can still be grazed, canopy shading will reduce annual dm growth by up to 25% but this loss is counter-balanced by extra dry matter growth on the ground saved from slips.
- Over 20-30 years under plantation tree planting at Whatawhata, sediment export predicted to drop by 60%, total P by 80%, nitrate by 70%.
- Over 20 years erosion is predicted to drop to 10-20% of pasture levels and rainfall interception is predicted to increase 20-25% and runoff will be 30 to 50% that of pasture.
- Under mature trees there are reductions of in-stream total P (~30%), DRP (~50%), total N (~50%) and nitrate (~50%)
- Following the first year without grazing faecal coliforms reduce by 80-90%

- After 15-20 years stream temperature is predicted to drop by 2-3ºC (daily mean) or 5-6ºC (daily max) allowing sensitive insect re-colonisation.
- Under mature trees there are reductions in annual (small) flood peak by 65 to 75% but minimal impact on the flood peak in really large storms
- The area eroded by slips/earthflows/gullies is reduced from 1% to 0-0.1% in small storms and from 10% to 1-2% in big storms.
- Where entire catchments are afforested the sediment load into waterways is reduced by 50 to 90%, though where sediment's already in a channel, it takes time to work its way downstream.

Land retirement

- Land retirement at Whatawhata has shown reductions in annual runoff (~10%) and reduced export of sediment (~60%), total P (~60%), total N (~80%) and nitrate (~90%)
- For retired land the area eroded by slips/earthflows/gullies is reduced from 1% to 0-0.1% in small storms and from 10% to 1-2% in big storms. These amounts are similar to afforestation with pines
- Where an entire catchment is retired the sediment load in rivers is reduced by more than 90% but where sediment's already in a channel, it takes time to work its way downstream.

Engineering measures

- The evidence for the benefits of engineering measures (e.g. detention dams, contouring) is largely anecdotal.
- Earthflow contouring and de-watering data from the East Coast indicates movement ceases for 10-20 years and that stock carrying capacity is raised to that of stable slopes (from 1-2 to 5-7 stock units/ha).

Suspended sediment in the Waitomo stream

- Suspended-sediment concentration is shown to be a function of flow rate
- For a given flow, suspended sediment concentration declined by about 40 percent over the eight-year period 1991-1999.
- The result is consistent with the land management programme of the Waitomo Landcare Group, which has been fencing and planting erosion-prone areas in the catchment with the aim of reducing the sediment load in the stream.
- Even though large loads were conveyed by severe floods during the winter of 1998 results indicate that the load would have been much more without the land management programme.
- A continuing monitoring programme is recommended.

Economic analysis of soil conservation benefits

- The benefits expected from soil conservation:
  - Land (soil) protected
  - Farm management benefits
  - Reduced downstream impacts (sedimentation, flooding, water quality)
  - Protection of farm infrastructure
  - Financial returns from forestry
  - Public infrastructure protected
  - Water quality protection and enhancement
  - Aesthetic enhancement
  - Resource protection/Property Values

- Benefits that can be quantified include:
  - Returns from timber (block planting)
  - Pastoral production
  - Saved infrastructural damage
  - Saved damage to public infrastructure (roading, utility networks)
  - Saved water supply treatment costs, insured loss
- The bulk of the quantifiable benefits tend to be received on-site i.e. by the property owner.
- **Non-quantifiable** benefits are associated with other proposed measures including riparian works, the retirement of areas of indigenous vegetation and river works. Additional non-quantifiable benefits are associated with biodiversity, aquatic ecology and resource protection.
- Benefits from soil conservation tend to be received are a number of levels;
  - Individual property / onsite / private
  - Specific interests / stakeholders (roading authorities, utility operators)
  - Local community / adjacent landowners / catchment
  - Wider community /region / nation
- Local Government Amendment Act No. 3 (1996) requirements - referred to as the contributor pays principle.
- Analysis of the quantifiable benefits and costs with and without soil conservation measures indicates an internal rate of return (IRR) ranging from 7% to 14%.

Catchment environmental monitoring

Catchment environmental monitoring commenced in 2003. Two priority catchments were selected for monitoring, the Pokaiwhenua and Mangare. The schedule of monitoring is outlined in the following table:

Monitoring	Planned Activity	2003/2004	2004/2005	2005/2006
Soil stability	None planned	None planned	Completed	None planned
Permanent water quality site	Install ISCO automatic water sampler	Not installed	Installation to be considered	Installation to be considered
Suspended sediment snapshot	Low flow completed. High flow snapshot at next sufficient rainfall event	High flow snapshot at next sufficient rainfall event	If not completed in 2003/2004	If not completed in 2004/2005
Riparian characteristic assessment	Complete baseline assessment along the mid section of the Pokaiwhenua River	Completed	Not scheduled	Scheduled
Photo points	Complete baseline assessment along the mid section of the Pokaiwhenua River	Completed	Completed	Scheduled
Water temperature	Install loggers and record stream temperatures along the mid section of the Pokaiwhenua River	Completed	Scheduled	Scheduled
Stream ecological health	Invertebrate samples taken to assess stream biological condition	Completed	Scheduled	Scheduled

Soil stability

A soil stability assessment of the Pokaiwhenua catchment to assess soil stability and soil conservation treatments and changes over that period has been completed.

- About 47% of the catchment had soil stability issues, is unstable, recently eroded or freshly eroded. Of that, 33% requires soil conservation treatment.
- About 14.1% has sufficient soil conservation treatments.
- About 10.6% of the catchment has insufficient or requires spaced pole planting, 2.5% block planting and 0.4% retiring.
- From 1992 to 2002 bare soil due to natural erosion has decrease by 67% from 0.9% to 0.4% of catchment area.
- From 1992 to 2002 bare soil due to land use disturbance has increased by 50% from 3.6% to 5.3% of catchment area.
- Changes in "natural bare ground" are difficult to interpret because of the confounding effect of storm events. However, increased soil conservation work over the same period would suggest decreases in natural erosion observed from 1992 to 2002 were at least partially attributable to this work.
- Disturbance due to land use has been increasing and is more ten times greater than disturbance by natural erosion. Potentially these types of disturbance can contribute sediment into waterways. It is necessary to include land use disturbance in any soil conservation planning.

Suspended sediment snapshots

A low flow suspended sediment snapshot sampling was conducted in June 2003 to provide background turbidity data to complement high flow data from a subsequent sampling. The combined data indicates the main sources of sediment within the catchment. Additional water quality data is also measured to provide an indication of pathogen and nutrient sources within the catchment. Results are presented as percentage of sites not meeting the water quality criteria.

- Turbidity (measure of suspended sediment) is satisfactory or better for all but one site, where earthworks were occurring upstream.
- Nutrients were the main concern with more than 50% of sites unsatisfactory.
- The levels of E. coli (indicating "pathogens" in the water from animal effluent) were generally satisfactory. The highest level was recorded on the Mangakaratu stream, downstream of Putaruru.
- E. coli loads, turbidity and nutrient loads are highly variable depending on whether stock are present in the stream during sampling. In the same respect very high levels indicate that stock do have access to streams.
- Low flow samplings do not provide a good indication of sediment losses (only background levels) because most sediment is moved during rainfall events.
- A high flow sampling is required.

Riparian characteristics survey

The purpose of the survey is to quantify the long term changes in riparian characteristics (erosion, vegetation and fencing) where soil conservation has been implemented.

Six 1km stream reaches tagged for soil conservation work were selected and surveyed on the Pokaiwhenua River and two 1km stream reaches on the Mangare Stream. The repeat surveys are schedule in the summer of 2005. Preliminary baseline data is presented.

- For the Pokaiwhenua survey:

- 12% of bank length is unstable. Unstable banks are most common where the vegetation is grass (67% of unstable banks). Over half of this length has been fenced.
- 58% of the riparian bank length is grass, the remaining 42% is woody vegetation. The component of native woody vegetation is 34% (about 76% of the woody vegetation), willow is 1% and 10% other exotic woody vegetation.
- 26% of bank length has been fenced on both sides, 44% on one side and 30% is not fenced on both sides.

- For the Mangare survey:
  - 61% of bank length is unstable. Unstable banks are most common where the vegetation is grass (95% of unstable banks). Over half of this length has been fenced..
  - 94% of the riparian bank length is grass, the remaining 6% is woody vegetation. The component of native woody vegetation is 0%, willow is 1% and 5% other exotic woody vegetation.
  - 49% of bank length has been fenced on both sides, 20% on one side and 31% is not fenced.

Photo points

For each of the surveyed 1km samples of stream in the riparian characteristics survey, 5 representative photos of the riparian margin are taken

- The initial year of survey was 2003/2004 with a second survey completed 12 months later in 2004/2005.
- For the Pokaiwhenua sites, there was little change in riparian characteristics between the two surveys (~1 year of riparian planting and fencing).
- For the Mangare sites, one site showed visual changes where there had been fencing and planting with willow poles on both banks.

Water temperature

Water temperature is being measured over a 1 km reach of the Pokaiwhenua River where there has been riparian planting. Measurements are over the summer months when water temperatures are at their highest

- The average daily maximum water temperature downstream of plantings is cooler for the selected 10 week period for both years of survey.
- There are insufficient data to determine any annual trend in temperature.
- The plantings are new and do not provide stream shade at present.
- More annual data is required.

Stream ecological health

Invertebrate sampling is carried out where the water temperature probes are deployed on the Pokaiwhenua River.

- Data includes invertebrate species counts, habitat scores, and stream physical parameter information.
- 2003/2004 was the first year of survey and no comparisons between years can be made until subsequent surveys are completed.

Historic photos

In addition to the photo points survey within the Middle Waikato monitoring programme there are historic photos showing visual changes resulting from soil conservation work in the Middle Waikato zone.

- There are identifiable changes evident 2 years following riparian planting and fencing.
- All photo series for each site show a visual decrease in unstable banks and bare ground and an increase in vegetation, especially woody vegetation.
- At 2 years, the most obvious visual change is a visual decrease in unstable stream banks and bare ground and an increase is grass and low vegetation.
- After 2 years (years 3-8) the most obvious visual change is an increase in woody vegetation.
- After 8 years (year 14) the most obvious visual change is an increase in the size of the woody vegetation.
- A visual increase in rank grass and low lying vegetation indicates stock exclusion.

Concluding remarks

Soil conservation research:

The information from Whatawhata Research Station supports the general soil conservation research from other parts of the country.

Space planting reduces the risk of mass movement. The economics of space planting are variable and depend on how differences in production are calculated.

Block planting (plantation) has major benefits for water quality (reduced nutrients, pathogens and stream ecology is improved). Erosion and subsequent sediment yields are decreased for young to mature trees and small storm peak flows are reduced. However, the economics are different to pasture.

Retirement of land has major gains for water quality (as for block planting).). Erosion and subsequent sediment yields are decreased and small storm peak flows are reduced. There are biodiversity benefits. Production is reduced to nil. However, inputs are significantly reduced.

Riparian planting and fencing combinations have a major water quality benefit and reduce stream bank instability. Stream bank instability is least where stack are excluded and woody vegetation is present. Improved bank stability from soil conservation work is supported visually by historic photos.

Riparian margin and in-stream biodiversity and ecology will benefit from riparian fencing and planting. Ungrazed riparian strips will effectively filter sediment, nutrients (mainly P) and pathogens.

The whole catchment approach of Waitomo does give results, with reduced sediment yields evident after 10 years. Based on other research in this report, nutrient and pathogen contamination of waterways and erosion are very likely to be reduced. Also, there are likely to be some biodiversity gains (riparian margin, in-stream and kaarst).

Soil conservation benefits

- Cost benefit analysis is difficult because there are quantifiable and non-quantifiable benefits, numerous contributors and benefactors at different scales (e.g. farm, catchment region).
- Soil conservation benefits are mainly on-site with less off-site benefits (e.g. improved water quality and less infrastructure damage).

Soil stability in the Pokaiwhenua:

- Changes in “natural bare ground” are difficult to interpret because of the confounding effect of storm events. However, increased soil conservation work over the same period would suggest decreases in natural erosion observed from 1992 to 2002 were at least partially attributable to this work.

- Changes in “land use bare ground” are considered to be real changes.
- Disturbance due to land use has been increasing and is more ten times greater than disturbance by natural erosion. Potentially these types of disturbance can contribute sediment into waterways.
- 12% of bank length is unstable. Unstable banks are most common where the vegetation is grass.
- 26% of bank length has been fenced on both sides, 44% on one side and 30% is not fenced on both sides. This is an indicator of stock exclusion from waterways.

Soil conservation required for the Pokaiwhenua

- About 47% of the catchment had soil stability issues, is unstable, recently eroded or freshly eroded. Of that, 33% requires soil conservation treatment.
- About 14.1% has sufficient soil conservation treatments.
- About 10.6% of the catchment has insufficient or requires spaced pole planting, 2.5% block planting and 0.4% retiring.
- A priority for riparian soil conservation (to reduce unstable stream banks) are unfenced grass riparian margins. 24% of the total bank length surveyed in the Pokaiwhenua survey was unfenced grass.
- It is necessary to include land use disturbance in any soil conservation planning.

1 Introduction

1.1 Background

The purpose of this paper is to provide a summary of existing soil conservation information that is relevant to the Middle Waikato Pilot Project.

Soil conservation work has been carried out in the Middle Waikato Zone before and following the implementation of project Watershed. This report presents research and monitoring results available to date to determine what environmental changes have occurred or can be expected to occur in the Middle Waikato Zone. The findings will provide support to determining the benefit of soil conservation work in the Middle Waikato Zone. Primarily, only research and monitoring results directly relating to the Middle Waikato Zone or research in areas similar to the Middle Waikato Zone are included.

The content of the summary reports presented in this review are largely unaltered in content and formatting. Summary points have been added to highlight the main ideas and results of the report.

1.2 Framework

This report combines numerous published and unpublished research and reports from a number of scientists and consultants. The main contributors and collators of information contained in this include Dr. Mike Dodd (AgResearch), Dr. John Quinn, Dr. Murray Hicks and Dr. Alistair McKerchar (NIWA), Dr. Doug Hicks (consultant) and Dr. Bill Dyck (consultant). There are two main sections within the report 1) Soil conservation research relevant to the Middle Waikato Zone and 2) Catchment environmental monitoring for the Middle Waikato Zone. Where possible the report presents a summary of the main findings of reports and published research followed by the references to the original documents.

2 Soil Conservation Research Information

This section includes summary information for:

1) the available research results and publications from Whatawhata Research Station (Mike Dodd and John Quinn),

2) the Waitomo Stream Catchment Suspended Sediment report (Alistair McKerchar and Murray Hicks),

3) the report of soil conservation benefits (Doug Hicks and Bill Dyck).

2.1 Hill Country Sustainable Management Research Update – Whatawhata Research Station

2.1.1 Introduction

The information in this section has been compiled by Dr. M. B. Dodd and Dr. J. M. Quinn. The compilation presents updated summary information for research at Whatawhata Research Station. the information compliments the soil conservation benefits information presented by Dr. Doug Hicks and Dr. Bill Dyck in 2001 as part of assessing the likely benefits of Project Watershed (see section 2.2).

2.1.2 Water Quality (Quinn, Stroud)

This information relates to data collected at Whatawhata prior to the land use changes in the catchment. Subsequent data is being collected at 11 sites in the 3 catchments, including sediment, nutrients, pH, EC, black disc, turbidity, temperature. Also flows, sediment, temperature, turbidity from 3 catchment weirs. Now have 3 years of data since changes, but limited ability to analyse (time constraints).

- Over one year, pastoral streams had 2 times higher SS and TP export and 4 times higher TN export than native forest streams.

- For most nutrient parameters, average water quality in streams was highest in native followed by pine forest and pastoral.

- For SS and turbidity, pine forest (30 years) was highest, native forest lowest.

- For water temperature, pastoral was highest, native forest lowest.

- Pastoral had 7% higher annual runoff, but native had 17% higher baseflows.

- Total N and P export is high relative to other NZ studies, with high likely contributions to both from runoff & erosion processes.

Summary points

- PASTURE streams export more nutrients and sediment than NATIVE streams

- (2 x SS; 2 x TP; 4 x N)

- PASTURE>PINE>NATIVE for nutrient outputs

- PINE > NATIVE for sediment

- PASTURE>NATIVE for water temperature

- PASTURE highest runoff

- NATIVE highest baseflow

- Whatawhata nutrient exports high –high runoff and erosion

2.1.3 Bugs (Donnison, Ross, Thorrold)

This information relates to data collected before and after the land use changes at Whatawhata, the paper is currently in press. Subsequent data is in the process of being collected at the 11 NIWA monitoring sites.

- Median *E. coli* levels 3-4 times higher on pastoral (where stock have access to streams) compared to 7-year old pines and native forest, which were similar.

- Seasonal pattern of *E. coli* levels was highest in summer and lowest in spring at all sites, so that all sites had levels associated with contact recreation risk during summer.

- Levels dropped by an order of magnitude (~10x) after removal of stock and pest control for planting pines, below that of 7-year pines/native forest.

- Almost all samples at all sites had *E. coli* and therefore water was never suitable for human consumption, pastoral streams almost always failed to meet stock drinking water guidelines (100/ml).

Summary points

- PASTURE streams have greater pathogen counts (~3-4 times) than pine and native

- Pathogen levels were highest in summer and lowest in spring - contact recreation risk during summer.

- Removal of stock and pest control dropped pathogens levels by an order of magnitude (~10x).

- All sites had pathogens and water was never suitable for human consumption.

- Pastoral streams almost always failed to meet stock drinking water guidelines (100/ml).

2.1.4 Stream Ecology (Collier et al.)

This information relates to data collected at Whatawhata before land use changes. Subsequent data on stream habitat, invertebrates and fish has been collected by NIWA but not analysed.

- No difference in total taxa richness between pastoral and native forest stream sites.

- Pastoral sites have higher percentages of mollusca, whereas native forest sites have higher percentages of *Trichoptera, Plecoptera* and Crustacea.

- Invertebrate community composition was less stable at pastoral sites, and pastoral and native sites differed in the responses of taxa numbers and density to a flood event.

Summary points

- pastoral and native forest taxa numbers are similar

- pastoral and native forest taxa are different

- pastoral communities are less stable than native forest communities

2.1.5 Grazing and Runoff (Elliott et al.)

This information relates to rainfall simulation and overland flow work in the Pukemanga sub-catchment (9ha) which has now ceased and the equipment is planned to be moved off-site.

- High intensity rainfall after winter grazing with sheep increased sediment concentrations by 13-16x.

- Concentrations of sediment and particulate nutrients correlated with bare ground levels.

- Concentrations, infiltration and ground cover took 6 weeks to return to pre-grazing levels. Damage and recovery periods were greater for cattle.

Summary points

- Pasture: winter sheep grazing in high intensity rainfall = 13-16x increase in sediment concentrations

- Sediment and nutrient levels correlate with area of bare ground (e.g. pugging)

- Recovery periods at least 6 weeks

2.1.6 Cattle Behaviour (Bagshaw)

This information relates to Caroline's PhD studies.

- Cattle exhibited a strong daily pattern of behaviour, that included time in the stream (~10 mins) and on the banks (~45 mins) during the afternoons.

- Cattle used both troughs and streams for drinking when both were available.

- Provision of alternative water supply did not change the distribution of cattle in paddocks, though troughs near streams meant that streams were used less for drinking.

- No strong evidence that forage availability affected the distribution of cattle in paddocks, though cattle drank less when high quality forage was available.

Summary points

- Cattle will spend time in stream (~10 minutes/day)

- Provision of troughs reduces stream time

- Better forage = less drinking

2.1.7 Terrestrial Biodiversity (Burns, Dodd)

This information relates to data collected from forest fragments at Whatawhata just prior to the land use changes in the catchment. Subsequent data has been collected but not yet analysed.

- Grazed fragments had 40% fewer native species, 70% less emergent canopy cover, 35% lower tree basal area, 40% less litter cover on the forest floor, 60% less understorey cover than ungrazed forest

- Forest fragment gullies had 17 and 25% RTC of possums, compared to 30+ in adjacent forest. Approx. 4% was achieved after one year with sustained bait station control.

Summary points

- Grazed fragments have fewer native species, fewer emergents, smaller trees less understory and forest litter.

- Sustained possum control is effective in forest fragments

2.1.8 Poplar Planting (Parminter, Dodd, Mackay)

This information relates to a study published in the NZGA Proceedings 1999, using a wide range of data from various sources.

- On-site monetary incentives are marginal at best, even under situations of high erosion rates and associated pasture and infrastructure losses, and incorporating timber harvest. IRR of 5-6%

- Result was strongly influenced by reductions in pasture productivity due to tree shading effects (20-30% after 20 years at 50-100 stems per hectare), and relatively insensitive to changes in levels of repair costs, stock GMs and erosion risk.

- An estimate of 36% for the subsidy required to give a neutral NPV.

Summary points

- Monetary incentives are marginal - IRR of 5-6%
- Pasture loss of 20-30% after 20 years at 50-100 stems per hectare
- Estimated 36% subsidy for neutral NPV.

2.1.9 Forecasting – the 30 Year Picture

- Stream temperature (Rutherford) Land use changes are predicted to reduce daily maximum stream temperatures by 5-6ºC and daily mean stream temperatures by 2-3 ºC after about 15-20 years.
- Sediment & nutrient runoff (Collins) Land use changes are predicted to result in an annual decrease in load (relative to the baseline simulation) of 35, 24, 27, 2, 21%, for suspended sediment, Total P, particulate P, soluble P, and NO_3-N respectively at the catchment outlet.
- Erosion & economics (Way) Adoption of forestry is predicted to improve the long-term profitability of the catchment farm, but requires external finance for implementation. Mean cashflow over the implementation period is reduced by ~$43k, and over the harvesting period is increased by ~$188k. Soil erosion is predicted to decrease by 40% of current levels, and rainfall interception is predicted to increase by 10-12% after 25-30 years.
- Stream carbon (Quinn) Land use changes are predicted to reduce TOC export by ~30% until 15 years, when stream bank shading is expected to release stored sediment and erosion carbon. At 20 years, TOC export is expected to peak at ~150%, then drop to 30% of current levels.

2.1.10 Summary Points

Parameter		Change*	Amount	Timeframe
Rainfall	interception	increase	10-12%	25-30 years
Stream temperature	maximum	decrease	5-6 °C	
	mean	decrease	2-3 °C	
Erosion		decrease	40%	
Nutrients	total P	decrease	35%	15-20 years
	particulate P	decrease	27%	
	soluble P	decrease	2%	
	NO_3-N	decrease	21%	
	TOC	decrease increase decrease	30% 150% 30%	at 15 years at 20 years at 30 years

* from baseline

2.2 Report for EW on Soil Conservation Benefits

2.2.1 Introduction

This section summarises research compiled by Hicks and Dyck and Dodd and Quinn on the

benefits of different soil conservation and land management practices.

The benefits outlined relate to:

- Pasture/stock management
- Cultivation practices
- Forest management
- Riparian fencing and planting
- Planting on hill slopes
- Land retirement
- Engineering measures

2.2.2 Benefits of Pasture/Stock Management

Benefits of pasture/stock management –Whatawhata

- Reduced sediment loss through runoff by up to 80% under a scenario of low treading damage (40% compared to 80%) (Elliott et al. 2002)

- Reduced late winter pasture growth rate losses of 5-10 kgDM/ha/d due to treading damage (Sheath & Carlson 1998)

- NB. Runoff under sheep grazing contributes low proportion (~1%) of catchment sediment export (Elliott & Carlson 2004)

Controlled grazing, to maintain a dense sward

- reduces pugging of wet soils and sheet erosion on dry soils

- improves water infiltration into soil

- area of bare ground is reduced by 20 to 100% (say up to 90%?) 1

- 8 to 91% (say up to 90%?) of pasture growth is saved, the following year 2

Ungrazed strips in ephemeral watercourses and surficial watercourses

- reduce rilling and gully initiation

- trap sediment within fields

- reduce sediment entering waterways
  by 26 to 52% (say up to 50%?) 3,4,5,6,7,8

Summary points

- For cattle, sediment loss through runoff is reduced by up to 80% under a scenario of low treading damage.

- Runoff under sheep grazing contributes low proportion (~1%) of catchment sediment export.

- Controlled grazing, to maintain a dense sward reduces the area of bare ground by 20 to 100%

- Ungrazed strips in ephemeral watercourses and surficial watercourses reduce sediment entering waterways by 26 to 52%

2.2.3 Benefits of Cultivation Practices

Benefits of cultivation practises –Whatawhata

- No information available

Well-timed cultivation, stubble-mulching and drainage

- doesn't reduce area of bare ground

- but maintains good soil structure

- avoids grain yield losses of 23 to 45% (say up to 50%?) 2

Fallow strips along surficial watercourses and drains

- reduce rilling and gully initiation

- trap sediment within fields

- reduce sediment entering waterways by 26 to 52% (say up to 50%?) 3,4,5,6,7,8

Summary points

- Well-timed cultivation, stubble-mulching and drainage avoids grain yield losses of 23 to 45%

- Fallow strips along surficial watercourses and drains reduce sediment entering waterways by 26 to 52%

2.2.4 Benefits of Forest Management

Benefits of forest management –Whatawhata

- No information available

Low-impact logging techniques

- reduce sheet erosion on dry soils of upper slopes

- reduce pugging on wet soils of lower slopes

- area of bare ground is reduced by 70 to 100% (say more than 70%?) 9,10,11,12

- don't reduce timber yield (the trees are still harvested)

Unharvested strips along ephemeral and surficial watercourses

- reduce rilling and gully initiation

- trap sediment from clear-felled compartments up-slope

- reduce sediment entering streams by 50 to 95% (say more than 50%?) 13,14

- can reduce timber yield, typically by about ?% (any FRI or LIRO data?

Summary points

- Low-impact logging techniques reduce sheet erosion on dry soils of upper slopes, reduce pugging on wet soils of lower slopes and the area of bare ground is reduced by 70 to 100%

- Unharvested strips along ephemeral and surficial watercourses reduce rilling and gully initiation,

- trap sediment from clear-felled compartments up-slope and reduce sediment entering streams by 50 to 95%

2.2.5 Benefits of Fenced Riparian Strips (No Planting)

Benefits of fenced riparian strips (no planting) –Whatawhata

- Reduces faecal coliforms by 35% (Collins & Rutherford 2004)

Buffer banks from erosion

- very little data about rank grass's effect on bank erosion

- almost all the surveys have been on riparian strips where trees have been planted

Keep stock out of streams

- channel disturbance is reduced

- faecal coliforms are reduced, typically from 500+ per 100 ml to <50 15,16,17

Provide a sediment, pathogen, nutrient and pesticide filter

- sediment input to streams is reduced by 40 to 84% (say 40%+?) 3,4,5,6,7,8
- dissolved P input is reduced by 27 to 76% (say 25%+?) 3,4,5,6,7,8
- dissolved N input is reduced very little
- particulate N input is reduced by 33 to 74% (say 30%+?) 3,4,5,6,7,8

Denitrify groundwater

- only where wetlands border the channel and contain denitrifying bacteria.
- where present, they can remove 90%+ of dissolved N 3,18,19
- & contribute it to greenhouse gas emission instead!

Provide in-stream food supplies and habitat for fish etc.

- food supplies are increased

Summary points

- Fenced riparian strips with no planting reduces faecal coliforms by 35% and buffer banks from erosion.
- Fenced riparian strips provide a sediment, pathogen, nutrient and pesticide filter;
- sediment input to streams is reduced by 40 to 84%,
- dissolved P input is reduced by 27 to 76%
- dissolved N input is reduced very little,
- particulate N input is reduced by 33 to 74%
- Keeping stock out of streams reduces channel disturbance and faecal coliforms are reduced, typically from 500+ per 100 ml to <50.
- Where wetlands border the channel and contain denitrifying bacteria they can remove 90%+ of dissolved N.

2.2.6 Benefits of Riparian Tree Planting

Benefits of riparian tree planting - Whatawhata

- Over 20-30 years sediment export predicted to drop by ~50%, total P by ~50%, nitrate by 40% (Collins 2001)
- After 15-20 years stream temperature predicted to drop by 2-3ºC (daily mean) or 5-6ºC (daily max) allowing sensitive insect re-colonisation (Rutherford 2000)

Trees reduce channel erosion

- length of bank eroded is reduced from 3-7% down to <1% in a small flood 21
- & from 24-39% down to 5-8% in a big one 21

Trees improve aquatic habitat

- reduce water temperature by shading
- contribute food by leaf-fall
- snags create niches for aquatic organisms

Wider riparian strips may be needed on steeper slopes

- not for bank stabilisation by tree planting!
- NIWA's model suggests wider strips are needed for nutrient stripping
- but the model's predictions conflict with some of NIWA's own field trial results

Riparian protection is most effective at protecting smaller streams and rivers

- no evidence that bank stabilisation by trees is better on smaller streams and rivers
- where trees are planted on them, NIWA measurements show lower water temperatures and better aquatic habitat

Summary points

- Over 20-30 years sediment export predicted to drop by ~50%, total P by ~50%, nitrate by 40%
- After 15-20 years stream temperature predicted to drop by 2-3ºC (daily mean) or 5-6ºC (daily max) allowing sensitive insect re-colonisation
- The length of bank eroded is reduced from 3-7% down to <1% in a small flood and from 24-39% down to 5-8% in a big flood

2.2.7 Benefits of Pole Planting on Slopes (Willows and Poplars Space-Planted in Pasture)

Benefits of pole planting on slopes -Whatawhata

- No additional data, but see Parminter et. al. 1999

Trees stabilise erodible soil on unstable slopes

- area eroded by slips/earthflows/gullies is reduced
- from 1% to 0.2-0.5% in a small storm 22,23,24,25,26
- & from 10% to 2-5% in a big one 22,23,24,25,26

Less erosion means less farm infrastructure damage. Proportionate reductions in :

- fence repair, typically $6 to $44 a hectare (averaged over the farm) 2
- track clearance, typically $1 to $26 a hectare 2
- building repair, typically $1 to $11 a hectare 2
- pasture re-sowing, typically $1 to $13 a hectare 2
- general clean-up, typically $3 to $4 a hectare 2

Stock can still be grazed on stabilised slopes

- at typical planting densities (up to 100 stems per hectare)
- canopy shading will reduce annual dm growth by up to 25% 27,28,29
- but loss is counter-balanced by extra dm growth on ground saved from slips
- (checked by running Agresearch's -25% figure through the DSP97 model)

Summary points

- Where trees are planted on erodible soil on unstable slopes the area eroded by slips/earthflows/gullies is reduced from 1% to 0.2-0.5% in a small storm and from 10% to 2-5% in a big one
- The likely proportionate reductions in farm infrastructure damage costs resulting from this reduced erosion are:
  - fence repair, typically $6 to $44 a hectare (averaged over the farm)
  - track clearance, typically $1 to $26 a hectare
  - building repair, typically $1 to $11 a hectare
  - pasture re-sowing, typically $1 to $13 a hectare
  - general clean-up, typically $3 to $4 a hectare
- On stabilised slopes at typical planting densities (up to 100 stems per hectare), stock can still be grazed, canopy shading will reduce annual dm growth by up to 25% but this loss is counter-balanced by extra dry matter growth on the ground saved from slips.

2.2.8 Benefit of Blanket Tree Planting on Slopes (Afforestation with Pines or other Timber Species)

Benefits of blanket plantation tree planting -Whatawhata

- Over 20-30 years sediment export predicted to drop by 60%, total P by 80%, nitrate by 70% (Collins 2001)
- Over 20 years erosion predicted to drop to 10-20% of pasture levels, and rainfall interception predicted to increase 20-25% (Way 1999)
- Reduces in-stream total P by ~30%, DRP by ~50%, total N by ~50%, nitrate by ~50% under mature trees (Quinn & Stroud 2002)
- Reduces faecal coliforms by 80-90% in first year without grazing (Donnison et al, in press)
- After 15-20 years stream temperature predicted to drop by 2-3ºC (daily mean) or 5-6ºC (daily max) allowing sensitive insect re-colonisation (Rutherford

Reduces runoff 30 to 50% over pasture

- this figure can be supported by the Nelson, Otago and South Canterbury hydrological studies but the Volcanic Plateau studies (Purukohukohu) suggest a reduction of c. 10% where annual rainfall is c. 1500 mm 30,31,32

Reduces annual (small) flood peak by 65 to 75%

Little impact on flood peak in really large storms

Reduces soil erosion

- area eroded by slips/earthflows/gullies is reduced
- from 1% to 0-0.1% in small storms 33,34,35,22,26
- & from 10% to 1-2% in big ones 33,34,35,23

Improves eroded soil

- Soil depth, structure and fertility build up under forest plantations (incl. pines)

Sediment load in rivers is reduced

- 50 to 90%+, where entire catchments are afforested 36,37,38
- afforesting just the eroded headwaters can reduce sediment load by 30 to 50% 36,37,38
- though where sediment's already in a channel, it takes time to work its way downstream

Some residual loss in production

- up to 2% of timber crop may be destroyed by erosion in a big storm 33,34,35
- cf. up to 10% of pasture, if an erodible headwaters is still grazed 33,34,35

Summary points

- Over 20-30 years under plantation tree planting at Whatawhata, sediment export predicted to drop by 60%, total P by 80%, nitrate by 70%.
- Over 20 years erosion is predicted to drop to 10-20% of pasture levels and rainfall interception is predicted to increase 20-25% and runoff will be 30 to 50% that of pasture.
- Under mature trees there are reductions of in-stream total P (~30%), DRP (~50%), total N (~50%) and nitrate (~50%)
- Following the first year without grazing faecal coliforms reduce by 80-90%
- After 15-20 years stream temperature is predicted to drop by 2-3ºC (daily mean) or 5-6ºC (daily max) allowing sensitive insect re-colonisation.
- Under mature trees there are reductions in annual (small) flood peak by 65 to 75% but minimal impact on the flood peak in really large storms
- The area eroded by slips/earthflows/gullies is reduced from 1% to 0-0.1% in small storms and from 10% to 1-2% in big storms.
- Where entire catchments are afforested the sediment load into waterways is reduced by 50 to 90%, though where sediment's already in a channel, it takes time to work its way downstream.

2.2.9 Benefits of Land Retirement on Slopes (Scrub and Bush Reversion)

Benefits of land retirement - Whatawhata

- Reduces annual runoff by ~10% (Quinn & Stroud 2002)
- Reduces export of sediment by ~60%, total P by ~60%, total N by ~80%, nitrate by ~90% (Quinn & Stroud 2002)

Reduced runoff compared to pasture

Reduced annual (small) flood peaks compared to pasture

Little impact on flood peak in really large storms

Reduced soil erosion compared to pasture

- area eroded by slips/earthflows/gullies is reduced
- from 1% to 0-0.1% in small storms 22,26
- & from 10% to 1-2% in big ones 23,39,40
- i.e. just as much as afforestation with pines

Improves eroded soil

- Soil depth, structure and fertility build up under scrub and bush

Sediment load in rivers is reduced

- by 90%+, where entire catchments revert 36,37,38
- little or no data on effect of allowing just the eroded headwaters to revert 36,37,38
- where sediment's already in a channel, it takes time to work its way downstream

No commercial production from retired land

Carbon sequestration by scrub or bush may eventually have commercial value

Biodiversity improves

- reversion creates habitat for native plants and birds
- it also creates habitat for animal pests

Summary points

- Land retirement at Whatawhata has shown reductions in annual runoff (~10%) and reduced export of sediment (~60%), total P (~60%), total N (~80%) and nitrate (~90%)
- For retired land the area eroded by slips/earthflows/gullies is reduced from 1% to 0-0.1% in small storms and from 10% to 1-2% in big storms. These amounts are similar to afforestation with pines
- Where an entire catchment is retired the sediment load in rivers is reduced by more than 90% but where sediment's already in a channel, it takes time to work its way downstream.

2.2.10 Benefits of Soil Conservation Engineering Measures

(Detention Dams, Debris Dams, Gully Control Flumes, Earthflow Dewatering, Riverbank Stabilisation)

Benefits of soil conservation engineering -Whatawhata

- No available information

Dams can reduce flood peaks in small basins

- anecdotal evidence but nobody has measured this in NZ

Debris dams retain sediment and reduce on-site erosion by maintaining bed level

- anecdotal evidence but nobody has measured this in NZ

Gully control flumes stop back-cutting

- anecdotal evidence but nobody has measured this in NZ

Earthflow contouring and de-watering

- East Coast data indicate movement ceases for 10-20 years 2
- pasture dm production can be raised to same level as stable slopes 2
- stock carrying capacity is raised from 1-2 to 5-7 stock units/ha 2

Riverbank stabilisation

Improved water quality and aquatic habitat from lower sediment levels

- anecdotal evidence but nobody has measured this in NZ

Summary points

- The evidence for the benefits of engineering measures (e.g. detention dams, contouring) is largely anecdotal.
- Earthflow contouring and de-watering data from the East Coast indicates movement ceases for 10-20 years and that stock carrying capacity is raised to that of stable slopes (from 1-2 to 5-7 stock units/ha).

2.3 Suspended Sediment in the Waitomo Stream

2.3.1 Introduction

The full report by Alistair McKerchar Murray Hicks (2002) is available; docs#830199.

- This report presents an analysis of 10 years of stream sediment measurements for the Waitomo Stream, highlighting the long term trends in sediment levels of the stream in response to soil conservation in the upstream catchment.
- The main findings of this report were been presented in a Report to the Waipa Zone Liaison Subcommittee (Hill, 2003). The body of this report is presented in this section.
- Although the study site is not in the Middle Waipa Zone the study does provide a good catchment scale example of water quality improvements resulting from soil conservation.

In an effort to reduce sediment loads in Waitomo Stream, an extensive land management programme of fencing and planting erosion prone areas has been undertaken since the late 1980s. Local observations are that the stream is cleaner, carries less sediment, and is visually more appealing. Further, the cost of removing sediment from the town water supply has reduced.

To monitor the impact of the land-management activity, a suspended sediment-monitoring programme has been undertaken on Waitomo Stream over the period 1990-2000. This study analyses the data collected for that programme for the following aims:

1. Assess the extent to which the mitigation measures have reduced the sediment load conveyed by the stream.

2. Suggest a 'generic' sediment monitoring strategy that could be applied elsewhere in the region to assess the effectiveness of measures to mitigate stream sediment inputs.

2.3.2 Waitomo Land-Care Group Activities

Over recent decades, suspended sediment (SS) in Waitomo Stream has contributed to the build-up of sediment in the Waitomo Caves and has affected the quality and appearance of the water, some of which is abstracted for rural and town supplies. To reduce sediment loads and improve water quality, Environment Waikato has been instrumental in forming a land-care group involving the community and a range of national and local agencies. Over the last 10 years, the group has funded more than 60 km of fencing in the catchment (catchment area of about 30 km^2) that excludes stock from 625 ha of native bush, 20 km of streams and wetlands, and 350 ha of slip-prone land. In addition, the group has facilitated riparian planting and retired land.

2.3.3 Data Collection and Analysis Approach

Environment Waikato has operated a standard stream gauging station on Waitomo Stream at Ruakuri Caves Bridge (station number 1943481) since 1984. At this location the topographic catchment area is 30.8 km^2. Eighty-five depth-integrated sediment samples were collected there over the period August 1990 to May 1999 during runoff events, and twenty-nine sets of auto-samples were collected during freshes in the period September 1997 to October 2000. There were five occasions when concurrent depth-integrated and auto-samples were collected.

The analysis approach consisted of:

1. Inspecting the data for bias

2. Developing sediment rating relationships for evidence of significant temporal shifts

3. Developing relationships between the depth-integrated and the auto-sampled sediment concentrations

4. Establish the level of variability in monthly and annual SS yields

5. Describing the characteristics of hysteresis which may contain clues as to the nature of the sediment supply processes and changes therein

6. Developing an event-yield predictor relation

2.3.4 Main Findings

Local observations are that the stream is cleaner, carries less sediment, and is visually more appealing. Further, the cost of removing sediment from the town water supply has reduced.

Depth-integrated suspended sediments gathered over the period demonstrate that the concentration of suspended sediment for a given flow rate has declined by about 40 percent. Much of the reduction in yield occurs in the period 1990-1994 and no trend is evident in auto-sampled data collected over 1997-2000. The result indicates that the land-care programme has been effective, even though floods in 1998 produced exceptionally large sediment loads (see Figure 1).

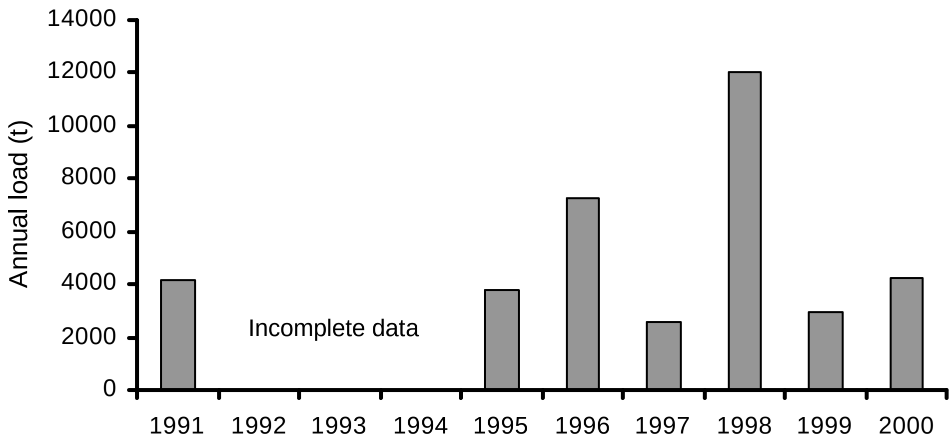

Figure 1: Calculated Annual Sediment Loads for Waitomo Stream (1991-2000)

Much larger loads would have occurred in the absence of the land-care programme. Characteristics of the events sampled indicated that the catchment is one of "restricted" sediment supply meaning sediment is supplied mainly by surface runoff early in an event. Sediment supply then diminishes indicating minimal ongoing erosion. Changes in the sediment load have induced a significant time trend in the sediment rating but this has required nearly a decade to identify.

2.3.5 Monitoring Recommendations

Continued monitoring of both the streamflow and the sediment concentration will be necessary to monitor the effectiveness of the continuing land-management activity.

As a general strategy to monitor the effectiveness of erosion control works on stream sediment loads, we recommend a sampling scheme aimed at identifying underlying time trends in sediment rating-flow relationships, either in terms of suspended-sediment concentration vs discharge, or, preferably, in terms of event sediment load. This is more likely to capture the effects of reduced stream sediment supply against a background of substantial climate-driven annual variability.

For sites where measures are being put in place to restrict stream sediment supply the following are recommended:

- Continuous streamflow monitoring
- A consistent and sustained programme of depth-integrated sampling over a range of flows and rising and falling stages to establish time trends in the instantaneous SSC-Q rating relationship.
- Identify time trends in the event-yield relationship and also in the hysteresis characteristics of the SSC-Q relation within events.

- Regular analysis of the particle size of the suspended load sampled by depth-integrated/whole flow samples.

- Sustain the sampling for an adequate duration for trends to emerge. A decade at least is recommended.

2.3.6 Summary Points

- Suspended-sediment concentration is shown to be a function of flow rate

- For a given flow, suspended sediment concentration declined by about 40 percent over the eight-year period 1991-1999.

- The result is consistent with the land management programme of the Waitomo Landcare Group, which has been fencing and planting erosion-prone areas in the catchment with the aim of reducing the sediment load in the stream.

- Even though large loads were conveyed by severe floods during the winter of 1998 results indicate that the load would have been much more without the land management programme.

- A continuing monitoring programme is recommended.

2.4 Economic Analysis of Soil Conservation Benefits

2.4.1 Introduction

This information is based on "Review of Scheme Funding Reports" (Brown Copeland and Co. Ltd)

The benefits expected from soil conservation can be described generally as follows:

- Land (soil) protected

- Farm management benefits

- Reduced downstream impacts (sedimentation, flooding, water quality)

- Protection of farm infrastructure

- Financial returns from forestry

- Public infrastructure protected

- Water quality protection and enhancement

- Aesthetic enhancement

- Resource protection/Property Values

Some soil conservation benefits can be quantified and are referred to as financial benefits. These take the form of saved production losses through the protection of grazing land, saved stock losses, farm management benefits such as that arising from sub-divisional fencing, saved loss of farm infrastructure and silvicultural benefits. These tend to accrue to the landholders on whose properties works have been carried out.

Financial benefits may also accrue to 'downstream' parties in the form of reduced damage to farm infrastructure, reduced sedimentation and reduced damage to public infrastructure namely roading.

Other benefits are classified as non-financial due to the difficulty in quantifying these in financial terms. These will include the more general water quality and resource protection benefits that tend to be received by the wider community or 'offsite' interests.

Those benefits associated with soil conservation that can be **quantified** include:

- Returns from timber (block planting)
- Pastoral production
- Saved infrastructural damage
- Saved damage to public infrastructure (roading, utility networks)
- Saved water supply treatment costs, insured loss

The bulk of the quantifiable benefits tend to be received **on site** i.e. by the property owner. This may be referred to as private benefit.

Indications are that no significant financial returns (in the form of production increases) can be expected from open pole planting unless the erosion rates are extreme. In the case of such planting, the benefits will relate to other factors such as saved infrastructural damage (quantifiable), aesthetics, stock shelter and shade and water quality (non quantifiable).

The **non-quantifiable** benefits listed above are also expected to be associated with other proposed measures including riparian works, the retirement of areas of indigenous vegetation and river works. Other non-quantifiable benefits including biodiversity, aquatic ecology and resource protection can also be expected to apply.

2.4.2 Effectiveness of Soil Conservation

Surveys undertaken during 2001 in the Matahuru Stream (Lower Waikato) and Mangarama Stream (Upper Waipa)) sub catchments have confirmed the effectiveness of soil conservation work[1]. The survey results indicated that where soil conservation measures have been applied, erosion may be reduced by 80% to 100% over a ten-year period.

2.4.3 Beneficiaries of Soil Conservation

Beneficiaries include those who benefit directly, such as landholders on whose properties the works have been completed, or those immediately downstream. These interests receive mainly financial benefit. Those who are not living in the immediate area receive benefits but these are more diffuse and less certain, and tend not to be financial benefits. The benefits and beneficiaries associated with a typical soil conservation project are summarised in Table 1 (based on that derived for the Paeroa Range Catchment Control Scheme Asset Management Plan[2]).

[1] Hicks, D. 2001: *Soil Conservation Survey of the Mangarama Catchment.* Prepared for Environment Waikato. #674099
Hicks, D. 2001: *Soil Conservation Survey of the Matahuru Catchment.* Prepared for Environment Waikato. #674102

[2] Environment Waikato 2000: *Asset Management Plan : Paeroa Range Catchment Control Scheme.* Policy Series 1999/23, Environment Waikato, Hamilton. #575481

Table 1: Example of Scheme Benefits, Beneficiaries and Contributors.

Benefits, beneficiaries and contributors							
	Pastoral Production	**Timber extraction**	**Infrastructure**		**Water Quality**	**Aesthetics**	**Resource Protection**
			farm	public			
Landholder	benefactor	benefactor			contributor	benefactor	
Adjacent/ downstream landholders			benefactor		benefactor	benefactor	
Local and wider catchment community				benefactor	benefactor	benefactor	
Hydro Power Generator					contributor		
Region/Nation					benefactor	benefactor	benefactor

Table 2 provides a further summary of the benefits received from soil conservation and the beneficiary groupings. These beneficiaries have been identified under the relevant section of the Local Government Amendment Act being Step One of the statutory process.

Table 2: Benefits and Beneficiaries

Nature of Benefit	Beneficiaries	Relevant Section of LGA (No.3)

• Land protected
• Farm Management
  – shelter, shade
  – subdivision
• Farm Infrastructure
• Forestry
• Reduced hydro lake sedimentation
	• Individual Scheme landholders (direct beneficiaries)
	• Hydro Power Generator
		122F(c)
		122F(c)

• Public Infrastructure protected • Water Quality enhancement	• Landholders • Local Community • Wider regional community • National and international	122F (c) 122F (b) i, iii 122F (b) iii 122F (b)i, ii and iii

• Aesthetic Enhancement
  – visual impact
  – environmental improvement
	• Landholders
	• Local Community
	• Regional community
	• Nation/International
		122F (c)
		122F (b) iii
		122F (b) i, ii, iii
		122F (b) i, ii, iii

• Resource Protection	• Local Community • Regional Community	122F (b) iii 122F (b) iii

The wider community beneficiaries will include those located within urban centres which are often located downstream of catchment based works. Reduced peak flows as a result of in stream stabilisation works, reduced sedimentation, reduced bank erosion and flooding are the primary benefits received. However, often a significant factor is the water quality and aesthetic enhancement provided to water bodies such as rivers and lakes and over which there may be high use by the local and often predominately, urban based population. Recreational surveys of Lake Arapuni[3] for example indicate that approximately one half of the users originate from within 50km of the lake, the remainder originating from further a field both within the Waikato region

[3] Davis I. R: May 1976 – Waikato Valley Authority – Lake Arapuni Survey

and beyond. It therefore seems reasonable that a portion of benefit should be attributed both to the local area (management zone) and to the wider regional and national community (catchment and region).

2.4.4 Contributory Effects

The Local Government Amendment Act No. 3 (1996) requires that costs to control negative effects which may be contributed by individuals or groups, should be allocated to those persons or groups to the extent to which their actions or inaction's contribute to the need for control works. This is referred to as the contributor pays principle. Contributory effects and contributors are summarised in Table 3.

Table 3: Contributory Effects

Contributory Effect	Contributor	Relevant Section of LGA (No. 3)
• Land clearance • Land development • Land use leading to sedimentation and water quality deterioration	Landowners/land developers	122F (d)
• Community based developments including roading leading to water and soil loss or deterioration	Local community	
• Hydro dam water quality deterioration	Hydro dam operator	

Where control works are required as a result of land development and its consequences in terms of land and water deterioration, it is contended that those responsible for the land through their actions or inaction's, have contributed to the need for control works. Similarly, where actions or inaction's associated with present land uses are having, or have the potential for adverse effects then contributory liabilities are created by the need for control works.

Some control works necessitated by community based developments may result in land and water deterioration. This would include erosion control works needed as a result of local roading or the construction of other associated public infrastructure.

There are exacerbation or contributory influences upon the water quality within most catchments. Landholders involved in pastoral use particularly, are contributing to both nutrient and sediment load of the waterways. It is therefore considered that landholders should fund some of the cost of reducing the impact of pastoral use.

In some cases the hydro generator may represent a contributor in terms of the legislation as the impoundment of the lakes for electricity generation has increased algal and macrophyte concentrations in hydro lakes and downstream waters. Contributions toward the costs of undertaking and managing protection works as a means of a compensatory reduction to nutrient inputs are consistent with the intent of the legislative requirements.

2.4.5 Quantification and Distribution of Soil Conservation Benefits

Economic analyses have been completed for most of the major soil conservation schemes within the Waikato River catchment. These were either undertaken during the approval stages or are post scheme analyses. Assessments were also undertaken as part of the development of Asset Management Plans. The relevant reports are identified as references to this report.

The information contained within the above has provided the basis for the allocation of benefits arising from soil conservation measures proposed under Project Watershed.

The key points are:

- There are both quantifiable and non-quantifiable benefits associated with soil conservation. Analysis of the quantifiable benefits and costs with and without soil conservation measures indicates an internal rate of return (IRR) ranging from 7% to 14% depending on scheme. The returns determined for the principal schemes were:

  Lake Taupo 7%
  Paeroa Range 8.7%

Reporoa	10%
Waitomo	14%.

- In regard to soil conservation, it is generally accepted that in justifying work programmes, (particularly where the IRR is less than 10%), the promotion of new programmes and continued maintenance of existing schemes relies on benefits which are not easily quantified. This refers to water quality enhancement and associated recreational, aesthetic and other values such as biodiversity.

- It is evident that the wider community places considerable weight on the above values and is willing to contribute toward their protection. This has been indicated from community consultation associated with Project Watershed and other data accumulated during the promotion of earlier catchment based programmes.

- Benefits from soil conservation tend to be received are a number of levels;

  - Individual property / onsite / private
  - Specific interests / stakeholders (roading authorities, utility operators)
  - Local community / adjacent landowners / catchment

- Wider community /region / nation

- A summary of the distribution of benefits across the principle beneficiary groups was prepared by Harris[4] based on a range of economic reports relevant to soil conservation. This summary is set out in Table 4.

Table 4: Range of Soil Conservation Benefits with Beneficiary Categories

Beneficiary Category	Range of Benefits (% of total benefits)	Type of Benefit
Landholder	25% - 67%	Saved losses from erosion, farm infrastructure, silviculture and aesthetics
Local Community	20% - 40%	Saved losses from local infrastructure, aesthetics, recreational benefits, domestic water
Catchment	30%	Flood damages, private property
Region	25% - 50%	Resource protection, water quality, recreational benefits, aesthetics
Utilities	4% - 30%	Saved damage to roading, hydro generation benefits (localised)
Contributor scheme works	15%	

Table 4 indicates a range of benefits assessed by a number of researchers over a range of project types and situations and is helpful as a guide as to the possible allocation of costs associated with soil conservation management and works promotion.

Most debate tends to centre on the balance between private and public benefit. The technical advisors agree that the most substantial portion of soil conservation benefit is received on site by the property owner in the form of both quantifiable and non-quantifiable benefit. This has been reflected historically by landowner contributions ranging typically from 50% to 65% of total cost depending on the level of off site or public benefit received. This earlier funding apportionment did not however include consideration of the contributory factors which is now required by legislation. Some technical work has indicated that a combination of private benefit and contributor

[4] Project Watershed: Review of Soil Conservation Works Funding – Report to Environment Waikato August 2001.

component of up to 75% of total may be justified, particularly where the value of the work to the wider community is less. This is compared to the 'high value' catchments identified by Harris, (being the Lake Taupo and Waitomo areas) where a lesser landowner benefit can be justified.

The most recent reviews indicate that the earlier allocation of costs up to 65% attributed as private benefit and up to 35% attributed to public benefit can be justified as a basis for the allocation of Project Watershed soil conservation costs. The further modification to this however is the inclusion of the contributory factor which may, (based on Table 6 derived by Harris) need to allow for up to a further 15% attributable to the private benefit component of which the private landowner component may be 10% - 12%.

Experience by staff involved with the promotion of soil conservation programmes has been that financial incentives greater than a third of total cost (that is at least 30%) are usually needed to encourage property owners to proceed with new soil conservation programmes. The perception of many owners therefore is that there are public benefits associated with the work, and that 'external' incentives of at least 30% are warranted.

While it is acknowledged that a level of work proceeds without these incentives, the experience of regional and unitary authorities is that the work does not proceed at any pace, is not targeted in priority sub catchments, and is often poorly planned and executed. This in itself has provided the justification for the historic involvement of regional authorities in the promotion of planned, co-ordinated and integrated soil conservation programmes. The current beneficiary information supports the wider community benefits received from soil conservation and supports a level of funding involvement by the wider community.

2.4.6 Summary Points

- The benefits expected from soil conservation:
  - Land (soil) protected
  - Farm management benefits
  - Reduced downstream impacts (sedimentation, flooding, water quality)
  - Protection of farm infrastructure
  - Financial returns from forestry
  - Public infrastructure protected
  - Water quality protection and enhancement
  - Aesthetic enhancement
  - Resource protection/Property Values

- Benefits that can be **quantified** include:
  - Returns from timber (block planting)
  - Pastoral production
  - Saved infrastructural damage
  - Saved damage to public infrastructure (roading, utility networks)
  - Saved water supply treatment costs, insured loss

- The bulk of the quantifiable benefits tend to be received **on-site** i.e. by the property owner.

- **Non-quantifiable** benefits are associated with other proposed measures including riparian works, the retirement of areas of indigenous vegetation and river works. Also, other non-quantifiable benefits including biodiversity, aquatic ecology and resource protection.

- Benefits from soil conservation tend to be received are a number of levels;
  - Individual property / onsite / private
  - Specific interests / stakeholders (roading authorities, utility operators)

- Local community / adjacent landowners / catchment
- Wider community /region / nation

- Local Government Amendment Act No. 3 (1996) requirements - referred to as the contributor pays principle.

- Analysis of the quantifiable benefits and costs with and without soil conservation measures indicates an internal rate of return (IRR) ranging from 7% to 14%.

3 Catchment Environmental Monitoring

3.1 Middle Waikato Zone Monitoring Programme

3.1.1 Introduction

This section of the report provides:

1. A summary of the monitoring approach and schedule.

2. Catchment scale data from the Middle Waikato Environmental Monitoring Programme.

Monitoring focuses on the Pokaiwhenua sub-catchment with 2 additional sections of stream monitored in the Mangare Catchment (riparian characteristic assessment and photo points only).

Table 5 contains the monitoring schedule from 2003/2004 through 2005/2006.

Table 5: Monitoring Schedule in the Middle Waikato Zone 2003-2006

Monitoring	Planned Activity	2003/2004	2004/2005	2005/2006
Soil stability	None planned	None planned	Completed	None planned
Permanent water quality site	Install ISCO automatic water sampler	Not installed	Installation to be considered	Installation to be considered
Water quality snapshot	Low flow competed. High flow snapshot at next sufficient rainfall event	Not completed	If not completed in 2003/2004	If not completed in 2004/2005
Riparian characteristic assessment	Complete baseline assessment along the mid section of the Pokaiwhenua River	Completed	Not scheduled	Scheduled
Photo points	Complete baseline assessment along the mid section of the Pokaiwhenua River	Completed	Completed	Scheduled
Water temperature	Install loggers and record stream temperatures along the mid section of the Pokaiwhenua River	Completed	Scheduled	Scheduled
Stream ecological health	Invertebrate samples taken to	Completed	Scheduled	Scheduled

	assess stream biological condition			

3.1.2 Soil Stability

Method and Progress

Dr. Doug Hicks undertook a soil stability assessment of the Pokaiwhenua catchment. Dr. Hicks completed a point sample photo interpretation of the 1992 and 2002 aerial photographs to assess soil stability and soil conservation treatments and changes over that period.

Results

The results indicated that about 47% of the catchment had soil stability issues, unstable, recently eroded or freshly eroded. The results also identified areas requiring soil conservation and assessed the extent of soil conservation treatments at the time of the 2002 aerial photography (Table 6).

Table 6: Percent of the Pokaiwhenua Catchment Requiring Soil Conservation and the Proportions of Sufficient Soil Conservation Treatments (Based on 2002 Aerial Photography).

Soil Conservation	None required	Spaced poles	Afforestation	Retirement
Required	14.1%	26.9%	4.2%	1.5%
Sufficient	na	16.3%	1.7%	1.1%
Absent or insufficient	na	10.6%	2.5%	0.4%

Changes in soil erosion/disturbance is categorised as due to natural erosion (e.g. slips) or land use (e.g. farm tracks). The changes in bare ground are summarised in Table 7.

Table 7: Changes in Bare Ground (Disturbance) in the Pokaiwhenua Catchment, 1992 to 2002.

Disturbance by natural erosion	
streambank erosion	- 50%
streambank deposition	no change
tunnels	no change
gullies	- 67%
landslides	- 50%
rock outcrops	no change
Disturbance by land use	
farm and forest tracking	+ 25%
tree harvest	+ 300%
cultivation	+ 200%
earthworks	no change
stock trampling	- 33%
drainage	- 50%

Natural erosion, expressed as a percentage of catchment area, was already low in 1992. Consequently the declines for any individual erosion type to 2002 are within margins of error and cannot be regarded as statistically significant. There is a total decline in natural erosion (all types combined) from 0.9% to 0.4%. Overall, bare soil due to land use disturbance has increased by 50% from 3.6% to 5.3% of catchment area.

Summary points

- About 47% of the catchment had soil stability issues, is unstable, recently eroded or freshly eroded. Of that, 33% requires soil conservation treatment.

- About 14.1% has sufficient soil conservation treatments.

- About 10.6% of the catchment has insufficient or requires spaced pole planting, 2.5% block planting and 0.4% retiring.

- From 1992 to 2002 bare soil due to natural erosion has decreased by 67% from 0.9% to 0.4% of the catchment area.

- From 1992 to 2002 bare soil due to land use disturbance has increased by 50% from 3.6% to 5.3% of the catchment area.

- Changes in “natural bare ground” are difficult to interpret because of the confounding effect of storm events. However, increased soil conservation work over the same period would suggest decreases in natural erosion observed from 1992 to 2002 were at least partially attributable to this work.

- Disturbance due to land use has been increasing and is more ten times greater than disturbance by natural erosion. Potentially these types of disturbance can contribute sediment into waterways. It is necessary to include land use disturbance in any soil conservation planning.

3.1.3 Suspended Sediment Snapshots

Method

High and low flow suspended sediment snapshot samplings provide an understating of sediment sources within a catchment. Low flow samplings provide background turbidity data to complement high flow data from a subsequent sampling during a high flow storm event. Combined the data will indicate the main sources of sediment within the catchment. Additional water quality data is also measured to provide an indication of pathogen and nutrient sources within the catchment. About 29 sites were selected throughout the catchment, at the bottom end of sub-catchments.. Water samples are collected and flow levels recorded at each site.

Progress

Low flow suspended sediment snapshot completed in June 2003. High flow snapshot not yet completed but will be carried out during the next sufficiently large rainfall event.

Results

Low flow suspended sediment snapshot June 2003

Summary results of the Low flow suspended sediment snapshot sampling, June 2003, are presented in Table 8. Results are presented as percentage of sites not meeting the water quality criteria

Table 8: Summary Water Quality Results from the Pokaiwhenua Catchment Snapshot Low Flow, June 2003.

Water quality parameter	Sites not satisfactory (%)	Highest loads (x limit)
Total turbidity Unsatisfactory total turbidity decreases water clarity and aquatic habitat health.	4	8[1]
Total nitrogen Unsatisfactory total N loads increase plant growth in the stream.	80	10
Total phosphorus	64	6

Unsatisfactory total P loads increase plant growth in the stream.		
E.coli Unsatisfactory *E. coli* loads in streams are a human health risk.	12	10

1 = earthworks upstream.

Turbidity (measure of suspended sediment) is satisfactory or better for all but one site, where earthworks were occurring upstream. Low turbidity is expected for the low flow sampling because sediment is transported mainly during high flows. Nutrients were the main concern with more than 50% of sites unsatisfactory. The levels of *E. coli* (indicating "pathogens" in the water from animal effluent) were generally satisfactory. The highest level was recorded on the Mangakaratu stream, downstream of Putaruru.

The low flow sampling provides background levels of turbidity (indicating suspended solids in the water) and other water quality parameters (total N, total P, and *E.coli*). These water quality analyses provide an indication of the state of water quality throughout the sub-catchment. The sampling was carried out at 25 sites throughout the Pokaiwhenua sub-catchment. Ten of these sites were situated on the Pokaiwhenua River.

There are several points to keep in mind when interpreting the data.

- The measures have not been adjusted to reflect the size of the catchments, streams, individual stream flow and total contribution to the whole Pokaiwhenua sub-catchment.

- The results are a measure of the water quality at the time of sampling and only provide an indication of the likely state of water quality upstream of the sample location.

- *E. coli* loads, turbidity and nutrient loads are highly variable depending on whether stock are present in the stream during sampling. In the same respect very high levels indicate that stock do have access to streams.

- Low flow samplings do not provide a good indication of sediment losses (only background levels) because most sediment is moved during rainfall events.

Summary points

- Turbidity (measure of suspended sediment) is satisfactory or better for all but one site, where earthworks were occurring upstream.

- Nutrients were the main concern with more than 50% of sites unsatisfactory.

- The levels of *E. coli* (indicating "pathogens" in the water from animal effluent) were generally satisfactory. The highest level was recorded on the Mangakaratu stream, downstream of Putaruru.

- *E. coli* loads, turbidity and nutrient loads are highly variable depending on whether stock are present in the stream during sampling. In the same respect very high levels indicate that stock do have access to streams.

- Low flow samplings do not provide a good indication of sediment losses (only background levels) because most sediment is moved during rainfall events.

- A high flow sampling is required.

3.1.4 Riparian Characteristics Survey

The purpose of the survey is to quantify the long term changes in riparian characteristics (erosion, vegetation and fencing) where soil conservation is implemented.

Method

Data is collected using an iPAQ palm PC which is a field based GIS system. This field GIS is designed to capture the attributes of the Riparian Characteristics Survey as described in DOC # 761140.

A selected 1km reach of stream margin where soil conservation work is planned, is surveyed (looking at both true left and true right banks concurrently) with erosion, vegetation, and fencing information for each bank entered into the iPAQ whenever a change occurs in any one of these parameters. Any obstructions to stream flow e.g. in-stream willows and stream accessways are also noted. A measuring wheel is used to determine the distance surveyed and also to establish the distance between changes for the various parameters.

Progress

Six 1km samples were selected for survey through the mid section of the Pokaiwhenua River with an additional two 1km samples surveyed in the mid section of the Mangare Stream. The Pokaiwhenua locations are where Project Watershed funded works are scheduled, where stream riparian margin access is possible and where landowner participation is forthcoming. The initial survey was conducted in the 2003/2004 year with the next survey to be conducted in 2005/2006. As 2003/2004 was the first year of survey benchmark information only has been collected and no comparisons between years can be made until subsequent surveys are completed.

Results

Please note that these results are provisional summaries and may differ following full statistical analysis. At present they are indicative of the likely results to be presented in the final report. The survey data are not indicative of the whole catchment but are indicative of the sites at which soil conservation works are being implemented.

Pokaiwhenua riparian characteristics survey 2003/04

The following summary survey data were collected where riparian soil conservation was planned or recently implemented in the Pokaiwhenua catchment in 2003/2004. Erosion, vegetation and fencing data summaries are presented in Tables 9,10 and 11 respectively.

Pokaiwhenua - erosion

An estimated 12% of the riparian bank length is considered unstable (Table 9). The fenced banks have slightly more unstable banks compared with unfenced banks. This is most likely because fencing has only occurred recently and slightly more The majority of unstable banks have grass vegetation (8%, or 75% of the total unstable bank length).

Table 9: Pokaiwhenua Erosion (Mean of Six 1 km Samples Identified for Soil Conservation and River Management Work)

Riparian **erosion** characteristics –Pokaiwhenua (% of total bank length)									
Erosion	stable	unstable							
	88	12							
Fencing	n/d	fenced				unfenced			
		7				5			
Vegetation		grass	willow woody veg.	other exotic woody	native woody veg.	grass	willow woody veg.	other exotic woody	native woody veg.

				veg.				veg.	
		5	<1	<1	1	3	<1	<1	<1

n/d = not detailed

Pokaiwhenua - vegetation

An estimated 55% of the riparian bank length is grass, the remaining 45% is woody vegetation (Table 10). The component of native woody vegetation is 34% (about 76% of the woody vegetation), willow is 1% and 10% other exotic woody vegetation.

Table 10: Pokaiwhenua Vegetation (Mean of Six 1 km Samples Identified for Soil Conservation and River Management Work)

Vegetation			
Grass	Woody vegetation		
55%	45		
	Exotic		Native
	11		34
	Willow	Non-willow	
	1	10	

Pokaiwhenua - fencing

The amount of fencing on one side or both sides of the waterway is an indicator of likely stock exclusion from the waterway. Stock exclusion reduces direct contamination of water by pathogens and direct damage to the stream ecology by trampling. Stock are excluded from both sides for 26% of the waterway, from one side for 44% of the waterway and are not excluded either side for 30% of the waterway.

Table 11: Pokaiwhenua Fencing (Mean of Six 1 km Samples Identified for Soil Conservation and River Management Work)

Riparian **fencing** characteristics –Pokaiwhenua					
Fencing - % of stream length	**no fence on both sides**	**fenced on one side**		**Fenced on both sides**	
	30	44		26	
Fencing – % of total bank length	**not fenced**	**fenced**			
	51	49			
Breakdown by vegetation	grass	grass	willow woody veg.	other exotic woody veg.	native woody veg.
	24	31	8	3	6

An estimated 17% of the banks have fenced woody vegetation. Currently, 24% of the total bank length is unfenced grass.

Mangare riparian characteristics survey 2003/04

The following statistics were calculated from the riparian survey data collected from sites identified for riparian soil conservation in the Mangare catchment in 2003/2004. Erosion, vegetation and fencing data summaries are presented in Tables 12, 13 and 14 respectively.

Table 12: Mangare Erosion (Mean of Two 1 km Samples Identified for Soil Conservation and River Management Work).

Riparian **erosion** characteristics –Pokaiwhenua (% of total bank length)							
Erosion	stable	unstable					
	39	61					
Fencing	unfenced	fenced			unfenced		
	32	34			27		
Vegetation	grass	grass	exotic woody veg.	native woody veg.	grass	exotic woody veg.	native woody veg.
	37	31	3	0	26	1	0

n/d = not detailed

Unstable banks are greatest where vegetation is grass (31%, or about 50% of all unstable banks). The data suggests that fencing does not reduce erosion. However, some caution is required with this interpretation because these areas may have only been recently fenced.

An estimated 94% of the riparian bank length is grass, the remaining 6% is woody vegetation (Table 13). The component of native woody vegetation is 0%, willow is 1% and 5% other exotic woody vegetation.

Table 13: Mangare Vegetation (Mean of Two 1 km Samples Identified for Soil Conservation and River Management Work).

<table>
<tr><th colspan="4">Vegetation</th></tr>
<tr><td>Grass</td><td colspan="3">Woody vegetation</td></tr>
<tr><td rowspan="5">94%</td><td colspan="3">6</td></tr>
<tr><td colspan="2">Exotic</td><td>Native</td></tr>
<tr><td colspan="2">6</td><td rowspan="3">0</td></tr>
<tr><td>Willow</td><td>Non-willow</td></tr>
<tr><td>1</td><td>5</td></tr>
</table>

Fencing is present on both sides for 31% of the waterway, on one side for 20% of the waterway and absent on both sides for 49% of the waterway (Table 14).

Table 14: Mangare Vegetation (Mean of Two 1 km Samples Identified for Soil Conservation and River Management Work).

<table>
<tr><td colspan="5">Riparian fencing characteristics –Mangare</td></tr>
<tr><td rowspan="2">Fencing - % of stream length</td><td>not fenced on both sides</td><td colspan="2">fenced on one side</td><td colspan="2">fenced on both sides</td></tr>
<tr><td>31</td><td colspan="2">20</td><td colspan="2">49</td></tr>
<tr><td rowspan="2">Fencing – % of total bank length</td><td>not fenced</td><td colspan="4">fenced</td></tr>
<tr><td>59</td><td colspan="4">41</td></tr>
<tr><td rowspan="2">Breakdown by vegetation</td><td>grass</td><td>grass</td><td colspan="2">exotic woody veg.</td><td>native woody veg.</td></tr>
<tr><td>57</td><td>37</td><td colspan="2">4</td><td>0</td></tr>
</table>

An estimated 4% of the banks have fenced woody vegetation. Currently 57% of the total bank length is unfenced grass.

Summary points

- Six 1km samples were selected for survey through the mid section of the Pokaiwhenua River with an additional two 1km samples surveyed in the mid section of the Mangare Stream. All sites were selected where soil conservation and river management work was planned or had recently commenced.

- Data presented are preliminary only. Data provides a baseline picture of the riparian erosion, vegetation and fencing and the relationship between these characteristics.

- For the Pokaiwhenua survey:

  - 12% of bank length is unstable. Unstable banks are most common where the vegetation is grass (67% of unstable banks). Over half of this length has been fenced.

- 55% of the riparian bank length is grass, the remaining 45% is woody vegetation. The component of native woody vegetation is 34% (about 76% of the woody vegetation), willow is 1% and 10% other exotic woody vegetation.

- 26% of bank length has been fenced on both sides, 44% on one side and 30% is not fenced on both sides.

- For the Mangare survey:

  - 61% of bank length is unstable. Unstable banks are most common where the vegetation is grass (95% of unstable banks). Over half of this length has been fenced.

  - 94% of the riparian bank length is grass, the remaining 6% is woody vegetation. The component of native woody vegetation is 0%, willow is 1% and 5% other exotic woody vegetation.

  - 49% of bank length has been fenced on both sides, 20% on one side and 31% is not fenced.

3.1.5 Photo Points

Method

For each of the surveyed 1km samples of stream in the riparian characteristics survey, 5 representative photos of the riparian margin are taken at distances of 0, 250, 500, 750, and 1000m. Each photo was framed to take in both stream banks with a scale pole placed in the field of view approximately 10m from the camera for reference. Photo details of GPS location, direction, and site information were recorded for each photo.

Progress

A photo point assessment was completed as part of the riparian characteristic assessment in 2003/04 with a further survey completed 12 months later in 2004/2005. The photo assessment is scheduled to be conducted annually.

Results

For each of the surveyed 1km samples of stream in the riparian characteristics survey, Five photo points were established and photographed. A total of 30 photo points for the Pokaiwhenua catchment survey and 10 photo points for the Mangare catchment survey were established (see the example photos in appendix 2). For the Pokaiwhenua catchment the photos indicate little change in riparian characteristics over the 12 month period between the two surveys. This was the situation for sample 2 of the Mangare survey. However, sample 1 in the Mangare catchment showed change where the surveyed reach of stream has been fenced and planted with willow poles on both banks.

Summary points

- For each of the surveyed 1km samples of stream in the riparian characteristics survey, 5 representative photos of the riparian margin are taken.

- The initial year of survey was 2003/2004 with a second survey completed 12 months later in 2004/2005.

- For the Pokaiwhenua sites, there was little change in riparian characteristics between the two surveys (~1 year of riparian planting and fencing).

- For the Mangare sites, one site showed visual changes where there had been fencing and planting with willow poles on both banks.

3.1.6 Water Temperature

Method

Two Hobo Water Temp Pro data loggers are deployed in the mid section of the Pokaiwhenua River with the distance between the 2 probes being approximately 1km. The temperature loggers are attached to waratahs which have been secured into the stream bed. The period of deployment is over the summer months when water temperatures are at their highest. The GPS location, a reference photo, and the date and time of deployment details are recorded.

Progress

Two stream temperature monitoring sites have been installed in the middle section of the Pokaiwhenua River to assess the affect of soil conservation (riparian planting) on stream shading and water temperature. The temperature probes were initially deployed Dec-Mar 2003/2004 and will be deployed during this period on an annual basis. To date two deployments have been made with data collected for 2003/2004 and 2004/2005.

Results

The same ten week window of data is selected for each year (starting January 1st) with the average of the daily maximum water temperature being derived to produce a single temperature for each site. The downstream temperature is then subtracted from the upstream temperature to derive a single number for the monitored section of river (see Table 15).

Table 15: Pokaiwhenua Average Daily Maximum Water Temperature Difference Between Upstream (Us) and Downstream (Ds) Locations for the 10 Week Period Starting January 1st

Year	Method	Difference (DegC)
2003/2004	us minus ds	0.23
2004/2005	us minus ds	0.31

Table 5 illustrates the downstream temperature was cooler on average than the upstream temperature by 0.23°C for the selected 10 week period during the 2003/2004 summer and 0.31°C during the 2004/2005 summer. There are insufficient data to determine any annual trend in temperature. At present little shading of the river occurs between the two probes. However, it is envisaged that as the vegetation grows and begins to shade the stream the downstream water temperature will gradually cool relative to the upstream water temperature. Currently the plantings are still young and with the average width of the river in this vicinity being 5-7 m it will be a number of years before any significant vegetative shading influence on the river is observed.

Summary points

- The average daily maximum water temperature downstream of plantings is cooler for the selected 10 week period for both years of survey.
- There are insufficient data to determine any annual trend in temperature.
- The plantings are new and do not provide stream shade at present.
- More annual data is required.
- Additional sites in the Mangare and Pokaiwhenua catchments are now available.

3.1.7 Stream Ecological Health

Method

Invertebrate sampling is carried out in the same two locations where the water temperature probes are deployed in the mid section of the Pokaiwhenua River. The sampling protocols used are those developed by the New Zealand Macroinvertebrate Working Group[5]. Sampling involves evaluating habitat attributes throughout a representative 100-metre reach of stream followed by sampling stream invertebrates from representative stream habitat types using a kick net. Invertebrates are identified and counted to provide a representation of community structure. The samples are collected between February and March of each summer.

Progress

The initial year of survey was in the 2003/2004 year with the survey to be repeated on an annual basis. As 2003/2004 was the first year of survey and no comparisons between years can be made until subsequent surveys are completed.

Results

The results for each sample are loaded into the Hydrol database. This includes invertebrate species counts, habitat scores, and stream physical parameter information.

Summary points

- Invertebrate sampling is carried out where the water temperature probes are deployed on the Pokaiwhenua River.
- Data includes invertebrate species counts, habitat scores, and stream physical parameter information.
- 2003/2004 was the first year of survey and no comparisons between years can be made until subsequent surveys are completed.

3.2 Historic Photos

In addition to the photo points survey within the Middle Waikato monitoring programme there are historic photos showing visual changes resulting from soil conservation work in the Middle Waikato zone. The photo series for 6 sites are shown in Tables 16 and 17.

Summary points

- There are identifiable changes evident 2 years following riparian planting and fencing.
- All photo series for each site show a visual decrease in unstable banks and bare ground and an increase in vegetation, especially woody vegetation.
- At 2 years, the most obvious visual change is a visual decrease in unstable stream banks and bare ground and an increase is grass and low vegetation.
- After 2 years (years 3-8) the most obvious visual change is an increase in woody vegetation.

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[5] Stark, J. D.; Boothroyd, I. K. G.; Harding, J. S.; Maxted, J. R.; Scarsbrook, M. R. 2001: Protocols for Sampling Macroinvertebrates in Wadeable Streams. Ministry for the Environment., New Zealand Macroinvertebrate Working Group Report No. 1.

- After 8 years (year 14) the most obvious visual change is an increase in the size of the woody vegetation.

- A visual increase in rank grass and low lying vegetation indicates stock exclusion.

Table 16: Photo Sites 1, 2 and 3 – Mangawara River (1997-2005)

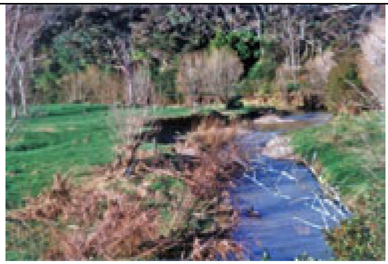
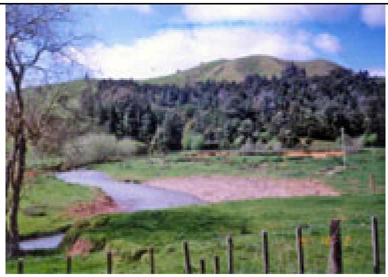
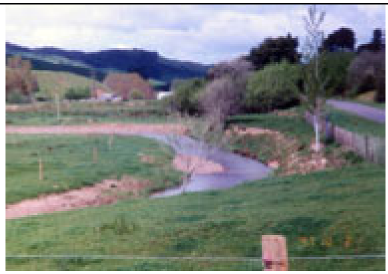
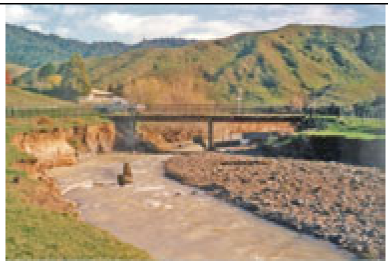
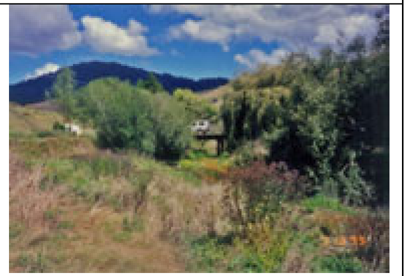
	Year 0	Year 2	Year 3	Year 8
Site 1				
Site 2				
Site 3				

Table 17: Photo Sites 1, 2 and 3 – Mangawara River (1985-2005)

	Year 0	Year 2	Year 3	Year 8 *
Site 4				
Site 5				
Site 6*				

* Site 6, year 8 is year 14.

4 Concluding Remarks

Soil conservation research:

The information from Whatawhata Research Station supports the general soil conservation research from other parts of the country.

Space planting reduces the risk of mass movement. The economics of space planting are variable and depend on how differences in production are calculated.

Block planting (plantation) has major benefits for water quality (reduced nutrients, pathogens and stream ecology is improved). Erosion and subsequent sediment yields are decreased for young to mature trees and small storm peak flows are reduced. However, the economics are different to pasture.

Retirement of land has major gains for water quality (as for block planting).). Erosion and subsequent sediment yields are decreased and small storm peak flows are reduced. There are biodiversity benefits. Production is reduced to nil. However, inputs are significantly reduced.

Riparian planting and fencing combinations have a major water quality benefit and reduce stream bank instability. Stream bank instability is least where stack are excluded and woody vegetation is present. Improved bank stability from soil conservation work is supported visually by historic photos.

Riparian margin and in-stream biodiversity and ecology will benefit from riparian fencing and planting. Ungrazed riparian strips will effectively filter sediment, nutrients (mainly P) and pathogens.

The whole catchment approach of Waitomo does give results, with reduced sediment yields evident after 10 years. Based on other research in this report, nutrient and pathogen contamination of waterways and erosion are very likely to be reduced. Also, there are likely to be some biodiversity gains (riparian margin, in-stream and kaarst).

Soil conservation benefits

- Cost benefit analysis is difficult because there are quantifiable and non-quantifiable benefits, numerous contributors and benefactors at different scales (e.g. farm, catchment region).
- Soil conservation benefits are mainly on-site. Off-site benefits include water quality and infrastructure.

Soil stability in the Pokaiwhenua:

- Changes in "natural bare ground" are difficult to interpret because of the confounding effect of storm events. However, increased soil conservation work over the same period would suggest decreases in natural erosion observed from 1992 to 2002 were at least partially attributable to this work.
- Changes in "land use bare ground" are considered to be real changes.
- Disturbance due to land use has been increasing and is more ten times greater than disturbance by natural erosion. Potentially these types of disturbance can contribute sediment into waterways.
- 12% of bank length is unstable. Unstable banks are most common where the vegetation is grass.

- 26% of bank length has been fenced on both sides, 44% on one side and 30% is not fenced. This is a good indicator of stock exclusion from waterways.

Soil conservation required for the Pokaiwhenua

- About 47% of the catchment had soil stability issues, is unstable, recently eroded or freshly eroded. Of that, 33% requires soil conservation treatment.

- About 14.1% has sufficient soil conservation treatments.

- About 10.6% of the catchment has insufficient or requires spaced pole planting, 2.5% block planting and 0.4% retiring.

- A priority for riparian soil conservation (to reduce unstable stream banks) are unfenced grass riparian margins. 24% of the total bank length surveyed in the Pokaiwhenua was unfenced grass.

- It is necessary to include land use disturbance in any soil conservation planning.

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Appendix 1: Aspects of Water Quality

Guidelines are based on national standards and guidelines.

Aspects of water quality monitored by Environment Waikato and used in catchment monitoring (section 3).

Water quality variable (units)	**Relevance**	**Categories**		
		Excellent	**Satisfactory**	**Unsatisfactory**
Turbidity (NTU)	Can restrict plant growth	<2	2–5	>5
Total ammonia (g N/m^3)	Toxic to fish	<0.1	0.1–0.88	>0.88
Temperature (°C)	Fish spawning May-Sep	<10	10–12	>12
	Fish health Oct-Apr	<16	16–20	>20
Total phosphorus (g/m^3)	Causes nuisance plant growth	<0.01	0.01–0.04	>0.04
Total nitrogen (g/m^3)	Causes nuisance plant growth	<0.1	0.1–0.5	>0.5
Human uses - recreation				
Current				
Escherichia coli, median limit (no./100 mL)	Human health	<23	23 – 126	>126

Appendix 2: Photo Points – Examples of Photo Points from the 2004 and 2005 Pokaiwhenua and Mangare Catchment Surveys

Pokaiwhenua Photo Point Examples, 2004 and 2005

 Pok01_04_0250m	 Pok01_05_0250m
 Pok02_04_0250m	 Pok02_05_0250m
 Pok02_04_0500m	 Pok02_05_0500m

 Pok03_04_0000m	 Pok03_05_0000m

 Pok03_04_0500m	 Pok03_05_0500m
 Pok06_04_0500m	 Pok06_05_0500m

Mangare Photo Point Examples, 2004 and 2005

 Mge01_04_0000m	 Mge01_05_0000m
 Mge01_04_0250m	 Mge01_05_0250m
 Mge01_04_0500m	 Mge01_05_0500m
 Mge01_04_0750m	 Mge01_05_0750m
 Mge01_04_1000m	 Mge01_05_1000m


Mge02_04_0000m


Mge02_05_0000m


Mge02_04_0500m


Mge02_05_0500m


Mge02_04_0750m


Mge02_05_0750m