WAIAU RIVER WORKING PARTY

SUMMARY OF REPORTS

29 March, 1995

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1. INTRODUCTION

Since the inaugural meeting of the Waiau River Working Party in October 1990, the Working Party has commissioned a variety of research studies and has received 30 formal reports. Additionally, the Working Party has received 8 tributary river reach analysis reports, 4 groundwater monitoring reports, and various other reports concerning energy, environmental economics, engineering, water supply, water quality, aquatic vegetation, mahinga kai, shorelines, and climate change, as well as photographic and video footage.

While this information has been fed into the group over the past five years and discussed in various meetings, it is still a mammoth task to disseminate and remember all of the findings which have been presented. The object of this report is to assist Working Party members by setting out the issues which led to the Working Party initiating a study, the executive summary section of the report, an outline of the recommendations or conclusions reached by that report, and a list of any other Working Party studies which are linked or relevant to the report.

2. WAIAU RIVER WORKING PARTY REPORTS

A1 - Avian Information from the Waiau Catchment

February 1992 : Author - W P Chisholm

Issue

To find out present, and historical where possible, avian species and habitat distributions within the Waiau catchment, in order to identify gaps in knowledge and determine where further study is required.

Executive Summary

A literature search was conducted for bird species, distribution, density and habitats on the Waiau catchment, Southland. Information was gathered from the Department of Conservation, Southland Fish and Game Council, Otago University library and individuals who have a knowledge of the area.

Little information is available on birds of the Waiau prior to the completion of hydro-electric development in 1974. The few records which exist would not be able to provide a suitable pre-hydro baseline of information to guide future research. Early records of birds around the turn of the century are of little value for assessing the impacts of hydro development as much of the changes to native bird distribution and density occurred as a result of introduced predators and early land development.

Since 1974 there have been a number of studies which will be of some value to the Working Party. Bird habitat information is available from the Department of Conservation Register of Sites of Special Wildlife Interest (SSWI) and Wetlands of Ecological and Representative Importance (WERI) databases. Surveys of Protected Natural Areas (PNA's) in the catchment give good descriptions of bird habitats through comprehensive vegetation inventories.

Other sources of information include Department of Conservation threatened species databases, the Atlas of Bird Distribution in New Zealand, Forest Research Institute records, various management plans and environmental impact reports. Of particular interest is the Redcliff wetland enhancement project. Bird counts done during this project show major increases in many waterfowl species. This shows the potential for future bird habitat identification and enhancement projects.

Recommendation Outline

1. To undertake a comprehensive habitat and seasonal bird distribution survey of the Waiau River below Lake Te Anau.

2. Hydrological studies of Lakes Te Anau and Manapouri should take into account the effects of river and lake level fluctuations on birdlife and their habitats.

3. Hydrological studies on the Waiau River mouth should take into account the effects of river mouth blockage on birdlife and habitats.

Relevant Working Party Reports

A8 - Aquatic Birds of the Waiau River November 1993 and March 1994

H2 - Waiau River Hydrology

A2 - Review of Fish Distribution in the Waiau River Catchment, Southland

February 1992 : Authors J W Hayes, S F Davis, D J Jellyman, I G Jowett

Issue

To find out present, and historical where possible, fish species and habitat distributions within the Waiau catchment, in order to identify gaps in knowledge and determine where further study is required.

Executive Summary

At least 29 species of freshwater fish occur in the Waiau River catchment, although only 14 of these are recorded in the MAF Fisheries Freshwater Fisheries database *(note: this database is now handled by NIWA).*

Most of the fish species are native, there being only four exotic species comprised of salmonids and perch.

Many of the fish species migrate to and from the sea as a necessary part of their life cycle, including at least 14 of the native fish species.

Because of the prevalence of migratory species, and the fact that hydro-electric development has been extensive, fish passage is the primary issue for conservation of fish populations in the Waiau catchment.

The effect of the Manapouri and Te Anau lake control structures on the distribution and abundance of many of the fish species present in the Waiau catchment is largely unknown. Therefore, it is recommended that a study be undertaken to determine present distributions and abundance, to establish the merits of providing good fish passage past the lake control structures.

Recommendation Outline

1. A study of the effects of the control structures on the distribution and abundance both of native and introduced fish species be undertaken.

2. The merits of establishing good fish passage past the lake control structures be investigated.

Relevant Working Party Reports

A4 - The Waiau River (Southland) Whitebait Fishery: A Consideration of the Impacts of the Mararoa Dam and Flow Diversion from the River

A5 - Minimum Flow Requirements for Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn

A9 - The Waiau River (Southland) Inanga Spawning Survey 1994

A10 - Fish Passage Problems and Options for Fish Passage at Mararoa Weir

A11 - A Calendar of Fish Migrations Through New Zealand River Mouths

I1 - Tikanga Maori Cultural, Spiritual and Historical Values of the Waiau River

R3 - The Waiau River Recreation Survey

A3 - A Review of the Aquatic Macrophytes of the Waiau Catchment

April 1992 : Author - W P Chisholm

Issue

To find out present, and historical where possible, aquatic macrophyte distributions within the Waiau catchment, in order to identify gaps in knowledge and determine where further study is required.

Executive Summary

Baseline information on the aquatic macrophytes of the Waiau catchment is reasonably good for the shorelines of Lakes Te Anau and Manapouri. The studies done on these lake shorelines and the Te Anau mires, as a result of proposals to raise the level of Lake Manapouri, have provided worthwhile information which includes the aquatic macrophytes. Dive surveys of the water plants in the lakes were conducted after hydro development, and given the sometimes slow rate of change in water plant communities, this information could be used as a baseline for future surveys.

Information on aquatic macrophytes in wetlands connected to the Waiau catchment is reasonably good, with Burrows and Dobson (1972) and the WERI database giving a good basic coverage. This information may be useful in the future, particularly in assessing the effectiveness of future wetland enhancement projects in the catchment.

Resurveys of the shoreline transects established in 1972 show the effectiveness of controls of lake levels in preventing damage to shoreline vegetation and habitats. The lack of information on deeper rooted aquatic plants shows that such information may be necessary to gauge the effects of sediment transport within the lakes. The aquatic plants database information from MAF Ruakura should help to provide the extra information needed to give a full vegetation sequence from the lake bed to upper shoreline. It may be worthwhile updating this information by doing a resurvey.

The shoreline of Lake Monowai gives a good indication of the eventual vegetation sequence which occurs when a more widely fluctuating lake level regime has operated for a long period. A general increase in more tolerant, adventive species (mainly introduced species) has occurred. Little can now be done to reverse this pattern, and the shoreline appears to have reached a new stability. Ongoing monitoring of existing transects is recommended, with the possibility of extending them to greater depth to get information on changes to the macrophyte beds.

Little information is available on the possible effects of eutrophication and silting of the lakes and lower Waiau River. Although no accidental discharges have been reported, more detailed information on eutrophication may be desirable. Phytoplankton monitoring close to the oxidation ponds may show up any excessive eutrophication. The effects of silting of macrophyte beds of the lakes and lower Waiau have not been studied. Theoretical studies of this issue suggest there may be a problem.

Other lakes could be used as "controls" for comparative studies of aquatic macrophytes. The Mavora lakes or nearby Lake Hauroko could be used for this purpose, although Hauroko is not part of the same catchment. Lake Gunn is another possibility.

Lakeweeds pose a significant threat to environmental, aesthetic and tourism values within the Waiau catchment. *Lagarosiphon* and waternet (*Hydrodictyon*) could colonise the lakes of the region within the next ten years. Prevention measures are recommended.

Recommendation Outline

1. Ongoing monitoring of shoreline vegetation transects in Lakes Manapouri, Te Anau and Monowai, extending existing transects to lower depths.

2. Monitoring of phytoplankton, blue-green algae and rooted aquatic plants near oxidation pond and stormwater discharge sites.

3. Comparative studies with "control" lakes (e.g. Lake Hauroko).

4. Put techniques in place for preventing the introduction and establishment of noxious waterweeds, particularly, *Lagarosiphon* and waternet (*Hydrodictyon*).

5. Comparative study of the aquatic macrophytes, and periphyton for the upper Waiau and lower Waiau Rivers and the Mararoa River.

Relevant Working Party Reports
A5 - Minimum Flow Requirements for Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn

A6 - Report on Periphyton and Invertebrate Communities in the Waiau River, February 1993

E2 - An Annotated Bibliography of the Shorelines of Lakes Manapouri, Te Anau, Monowai, Hauroko, North Mavora and South Mavaora

A4 - The Waiau River (Southland) Whitebait Fishery: A Consideration of the Impacts of the Mararoa Dam and Flow Diversion from the River

May 1993 **:** Author - R M McDowall

Issue

> *The impact on the Waiau River whitebait fishery of the construction of the dam at Mararoa, and the reduction in flows down the Waiau River and at its mouth.*

Executive Summary

Impacts of flow management practices on the Waiau whitebait fishery are likely to fall into two categories: (a) the impacts of mouth blockage, and (b) changed flow patterns.

The potential for reduced flows to lead to mouth blockage of the Waiau River is a matter for serious concern for the fishery. If the mouth closes, entry of fish into the river is prevented; if the mouth is only partially blocked entry is still possible, but hindered. This prevention or hindrance affects the fishery at two levels. Firstly the fish are not available to fishers. Secondly, and of more long term concern, breed stock, upon which sustainability of the whitebait fisheries of Southland depends, cannot enter the river and occupy rearing and feeding habitats, mature and breed.

The impacts of reduced flows in the Waiau and reduced discharges to sea at its mouth are difficult to evaluate, in the absence of any pre- or post-impoundment figures for the productivity of the fishery. But, reduction in the general "normal" flow of the Waiau, does not necessarily result in a reduction in its fishery. To the extent that substantial floods still flow from the Waiau (when tributaries flood and/or the Mararoa is diverted downstream), natural flood events no greatly different from those of pre-dam times should still attract whitebait to the Waiau River mouth.

On the basis of what little is known about whitebait catches and fisheries in the rivers of South Westland and Southland, there is no reason why the Waiau River, in its abstracted form and given that substantial floods still take place from the Waiau tributaries any by the diversion of the Mararoa, should not sustain a whitebait fishery of at least regional significance, particularly if flood flows during the spring continue to be discharged into the river from the Mararoa River and Lake Manapouri, to ensure that the Waiau River mouth does not become seriously blocked by coastal drift of beach gravels, and to stimulate runs up the river.

Recommendation Outline

No recommendations were included in this report, however the final sentence from the conclusion:

> "...flood flows during the spring continue to be discharged into the river from the Mararoa River and Lake Manapouri, to ensure that the Waiau River mouth does not become seriously blocked by coastal drift of beach gravels, and to stimulate runs up the river."

has been taken as a recommendation from this report.

Relevant Working Party Reports
A2 - Review of Fish Distribution in the Waiau River Catchment, Southland

A5 - Minimum Flow Requirements fro Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn

A9 - The Waiau River (Southland) Inanga Spawning Survey 1994

A11 - A Calendar of Fish Migrations Through New Zealand River Mouths

A5 - Minimum Flow Requirements for Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn

May 1993 - Author : I G Jowett

Issue

> *Flow required in the Waiau River between Mararoa Weir and Borland Burn to provide for migrating trout, maintain instream habitat for adult brown trout and benthic invertebrates. Assess quality of habitat maintained by an increased residual flow.*

Executive Summary

Three reaches were surveyed, each of quite different character, and each considered to be characteristic of a larger section of the river. The most upstream reach, just below Excelsior Creek, had a flow of 0.52 m^3/s during the survey (with the control gates shut). It was well confined with large substrate elements and is typical of the river between the weir and Whare Creek. In the middle reach, just upstream of Redcliff Creek, tributaries had increased the flow to 2.1 m^3/s. This part of the river was steeper and less confined with more varied habitat, ranging from a deep pool to a steep narrow riffle and broad runs. At the lower reach, at Blackmount, where the flow had further increased to 3.9 m^3/s. This reach sampled the type of habitat in the river below Redcliff, where the slope lessens and there are long uniform sections of wide slow flowing water, broken by the occasional riffle.

The Blackmount reach was shallowest, with an average water depth of 0.24 m. The minimum passage depth occurred in the Excelsior reach, where the maximum depth in the shallowest cross-section was 0.17 m. Although this is generally considered to be sufficient for trout passage, it is probable that there are sections of the river where the passage depth is less than 0.15 m. However, water depth in the shallowest cross-section was predicted to increase at a rate of 0.04 m for every 1 m^3/s increase in flow so that a small increase in flow would probably provide adequate passage depths in the section of river below the Mararoa Weir.

In the upper and lower reaches (Excelsior and Blackmount) the variation of adult brown trout habitat and food producing (benthic invertebrate) habitat with flow was remarkably similar, with a rapid increase in both types of usable habitat as the flow increased up to about 10 m^3/s and a slower rate of increase above that. Less variation was apparent in the Redcliff reach, because of its steepness and higher water velocities at low flows. Flow assessments for all three reaches were based on both trout and food producing criteria.

The amount of potential habitat in the river with flows of 15-30 m^3/s was comparable with the best rivers in the "100 rivers" survey, some of which were renowned trout rivers. Even flows in the range of 7.5-12.5 m^3/s would create habitat equivalent to that of the top ten rivers in the "100 rivers" survey.

When the potential habitat in the three reaches was averaged to give a clearer appreciation of the overall variation with flow, it showed that a residual flow in excess of 30 m^3/s would enhance adult brown trout and food producing habitat considerably. For flows in excess of 15 m^3/s, the sum of the trout and food producing habitat exceeded any of the rivers surveyed previously, indicating that the Waiau River between the Mararoa Weir and the Borland Burn is a potentially excellent trout river.

Recommendation Outline

That consideration be given to maintaining a minimum flow in excess of 10 m^3/s in the Waiau River below the Mararoa Weir.

Relevant Working Party Reports

A2 - Review of Fish Distribution in the Waiau River Catchment, Southland

A6 - Report on Periphyton and Invertebrate Communities in the Waiau River, February1993

H1 - Hydrological Data Summary

A6 - Report on Periphyton and Invertebrate Communities in the Waiau River, February 1993

February 1993 : Author - Barry J F Biggs

Issue

Initial resource assessment of the benthic communities in the Waiau River, suggesting effects of current low-flow regulation on benthic communities and identifying more detailed studies which may be necessary for assessment of alternative flow regimes.

Executive Summary

An analysis of periphytic algae and invertebrates in the Waiau River between the Mararoa Weir and the Borland Burn was carried out in February, 1993, to provide a background description of the communities and to indicate the likely effects of low flow regulation in the river. This work was also designed to complement the trout habitat analysis reported by Jowett (1993). An abundant growth of periphyton was recorded in the Excelsior reach whereas a patchy, but generally low, growth occurred in the Redcliff and Blackmount reaches. Overall, highest biomasses of periphyton were located where velocities were low (<0.1 m/s), particularly in the Excelsior reach where filamentous green algae dominated the communities. The two lower reaches were dominated by cosmopolitan taxa and one green filamentous alga (*Bulbochaete* sp.) which is not common elsewhere in New Zealand.

The occurrence and distribution of many of the invertebrate taxa reflected these differences in periphyton development. Areas of high periphyton biomass (eg. the Excelsior reach) were dominated by small burrowing invertebrates (eg. chironomids and oligochaetes; which are normally indicative of polluted conditions) and some caddis-fly larvae. Conversely, areas with low periphyton (parts of the Redcliff and Blackmount reaches) had much lower densities of burrowing invertebrates, and higher proportions of taxa preferring clean substrates (eg. mayflies). These taxa are more available as food for adult trout. Thus, the low flows, and resulting low velocities in the river, appear to be having an important affect on the structure of benthic communities. An increase in mean water velocities in the study reaches to at least 0.3 m/s would help control the accumulation of periphyton and aid the development of a more diverse 'clean-water' invertebrate fauna.

Recommendation Outline

No recommendations were included in this report, however the following has been taken from the discussion as a recommendation from this report:

> The relationship between periphyton biomass and water velocity suggests that an increase in flows in the Waiau could be used to control the accrual of the periphyton. Flows which gave a mean reach velocity of greater than 0.3 m/s should be sufficient to do this.

Relevant Working Party Reports

A3 - A Review of the Aquatic Macrophytes of the Waiau Catchment

A5 - Minimum Flow Requirements for Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn

A7 - Native Fish Populations of the Waiau River (Southland) and the Impacts of the Lake Manapouri Control Structure (the Mararoa Weir)

August 1994 : Author - R M McDowall

Issue

Determine the native fish fauna of the estuary, mainstem and lower tributaries of the Waiau River and the impacts on populations of the reduced flows. Recommend optimum flows for native fish, especially in the upper part of the lower Waiau River and optimise habitats in the Waiau River Lagoon for all life stages of fish species present.

Executive Summary

The Waiau River has population typical of the rivers of southern New Zealand, with 15 native freshwater species plus two marine wanderers. Most of these have obligatory sea-migratory life stages which means that an open river mouth and free passage up and down stream are pre-requisites for their occurrence in the river. Low flows in the river increase the likelihood of mouth closing which would seriously threaten the already sparse populations of migratory native fish if closure was coincident with migration seasons and long-lasting. In spite of this diversity of species, the fauna is highly impoverished over much of the river as few species penetrate up beyond the estuary/lower reaches to Tuatapere, and those few that do are rarely abundant beyond the estuary.

In these characteristics the Waiau is not dissimilar to what is known for the fish faunas of the other rivers of the Southland Plains such as the Oreti, Aparima and Mataura. The sparseness of the fauna can be attributed to a failure by most fish species to enter the river in large numbers followed by their failure to migrate upstream beyond the estuary and lower reaches.

Studies of native fish habitat have shown that most species favour of cobble gravel substrates in edge habitats, usually less than 25 cm deep. Given this fact, combined with the very low species diversity in the Waiau River in its upstream reaches where flows are heavily reduced, the contention that a residual flow there of around 10 cubic metres per second, designed to optimise the trout fishery, will provide adequate habitat for native fish, is supported. There is no reason to implicate the sparseness of the fauna with the impacts of flow variation and impoundment of the upper river that result from the construction of the Mararoa Weir.

The Waiau River estuary supports a diverse fauna typical of New Zealand river estuaries (six freshwater/estuarine species plus two marine wanderers). Habitat conditions in the estuary remain largely unspoiled, though catchments that drain into the estuary have been heavily deforested and converted to pasture, with most swamplands drained. The fauna of the estuary would be enriched by allowing riparian lands to return to indigenous vegetation and the redevelopment of wetlands. However, the quality of these restored habitats will always be subjected to the influence of streams draining farmlands further back from the estuary. These influences may compromise the habitat values that could be restored around the estuary itself.

Recommendation Outline

No recommendations were included in this report, however the following has been taken from the discussion as a recommendation from this report:

> "Given the very sparse nature of the fauna encountered, there can be no doubt that Jowett's (1993) assertion that 'suitable habitat for [common river galaxias, longfinned eel, upland and common bully] will be available at practically any flow' is correct, and can be extended to include torrentfish and bluegilled and redfinned bullies".

Relevant Working Party Reports

A2 - Review of Fish Distribution in the Waiau River Catchment, Southland

A4 - The Waiau River (Southland) Whitebait Fishery: A Consideration of the Impacts of the Mararoa Dam and Flow Diversion from the River

A5 - Minimum Flow Requirements for Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn

A8 - Aquatic Birds of the Waiau River November 1993 and March 1994

April 1994 **:** Author - P M Sagar

Issue

> T*o assess habitat requirements of target species and how distribution and abundance may have been affected by hydro-electric power development; and to determine flow requirements necessary to maintain habitats.*

Executive Summary

The purpose of this study was to determine the aquatic bird population of the Waiau River between the Mararoa Weir and the sea to :

> - assess the habitat requirements of target species - Pied Oystercatcher, Pied Stilt, Banded Dotterel, Black-fronted Dotterel, Black-billed Gull, Black-fronted Tern, White-fronted Tern.
>
> - assess how the distribution and abundance of the target species may have been affected by hydro-electric power development.
>
> - determine the flow requirements necessary to maintain habitats for aquatic birds.

Three unconfined reaches were surveyed twice, during the breeding and post-breeding seasons. The most upstream reach, in the Redcliff area, supported the fewest birds. This was probably the result of predominantly large substrates which do not provide suitable habitat for breeding and feeding.

The Clifden-Wairaki reach provided large areas of suitable feeding and breeding habitat for all the target species, and with the exception of Black-fronted Dotterels, this was reflected in the numbers recorded of each species. As expected, the lagoon and lower river supported the greatest abundance and diversity of birds, with coastal and freshwater species represented. Large colonies of breeding Black-backed Gull, Black-billed Gull and White-fronted Tern occurred in this area, as well as a large roost of the marine Spotted Shag.

However, with the exception of Black-billed Gull and White-fronted Tern few target species were recorded in this downstream area, primarily because vegetation had encroached on suitable habitats. Reduced flows as a result of hydro-electric power development have probably increased the amount of habitat available for the feeding and breeding of the target species. However, some of this perceived benefit is probably offset by greater access to breeding colonies by mammalian predators and further encroachment of vegetation in the floodplain.

Increasing the residual flow by 10-20 m^3/s would probably isolate breeding colonies from predators, but only major floods would remove the encroaching vegetation.

Recommendation Outline

No recommendations were included in this report, however the following has been taken from the discussion as a recommendation from this report:

> The Waiau River supports 1.3-3.9% of the entire New Zealand population of Black-fronted Terns and a minimum of 5.8% of the Southland population of Black-billed Gulls. The reduction in mean flow has probably resulted in more habitat being available for breeding and feeding; however, some of these apparent benefits would be offset by the greater access to breeding colonies of such predators as mustelids and cats. Encroachment of vegetation in the lower river has offset any benefits of increased habitat availability because of lower flows.

Relevant Working Party Reports
A1 - Avian Information from the Waiau Catchment

A9 - The Waiau River (Southland) Inanga Spawning Survey 1994

June 1994 : Author - P J McClelland

Issue

> *Whitebait habitat in lower Waiau River, impact of river flows on habitat and suitable protection/enhancement for habitat.*

Executive Summary

One confirmed and several unconfirmed spawning sites were located. Possible effects of the current water regime on inanga spawning were split into two categories:

> 1. Floods/Freshes - floods may affect spawning by raising the water level at the time of spawning, above the usual spring tide level or by washing away eggs after laying or smothering eggs with a high silt loading.
>
> The Mararoa Weir generally evens out flows (currently at a greatly reduced level). This may be beneficial by making the tide the overriding influence on water levels in the spawning areas. But it also means that any releases of water have a greater percentage increase over normal river flows. As the Weir is generally only opened at times of high lake levels and/or dirty water coming down the Mararoa, the silt loading of the Mararoa water will probably be higher than when normally diluted with Manapouri water. This silt loading would lead to a greater risk of smothering the eggs as large amounts of silt can be dropped in the quieter backwaters which are frequently the spawning areas.

2. Mouth Blockage - if the mouth is blocked for any significant period prior to and during the spawning period, it will affect the spawning sites, as the river rather than the tide becomes the main influence on water levels. Thus rather than the eggs being protected from predation by being laid at the peak of spring tides, the water level either keeps rising, making the eggs vulnerable to predation, or the mouth opens and the water level drops, leaving the eggs high and dry.

Suggested methods for protecting known and probable spawning sites were the controlling of encroaching willow trees and by fencing the area to keep out cattle and planting the area with flaxes. Habitat enhancement such as constructing ponding areas and planting programmes was also suggested.

Recommendation Outline

1. That willow control be undertaken near the known spawning site.

2. That cattle be excluded from the known, and likely, spawning sites.

3. That habitat enhancement in the area adjoining the estuary take place.

4. That more survey work be carried out to locate further spawning sites.

Relevant Working Party Reports
A2 - Review of Fish Distribution in the Waiau River Catchment, Southland

A4 - The Waiau River (Southland) Whitebait Fishery: A Consideration of the Impacts of the Mararoa Dam and Flow Diversion from the River

A11 - A Calendar of Fish Migrations through New Zealand River Mouths

A10 - Fish Passage Problems and Options for Fish Passage at Mararoa Weir

August 1994 : Author - Charles Mitchell

Issue

The passage of fish past the Mararoa Weir.

Executive Summary

The weir has the potential to control the upstream distribution of several species of native and introduced fish. It is generally conceded that fish passage must be provided over the weir. What is required is a low maintenance, highly effective fish pass. A further variable is that ECNZ may release a compensation flow down the Waiau River. It would be desirable to integrate both the fish pass and the compensation flow structures.

Siltation and the deposition of gravel, exacerbated by diversion of the Mararoa River directly toward the control gates, appears to have totally blocked up the existing fish pass. Desiltation and maintenance is made particularly difficult by the encased design. The interior is essentially inaccessible. Therefore the cost and logistics involved with keeping this fish pass working, are probably unreasonable under present day economic realities.

Most fish migrate up to the weir after a fresh, attracted by the volume of spilled water. Fish numbers build up below the weir when the gates finally close. Public concern over the fate of the trout and elvers which can be seen below the weir detracts from the image of ECNZ as a good corporate citizen. Past tagging studies indicated that brown trout did not migrate through the fish pass. Rainbow trout did use the fish pass. An examination of size-frequencies and ages of eels above the Mararoa Weir indicated that recruitment of these migratory fishes had been reduced since the weir was built Eels still remain common above the weir, these long-lived fishes are well adapted to maintain populations in habitats where access may only be possible at intervals. But without an effective fish pass eels will eventually become greatly reduced in numbers in the upper catchment.

An effective fish pass structure faces the following constraints: It has to be built within a reasonable cost envelope and must conform to existing structures and their operation. Water velocities within the fish pass have to be low enough to allow elvers and other small native fishes upstream. The fish pass must be deep and wide enough to allow adult trout to swim upstream. The entrance of the fish pass must be located at or immediately below a point where a barrier to further upstream movement for fish is present. This barrier must remain an effective barrier over a wide range of flows.

Six options to allow fish passage across the Mararoa Weir were outlined.

Recommendation Outline

The recommended preference (without access to costings and engineering expertise on the feasibility) was for a combination of a Denil fishway fitted onto the existing fish pass entrance and led around the right wingwall at a slope of between 5^{o}-10^{o}. This fish pass would need to extend around the wingwall to an entrance in the scour pool, below the gates and upstream of the accumulation of gravels in the stilling basin.

A fish pass is likely to be necessary for eels and lamprey.

Relevant Working Party Reports
A2 - Review of Fish Distribution in the Waiau River Catchment, Southland

A4 - The Waiau River (Southland) Whitebait Fishery: A Consideration of the Impacts of the Mararoa Dam and Flow Diversion from the River

A5 - Minimum Flow Requirements for Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn

A11 - A Calendar of Fish Migrations through New Zealand River Mouths

September 1994 **:** Author - R M McDowall

Issue

Passage of migrating native fish through the Waiau River mouth.

Executive Summary

Diadromous fishes are migrating between New Zealand coastal seas and the rivers that drain into them, at almost all times of the year. There is clear seasonal partitioning, however, in the directions of these migrations, with much more upstream migration taking place during the spring, and downstream migration occurring during summer through into early winter. Patterns of migration in the Waiau River (Southland) are similar to the above.

Recommendation Outline

No recommendations were included in this report, however the following has been taken from the discussion as a recommendation from this report:

> The Waiau River supports a regionally valued whitebait fishery, for which an open river mouth during August through mid-November is desirable. For the river to contribute its regional share to the maintenance of the fishery through reproduction in the river, mouth opening from about late February through May is desirable. Migrations of adult eels to spawn, and the return of juvenile eels to regenerate the stocks would be well accommodated by the same opening times.

Relevant Working Party Reports

A2 - Review of Fish Distribution in the Waiau River Catchment, Southland

A4 - The Waiau River (Southland) Whitebait Fishery: A Consideration of the Impacts of the Mararoa Dam and Flow Diversion from the River

A9 - The Waiau River (Southland) Inanga Spawning Survey 1994

C1 - Geomorphic Processes and Coastal Change in the Lagoon System, Lower Waiau River, Southland

May 1994 : Author Professor R M Kirk and Dr J Shulmeister

Issue

> *To understand the interactive processes between the river and coastal system, particularly in terms of mouth opening/closing/movement.*

Executive Summary

This report concerns development and change in the landforms of the lower Waiau River and adjacent coastline. The investigation has been carried out in particular light of principles, controlling relationships and physical processes known to affect other South Island, coarse-grained river mouth systems.

Changes that have occurred in the post-control period, together with their management implications have been approached by first determining the long term geological evolution of the barrier beach, the lagoon and the adjacent coast. This has provided a clear context against which to assess human-induced changes in the river mouth system for both the period prior to control for hydro-electric power generation and for the post control period. The stance adopted has been that control for power generation has been one of a number of influences on the system. Each influence initiates a sequence of changes that have a distinct time scale ("relaxation time") as well as a variety of expressions in the landscape. Change is ongoing in the system and not readily either preventable or reversible.

The modern Waiau coastal system has developed in the last 6000 years. The system may have been depositional immediately after 6000 year BP when sea level reached an elevation near its present value.

The present barrier enclosing the mouth of the Waiau River is effectively modern in age. This reflects a continuing process of river sediment supply, reworking through the barrier and loss of sediment to other parts of the coastal system. The internal structure and composition of the barrier have been established.

The barrier is built of materials supplied from the Waiau River and has no significant admixture of sediments from any other source (eg. the updrift coast or the sea bed). The barrier is thus particularly sensitive to hydrological and sediment delivery changes in the Waiau River catchment.

Net longshore sediment transport appears to occur from east to west, though transport to the east can occur from time to time. Net transport westward is reflected in persistent westerly offsets of the Waiau River mouth and in the historical patterns of erosion and accretion along the coast.

The eastern (updrift) shore is predominantly erosional. It is nourished only spasmodically, if at all, by sediments from the Waiau River.

The western (downdrift) shore is mildly accretional. It receives sediment from both the Waiau River and the eroding eastern shore by longshore drift.

It is possible that tectonic uplift has influenced the system at some time in past several thousands of years. This would have induced scour in the lower river channel and increased the sediment supply to the coast (both east and west of the mouth), as well as promoting barrier beach growth. Tectonic uplift of uncertain amount and timing may explain the steep gradients and coarse grain sizes found in the lower river (within 2.5 km of the coast).

Forest clearance and conversion to pasture have also influenced the river system and its relationships with the coast. Most notably this caused an increase in coarse sediment supply to the lagoon (and ultimately to the coast). Most of this supply originates from bed and bank erosion in the lower Waiau itself and reflects a change in channel adjustment style that began prior to control and which has been accelerated since control. Much of this adjustment will now be complete.

In historical time, particularly in the post-control period there has been growth of the barrier beach at the Waiau mouth. The downdrift, western shore has been in mild sediment budget surplus.

The most significant post-control hydrological changes affecting the mouth system have been the reduction in the level of minimum flows in the river and a substantial reduction in moderately high energy events associated with discharge peaks greater than the mean flow.

Lower minimum flows have contributed to mouth closure. Closure is most probably in the autumn equinox and winter. It is at these times when river flow is low and high energy waves on the adjacent coast have their greatest frequency of incidence.

Large floods still pass down the river but there has been a reduction in moderately large flows with discharges greater than the mean flow.

In the post-control period excursions, both eastward and westward of the mouth have reduced. Prior to control excursions involved up to 4km of coast. Since control the mouth has been less mobile and has had a dominantly westerly (downdrift) offset.

The Waiau River mouth system has been shown to be rather delicately responsive to changes in catchment conditions. It seem probable that coarse sediment supply to the barrier will decline over the coming decades as adjustment to hydrological changes in the catchment is completed. The outlook is for barrier growth to slow or cease and for excursions of the mouth position to again increase.

In terms of the "large river-small river" concept shown to be important to the behaviour of many other coarse-grained South Island river mouth systems, it has been shown that the Waiau has derived much of its character as a "small" river unable during formation of the system to maintain itself against coastal erosion. In the historical period, mainly as a result of human change in the catchment (including but not limited to control for hydro-electric power generation) the Waiau became a "large" river, able to more than maintain its mouth against marine erosion. The outlook is for it to once again become a hydrologically "small river". The time scale of adjustment to the post-control changes is not know with certainty but is in the order to 50 years with most of the changes occurring in the first half of the post-control period, ie: most of the change has already occurred.

The burden of these conclusions is threefold. First, that changes introduced by control are overlaid on natural and other human changes occurring in the system. It is incorrect to ascribe all change in the mouth system to post-control hydro-related change. Secondly, the changes induced in the mouth system by control are largely but not completely self-correcting given sufficient "adjustment time". Thirdly, there is no management action that can reasonable be taken that will either prevent the process of adjustment from being completed, or that will reverse the cycle of changes initiated in 1969.

It is especially important to note that lagoon and barrier beach behaviour are the outcomes of interaction between coastal processes (mainly wave action) and river processes. The extremes of river flow (both high and low), their durations and their timings relative to coastal storms are the main controls of barrier breaching and mouth excursion. These aspects of behaviours are not well related to mean flow in the river and thus are not likely to be much affected by altering the mean flow.

Recommendation Outline

No recommendations were included in this report, however the following has been taken from the conclusion as a recommendation from this report:

> "There should be further investigation of the influence of tectonics on the Waiau Valley and its adjacent coast."

Relevant Working Party Reports

E3 - Channel Adjustments along Waiau River, 1946-1992: Assessment of the Impacts of Flow Regulation

H2 - Waiau River Hydrology

E1 - River Reach Analysis of the Waiau River, Southland, from Mararoa Weir to Te Waewae Bay

May 1992 : Author - Gary J Brierley

Issue

To develop an understanding of the character and evolution of the lower Waiau River, in particular changes to the erosion/sedimentation regime induced by flow regulation.

Executive Summary

Eleven reaches of the Waiau River downstream of the Mararoa Weir are identified and characterised as valley setting, channel character and river bar scales. A distinct pattern in river reaches of the Waiau is discernible, with an alternating sequence of bedrock/terrace constrained reaches and less constrained reaches with multi-channelled planform geometries. These are transitional to a lowland reach downstream of Tuatapere, where planform adjustments are more prevalent than in any other reach along the river.

Duncraigen, Motu, Clifden Suspension Bridge, Hagen Road and Orauea were all bedrock or terrace-constrained reaches. Wairaki, Lill Burn and Downstream o'Clifden were all unconfined reaches. Tuatapere was a lowland reach described as a wandering gravel-bed river reach. The Tuatapere reach had a considerably greater proportion of active gravel surfaces than any upstream reach and maintained a relatively steep channel bed slope.

As a reach widens, the ability of the flow to carry sediment is reduced as flow energy is dissipated over a broader area. This is termed the competence limit. In many instances large volumes of sediment are added to the river at tributary confluences (affecting the capacity limit). The river either has sediment which is too coarse for it to carry, or there is simply too much sediment for the river to carry, and hence within-channel sedimentation results in the formation of mid-channel bars. These are subsequently dissected by flows of differing magnitude to produce compound bar features. At the downstream limit of unconfined reaches, bedrock once more imposes a lateral constraint on the channel and sedimentation is restricted to lateral and point bar features.

Thirty-three samples were collected to analyse grain size variation in the lower 100 km of the Waiau River. The downstream gradiation in clast sizes described in this study is completely counter-intuitive, as the coarsest sample was measured at the mouth of the river.

Channel adjustments of the Waiau River following flow regulation have been restricted primarily to those reaches where the river has space to adjust laterally or reaches where there are significant inputs of sediment from tributary catchments. These effects operate to differing extents in 7 reaches (Redcliff, Waicoe, Wairaki, Lill Burn, Downstreamo'Clifden, Orauea and Tuatapere). While the Tuatapere reach has experienced considerably greater channel adjustments than all other reaches in the past 10 years, significant adjustments are also evident in the Wairaki, Lill Burn and Downstream o'Clifden reaches.

Recommendation Outline

1. Further study on channel adjustments of the Waiau following flow regulation as a base-line inventory of the contemporary condition of the river.

2. Study on the tributary impacts of flow regulation along the lower Waiau.

3. Put in place an appropriate strategy to monitor the nature, rate and controls of sediment movement in the Waiau River.

4. Integration of information on GIS.

Relevant Working Party Reports

C1 - Geomorphic Processes and Coastal Change in the Lagoon System, Lower Waiau River, Southland

E3 - Channel Adjustments along Waiau River, 1946-1992: Assessment of the Impacts of Flow Regulation

E4 - Reach Analysis of Waiau River Tributaries Immediately Downstream of Mararoa Weir (Lake Manapouri Control Structure)

E5 - Waiau River Regional Setting and Whitestone River Reach Analysis

E6 - Tributary Characterisation and Assessment of Tributary Impacts on the Geomorphic Behaviour of Waiau River, Southland, New Zealand

E7 - Tributary River Reach Analysis of Waiau River Catchment, Southland

H2 - Waiau River Hydrology

E2 - An Annotated Bibliography of the Shorelines of Lakes Manapouri, Te Anau, Monowai, Hauroko, North Mavora and South Mavora

January 1993 : Author - M B Single

Issue

Review literature available regarding the shorelines of the Waiau River and catchment lakes and identify gaps in knowledge and recommend future research.

Executive Summary

The annotated bibliography incorporated in this report is directed specifically towards lakeshore morphology and processes. Basically, this covers beaches and shorelines of the lakes, and the wave environment, including adjustments of lake water levels that shape them. There is some inclusion of literature dealing with vegetation around the lakes but this is limited to those works that address vegetation issues at the shores. It should be noted that the bibliography does not encompass the many reports concerned with the Waiau and Mavora Rivers, although aspects of the Upper Waiau and the Lower Waiau between Lake Manapouri and the confluence with the Mararoa River that are relevant to the wider lakeshore process environment have been included.

Material for this review has been collated from four major sources plus existing bibliographies (Pickrill and Maciver 1978, and Moore 1980), and includes published journal articles and reports, unpublished reports for Electricity Corporation, Southland Regional Council, the Guardians, Ministry of Works, and DSIR, and two unpublished university Ph.D. theses. The sources of material were Southland Regional Council (through T J McClelland, Project Manager, Waiau River Working Party), Dr R M Kirk (Associate Professor, Department of Geography, University of Canterbury), the Map Library, Department of geography, and the Main Library of the University of Canterbury.

No single source contains all of the material contained in this review, however the majority of the unpublished reports are held by Southland Regional Council or the Guardians of Lakes Manapouri, Monowai and Te Anau.

Recommendation Outline

1. Further information about the shore and beach morphologies and adjustments of Lake Hauroko and the Mavora Lakes to be gathered as a comparison to the beach adjustments of the controlled lakes.

2. Further information as to the influence of beach sediment type and character as a control on beach response to processes.

3. A study of the relationship between beach erosion and sedimentation process and the biotic environment on the lakes (important for wildlife, recreational and sport fishery values).

Relevant Working Party Reports
H2 - Waiau River Hydrology

E3 - Channel Adjustments Along Waiau River, 1946-1992: Assessment of the Impacts of Flow Regulation

January 1994 : Author - Gary J Brierley in collaboration with Keith Fitchett

Issue

The relationship between flood history and channel adjustments and evaluate the role of flow regulation associated with hydro-electric power development on channel adjustments along the Waiau River between Lake Te Anau and Te Waewae Bay.

Executive Summary

(note: the summary contained in this report is 25 pages long, therefore considerable "editorial license" has been exercised in this version of the executive summary)

In general, rates of erosion and deposition were crudely balanced prior to flow regulation. Immediately following flow regulation, however, the Waiau River endeavoured to attain a new equilibrium condition. Deposition became dominant and the channel contracted. The width of the active channel zone decreased, as bars became bank-attached and secondary channels were abandoned. Accordingly, there was a reduction in braided index and a reduction in channel multiplicity. Sinuosity also increased, albeit marginally, although some subreaches straightened. Many of these planform adjustments were initiated in the period before flow regulation. Reduction in mean flow and amelioration of major floods associated with flow regulation have served to greatly increase the rate of channel adjustments along laterally unconfined reaches of Waiau River.

Channel adjustments in the latter half of the 1970's were not as dramatic as changes evident between 1969-1974. A depositional regime prevailed, however, until major flood events between 1982-1984 induced substantial erosion along most of the river, although bank erosion was not as prevalent as expected. The channel zone was effectively flushed during these floods, but channel recovery between February-June 1984 was rapid. Impacts of the sustained high discharge condition in late 1988 differed significantly from reach to reach and even within-reach, as the erosion/sedimentation regime adjusted to local sediment

availability, bar configuration and flow alignment in each subreach. Channel adjustments between 198401989 were most dramatic along the lower course of the river. Significant reworking of materials occurred between 1989-1992.

The statistical similarity of rate of change of erosional and depositional adjustments in Wairaki, Lill Burn and Downstream o'Clifden reaches is remarkable. In all three reaches there is less than 10% variability in the relative rates of change of erosion and deposition after 1969. This suggests that whatever balance in erosion and deposition was evident before 1969, it was maintained or re-established after 1969. In other words, the erosion and depositional regime was either never significantly affected by flow regulation in these reaches or an equilibrium condition has subsequently been regained.

The summary relationship between erosion and deposition in Tuatapere reach differs notably from other reaches described. Summary changes in erosion/sedimentation regime in Tuatapere reach after 1969 show a 30% increase in rate of erosion and an increase of almost 70% in rate of deposition. Given the magnitude of channel adjustments in this reach, this indicates a clear shift in regime towards depositional dominance. Adjustments have been markedly variable in the differing subreaches, reflecting the shift in the position of bends over the period of record. While erosion increased by >45% along banks and in the within-channel zone between 1947-1969, the increase in rate of erosion between 1969-1992 was almost entirely accommodated by erosion in the within-channel zone. This implies, in relative terms at least, that margins of Waiau River have stabilised after flow regulation.

Several factors could account for the apparent depositional imbalance in Tuatapere reach. This is the most alluvial reach along Waiau River, and may be most sensitive to change. As the lowland reach, it is the reach of sediment accumulation, and the sedimentation pattern may have been modified in association with flow regulation. A more likely explanation, however, is the nature of the interaction between the river and the gravel barrier system. Changes to the rate of sediment movement through the lower course of Waiau River associated with flow regulation, possibly exaggerated by the modified sediment contribution from tributary catchments, may have changed the relationship between Waiau River and its barrier system, such that the plan form geometry of Tuatapere reach has responded to an altered set of boundary conditions.

Recommendation Outline

1. Channel outlines be traced from air photographs taken every 10 years or following flood events >2000m^3/s. Analysis should be restricted to the primary tributary confluences and the lowland plain.

2. A monitoring program in the upper Waiau to assess rates of bank erosion to differing flow releases through Lake Te Anau Control Structure.

3. A monitoring program to assess sediment build-up at the river mouth, determining the location, rate and character of materials that are accumulating and changes to the nature of material throughput to the gravel barrier system.

Relevant Working Party Reports

C1 - Geomorphic Processes and Coastal Change in the Lagoon System, Lower Waiau River, Southland

E1 - River Reach Analysis of the Waiau River Downstream of the Mararoa Weir

E4 - Reach Analysis of Waiau River Tributaries Immediately Downstream of Mararoa Weir (Lake Manapouri Control Structure)

E5 - Waiau River Regional Setting and Whitestone River Reach Analysis

E6 - Tributary Characterisation and Assessment of Tributary Impacts on the Geomorphic Behaviour of Waiau River, Southland, New Zealand

E7 - Tributary River Reach Analysis of Waiau River Catchment, Southland

H2 - Waiau River Hydrology

E4 - Reach Analysis of Waiau River Tributaries Immediately Downstream of Mararoa Weir (Lake Manapouri Control Structure)

April 1994 : Author - Gary J Brierley

Issue

Tributary impacts of flow regulation along the lower Waiau.

Executive Summary

This report briefly summarises information collected on the geomorphic character of Excelsior, Whare and Redcliff Creeks, the first three left-bank tributaries of Waiau River downstream of Mararoa Weir. All are relatively steep and short tributaries which drain from the Takitimu Mountains. All three catchments have vast volumes of material available for transport, supplied both by rapid erosion in the friable, volcanic Takitimu's and glacially-derived sediments in Waiau terraces. Reworking of materials from these sources have produced an extensive fan-complex along the western margin of the Takitimu's, within which tributary streams have incised.

The character of Waiau River at the three tributary confluences differs notably. Excelsior Creek joins Waiau River in confined Duncraigen (or Excelsior) reach, whereas Whare Creek joins at the head of Redcliff reach and Redcliff Creek joins at the broader downstream end of Redcliff reach. Such factors serve to modify tributary impacts on Waiau River, especially in terms of lateral constraint (accommodation space), bed condition (armouring) and potential for sediment reworking.

Analysis was restricted to the downstream end of each tributary, between Blackmount-Redcliff Road and Waiau River.

Recommendation Outline

This report was descriptive in nature and did not contain any recommendations.

Relevant Working Party Reports

E1 - River Reach Analysis of the Waiau River Downstream of the Mararoa Weir

E3 - Channel Adjustments along Waiau River 1946-1992: Assessment of the Impacts of Flow Regulation

E5 - Waiau River Regional Setting and Whitestone River Reach Analysis

E6 - Tributary Characterisation and Assessment of Tributary Impacts on the Geomorphic Behaviour of Waiau River, Southland, New Zealand

E7 - Tributary River Reach Analysis of Waiau River Catchment, Southland

H2 - Waiau River Hydrology

E5 - Waiau River Regional Setting and Whitestone River Reach Analysis

April 1994 : Author - Gary J Brierley, Alistair Beveridge, Amanda Hajnal

Issue

Tributary impacts of flow regulation along the lower Waiau.

Executive Summary - Regional Setting

This report outlines the broad regional setting of Waiau River as a means of providing the background context, or boundary conditions, within which the river operates. Summary information was compiled on regional geology, geomorphology, soils, climate and social history from various reports, assessed in conjunction with field observations and analysis of relevant air photographs, 1:50,000 and 1:63,360 topographic maps, 1:50,000 and 1:250,000 geological maps and various NZ Meteorological Service sheets.

Recommendation Outline - Regional Setting

This report was descriptive in nature and did not contain any recommendations.

Executive Summary - Whitestone River

This report updates the Whitestone River reach analysis report submitted in April 1993. Analysis has been extended 5 km upstream, following field work completed in July 1993. Two further reaches have been identified, Lady Burn and Glen Echo, the previously-named Margin Forest reach has been extended upstream and renamed Mount Prospect reach.

The manner and extent of human modification of Lower Whitestone River has resulted in a disequilibrium river style. Stop banks, diversion channels, and bank protection structures such as rip-rap, groynes, mounded gravels and willow plantings constrain the natural behaviour of the river. The irregular distribution and timing of engineering controls has resulted in the river being in a permanent state of adjustment, in terms of its planform geometry, bed material calibre and aggradational regime. Bed gravels are generally poorly sorted and discrete lobes of finer clasts are evident, with occasional extensive sand sheets. These sands may have resulted from channel-bed disturbance, as matrix materials are winnowed from interstices beneath previously armoured surfaces, and may contribute to the 'dirty water' recorded in lower Mararoa River.

Recommendation Outline - Whitestone River

This report was descriptive in nature and did not contain any recommendations.

Relevant Working Party Reports

E1 - River Reach Analysis of the Waiau River Downstream of the Mararoa Weir

E3 - Channel Adjustments along Waiau River 1946-1992: Assessment of the Impacts of Flow Regulation

E4 - Reach Analysis of Waiau River Tributaries Immediately Downstream of Mararoa Weir (Lake Manapouri Control Structure)

E6 - Tributary Characterisation and Assessment of Tributary Impacts on the Geomorphic Behaviour of Waiau River, Southland, New Zealand

E7 - Tributary River Reach Analysis of Waiau River Catchment, Southland
H2 - Waiau River Hydrology

E6 - Tributary Characterisation and Assessment of Tributary Impacts on Geomorphic Behaviour of Waiau River, Southland, New Zealand

April 1994 : Author - Gary J Brierley and Alistair Beveridge

Issue

Tributary impacts of flow regulation along the lower Waiau.

Executive Summary

This report characterises the primary physical characteristics of tributaries of Waiau River with catchment areas >10km^2. This information was compiled from existing reports and field observations made in conjunction with relevant topographic and geological maps and pertinent aerial photographs. The aim of this report is to provide the geomorphic context within which to view tributary impacts on the character of Waiau River in the period post-regulation.

The following factors appear to have the greatest influence in determining tributary impacts on Waiau River:

(I) Catchment size
Large catchments are able to produce higher, sustainable sediment discharges than the smaller catchments which have smaller, spasmodic sediment discharges.

(ii) Availability of unconsolidated sediment
The greater the availability of unconsolidated sediment, in combination with the ability to erode and transport it, greatly influences tributary impacts on Waiau River.

(iii) Conditions in Waiau River
Tributaries which flow in Waiau River in confined reaches have little or no effect on the trunk stream. However, tributaries flowing into less confined reaches have greater potential to modify the geomorphic behaviour of Waiau River.

Inevitably, it is the combination of these factors which brings about greatest modification in the upstream and downstream behaviour of Waiau River adjacent to the confluence zone.

Recommendation Outline

This report was descriptive in nature and did not contain any recommendations.

Relevant Working Party Reports
E1 - River Reach Analysis of the Waiau River Downstream of the Mararoa Weir

E3 - Channel Adjustments along Waiau River 1946-1992: Assessment of the Impacts of Flow Regulation

E4 - Reach Analysis of Waiau River Tributaries Immediately Downstream of Mararoa Weir (Lake Manapouri Control Structure)

E5 - Waiau River Regional Setting and Whitestone River Reach Analysis

E7 - Tributary River Reach Analysis of Waiau River Catchment, Southland

H2 - Waiau River Hydrology

E7 - Tributary River Reach Analysis of Waiau River Catchment, Southland

September 1994 : Author - Gary Brierley

Issue

Tributary impacts of flow regulation along the lower Waiau.

Executive Summary

The assessment of river character and behaviour fro Waiau trunk stream, Mararoa River, Whitestone River, Home Creek, tributary streams draining from the Takitimu's (Excelsior, Whare and Redcliff Creeks), Borland Burn, Wairaki River and Lill Burn constitute primary data for comparison in future years. The reach analysis framework, which outlines the geomorphologic character of section of river defined on the basis of physical parameters, forms a suitable framework for assessment of subsequent adjustments. Series of photographs, grain size statistics and assessment of the assemblage of geomorphic units in each river reach can form the baseline for comparison of changes for decades into the future.

The information in this report and other reports written as part of the tributary river reach analysis project constitute baseline information on the geomorphological behaviour of Waiau catchment. Combined with the channel adjustments report, this provides direct insight into river responses to flow regulation associated with Manapouri Power Scheme. This information is used to suggest two potential monitoring programs assessing long-term changes in the sediment budget of lower Waiau River and using geomorphology as a basis to assess river health.

Recommendation Outline

1. Assess sediment movement through lower Waiau River via two monitoring components (I) a sediment budget exercise outlining theoretical expectations of bedload transport predictions for the flow regime prior to flow regulation, and (ii) a monitoring program to assess future channel adjustments and changes in the sediment regime of lower Waiau River and the barrier system.

2. Assessment of river "health" using Adaptive Environmental Assessment and Management.

Relevant Working Party Reports
E1 - River Reach Analysis of the Waiau River Downstream of the Mararoa Weir

E3 - Channel Adjustments along Waiau River 1946-1992: Assessment of the Impacts of Flow Regulation

E4 - Reach Analysis of Waiau River Tributaries Immediately Downstream of Mararoa Weir (Lake Manapouri Control Structure)

E5 - Waiau River Regional Setting and Whitestone River Reach Analysis

E6 - Tributary Characterisation and Assessment of Tributary Impacts on Geomorphic Behaviour of Waiau River, Southland, New Zealand

H1 - Hydrological Database Index

November 1991 : Author - D C Riddell

Issue

Review the hydrological data currently available for the Waiau catchment.

Executive Summary

The purpose of this brief document is to give an overview of hydrological data currently in existence for sites within the Waiau catchment. Its main use will be as a quick reference guide.

Section 1 is a listing of the data which is held in computer archives and which is available for use by the Waiau River Working Party and its task groups.

All other sections present summaries in one form or another of data for **key** sites within the catchment - these being the lake levels, inflows and outflows and flow information for sites on the upper and lower Waiau Rivers and the Mararoa River. Some information is also presented for Lake Monowai.

By and large the information which is presented has been derived from TIDEDA processes and there has been minimal interpretation applied.

Recommendation Outline

This report was descriptive in nature and did not contain any recommendations.

Relevant Working Party Reports
H2 - Waiau River Hydrology

H4 - Separation of Manapouri Lake Control Spill into Mararoa River and Lake Manapouri Components

H5 - Lower Waiau River - Flow Attenuation and Times of Travel (Part A) and Flow Recession Profile and Times of Travel (Part B)

H2 - Waiau River Hydrology

April 1993 : Author D C Riddell; H Freestone; S Nutting

Issue

Understanding of the hydrological system of the Waiau catchment.

Executive Summary

This study concerns the Waiau River catchment and its hydrology. The Waiau River receives most of its water from the Fiordland National Park section of its catchment. The part of the catchment that is in Southland outside of the Park yields much less water. These facts are an important starting point when studying the river, its tributaries and the lakes which are so much a part of it.

The presentation of hydrological data throughout the report is generally quite detailed and is analysed with respect to time, location and variation in magnitude. To introduce the more detailed analysis of data collected throughout the catchment, some descriptive and supporting information is presented in the introduction. The hydrology of the main river and the lakes is covered well with a fairly extensive database. Because the catchment is managed in a very complex manner it is essential that the database be maintained.

Key summary data is found in tables and figures throughout the report, and in chapters 3 and 4 as summary sections. Chapter 5 entitled 'Water Balance' presents a brief summary of the location of water within the Waiau catchment. This report does the following:

- presents a map of the catchment, tables significant subcatchments, has a section on lake details and provides a river channel slope diagram.

- describes rainfall. Maps and tables of rainfall data are presented.

- presents detailed analysis of flow data from the gauging stations within the catchment. Low flow, mean flow and flood flow data is presented graphically, statistically and in tabular form. Pre- and post-hydro development data is presented and compared.

- presents detailed analysis of lake level data for the two main lakes.

- presents the distribution of river flow throughout the catchment. Special emphasis is given to tributary flow below the Manapouri Lake Control Structure.

- suspended sediment data and some river bed/gravel movement data is presented.

- detailed analysis of river water temperature is made.

- details of how the Manapour Power scheme relates to the catchment are presented.

- the hydrology of Lake Monowai is presented as a separate section.

- Lake Hauroko hydrology is being monitored as a natural catchment so that comparisons can be make with the nearby controlled lakes, Te Anau and Manapouri.

- details of river mouth migration are given.

Recommendation Outline

1. Carry out a detailed study of tributary inflow to the Waiau River below the Lake Control structure.

2. Undertake a single dry weather survey of the tributary flows to lakes Te Anau, Manapouri and Monowai, gauging flows and producing a water source map/table.

3. Study sediment source areas, significance of North and South Mavora lakes to the Mararoa catchment.

4. Periodic resurvey of river cross sections in the lower Waiau River.

5. Study snow, ice and evaporation data.

6. Expand the Hauroko/Manapouri comparison.

7. Update and expand this study in the future.

Relevant Working Party Reports
E1 - River Reach Analysis of the Waiau River Downstream of the Mararoa Weir

E3 - Channel Adjustments along Waiau River 1946-1992: Assessment of the Impacts of Flow Regulation

E4 - Reach Analysis of Waiau River Tributaries Immediately Downstream of Mararoa Weir (Lake Manapouri Control Structure)

E5 - Waiau River Regional Setting and Whitestone River Reach Analysis

E6 - Tributary Characterisation and Assessment of Tributary Impacts on Geomorphic Behaviour of Waiau River, Southland, New Zealand

E7 - Tributary River Reach Analysis of Waiau River Catchment, Southland

H1 - Hydrological Data Summary

H3 - Cursory Analysis of Tuatapere Water Supply Data

H4 - Separation of Manapouri Lake Control Spill into Mararoa River and Lake Manapouri Components

H5 - Lower Waiau River - Flow Attenuation and Times of Travel (Part A) and Flow Recession Profile and Times of Travel (Part B)

H3 - Cursory Analysis of Tuatapere Water Supply Data

November 1993 : Author - D C Riddell

Issue

Sourcing of Tuatapere water from Waiau River and bore supply.

Executive Summary

Tuatapere water supply bore water pumps operate on average for 22.7% of the time whereas the pumps which supply water from the river operate on average for 10.8% of the time. Given that the river pumps can supply water at about twice the rate of the bore pumps it follows that roughly half of Tuatapere's water is supplied from the river and about half from groundwater.

While there are some long time spans when it is not possible to pump from the river, there are no particularly long periods when the bore water has not been pumped. This is because there are no particularly long periods when the river level is not affected by at least small which increase the suspended sediment concentration.

Recommendation Outline

That preliminary investigations be made of alternative schemes to deliver high quality water with 100% continuity of supply.

Relevant Working Party Reports
H2 - Waiau River Hydrology

H4 - Separation of Manapouri Lake Control Spill into Mararoa River and Lake Manapouri Components

November 1993 : Author - D C Riddell

Issue

Understanding how much spilled water from the Mararoa Weir comes from high lake levels (Lake Manapouri) and how much comes from Mararoa River spills (dirty water).

Executive Summary

From 1978 to 1991 inclusive spill occurred for 35% of the time. 16% of the time spill was due to high lake levels (Guidelines for Lake Manapouri), 19% of the time spill was due to Mararoa River levels (dirty water). The average spill flow was $72m^3s$.

77% of the spill volume (average $55m^3/s$) was from Lake Manapouri (complying with Guidelines) and 23% of the spill volume (average $17m^3/s$) was from Mararoa River (dirty water spills). 12% of the Lake Manapouri inflow (which includes Mararoa River flow) was spilled and 48% of the Mararoa River flow was spilled.

Spill flow exceeded 10 cumecs for 34% of the time, 20 cumecs for 33% of the time and 50 cumecs for 29% of the time.

Recommendation Outline

This report was descriptive in nature and did not contain any recommendations

Relevant Working Party Reports
H2 - Waiau River Hydrology

H5 - Lower Waiau River Flow Attenuation and Times of Travel (Part A) and Flow Recession Profile and Times of Travel (Part B)

June 1994 : Author - D C Riddell

Issue

Understand the rising flow profile, flow attenuation and times of travel of water released from the Mararoa Weir and to determine what happens to the flow profile as outflow from the Mararoa Weir is progressively reduced.

Executive Summary

In a flood Manapouri Lake Control (MLC) gates are opened progressively in steps as the lake level and/or Mararoa River level increases. As the flood wave progresses downstream from MLC there is no discernible attenuation (or flattening) of the flow hydrograph. Frequently in fact there is further augmentation of Lower Waiau River flows from the lower tributaries.

Although there is no attenuation, the "step effect" does become less pronounced with distance downstream but nevertheless is still very evident, even at Tuatapere. When MLC gate openings are adjusted, the new flow immediately downstream of the gates takes about 30 minutes to stabilise. When MLC gate openings are increased, the flow at Sunnyside can start increasing as little as 2 hours later and at Tuatapere as little as 7 hours later. River flow at Sunnyside stabilises after a maximum of five hours, and at Tuatapere after a maximum of 11 hours, following an increase in MLC outflow.

As a flood recedes and lake level and/or Mararoa River level drops the MLC gates are progressively closed in steps. As with flow increases, flow decreases are also noticeably stepped all down the lower Waiau River. As with increases, flow reductions can also be noticed after as little as two hours at Sunnyside, and seven hours at Tuatapere, following a MLC outflow reduction. The minimum time for reduced downstream flow to stabilise is 4.5 hours at Sunnyside and 11 hours at Tuatapere.

At low flows the lag times are much greater so that when MLC gates are closed completely (outflow reduced to zero) the effect is not apparent at Sunnyside until 5 hours later and Tuatapere 14 hours later. Following on from this, when the gates are closed, the reduced downstream flow does not stabilise at Sunnyside until after 11 hours has elapsed, and at Tuatapere until after 26 hours has elapsed.

An addendum to this report covers additional information gathered from a controlled release of 45 cumecs at MLC gates when the lower Waiau River flows were very low (about 10 cumecs at Sunnyside and 40 cumecs at Tuatapere). The times of travel are approximately twice those given earlier in the report due to the extremely low flow in the Waiau prior to the spill. Times given are: Sunnyside flow increasing 7 hours after opening and stabilising 11 hours after gates were opened. Tuatapere flow increasing 17 hours after gates opened and stabilising 20 hours after opening.

Recommendation Outline

This report was descriptive in nature and did not contain any recommendations

Relevant Working Party Reports

H2 - Waiau River Hydrology

I1 - Tikanga Maori Cultural, Spiritual and Historical Values of the Waiau River

February 1993 : Author - Susan Corry and Rachel Puentener

Issue

Understanding the tikanga maori values of the Waiau River catchment.

Executive Summary

The Maori view of the environment and rivers is a holistic and complete view. A river is viewed as a whole, from the mountains to the sea. The natural form and character of a river is not divorced from the life which flows from the water. Nor is the river at its source in the mountain and lakes seen in isolation from the river as it enters the sea. All dimensions of a river are seen as one life-force.

The blockage of the water at the Te Anau and Mararoa control structures is draining away the life-force of the Waiau River. At times the river bed below the Mararoa Weir has been completely dry as the gates have been closed with no water passing through. No longer is the Waiau River a complete, uninterrupted body of water doing the job it was initially intended to do. The manipulated decrease, stoppage, and fluctuation of the present water flows have upset the natural balance of the Waiau River that existed prior to the Manapouri Power Scheme. The effects of this imbalance are being felt throughout the whole river system, and beyond, into Te Waewae Bay.

This report identifies the concerns of the mana whenua regarding the Waiau River, and in particular notes that the preservation of the mauri and wairua requires the treatment of the cause of the problem as well as the symptoms.

Recommendation Outline

1. Active and ongoing participation of mana whenua and iwi in all resource management decision making processes.

2. A continuous flow of water throughout the entire length of the Waiau River at all times.

3. The water quality in the Waiau River should be capable of sustaining life at all times.

4. All issues of concern to the mana whenua in this report, and any further concerns, be taken into account and given effect by all other groups.

5. The results of the mahinga kai inventory be given to iwi for their future use and information.

6. Access to traditional mahinga kai sites and resources be available to mana whenua.

7. Specifically address and report upon the issue of Maori access to mahinga kai sites following completion of the legal hierarchy report.

8. The wetlands associated with the Waiau River be maintained and/or restored where possible.

9. Address the concerns of the mana whenua in relation to the changing coastal environment and the possible effects on kai moana that these changes may have.

10. Survival of native fish species be given priority over introduced species.

11. Provide for and ensure successful upstream and downstream migration of native fish species.

12. Investigation, involving iwi, into the effect of the Manapouri Power Station on the downstream migration of eels.

13. Commercial fishing banned in the Waiau River and adjoining lakes.

14. No resource management decisions in the Waiau River catchment should disturb any waahi taonga sites.

Relevant Working Party Reports

A4 - The Waiau River (Southland) Whitebait Fishery: A Consideration of the Impacts of the Mararoa Dam and Flow Diversion from the River

A5 - Minimum Flow Requirements for Instream Habitat in the Waiau River, Southland, from the Mararoa Weir to the Borland Burn

A7 - Native Fish Populations of the Waiau River (Southland) and the Impacts of the Lake Manapouri Control Structure (the Mararoa Weir)

A9 - The Waiau River (Southland) Inanga Spawning Survey 1994

A10 - Fish Passage Problems and Options for Fish Passage at Mararoa Weir

A11 - A Calendar of Fish Migrations Through New Zealand River Mouths

C1 - Geomorphic Processes and Coastal Change in the Lagoon System, Lower Waiau River, Southland

N2 - Legislation Hierarchy Report: Part A - Summary; Part B - Report

R1 - Report on Tourism and Recreation in the Waiau Catchment

N1 - The Role of Manapouri within the ECNZ Generation System
December 1993 : Author - Russell Howie, Robin Brasell, Stuart Powell

Issue

Understanding the integrated nature of the ECNZ generation network, the unique characteristics of the Manapouri Power Station and its importance in the national network, and links to issues such as future supply, energy efficiency and electricity pricing.

Executive Summary

The first section of this report includes a discussion of the characteristics of the ECNZ generation system, including a description of the daily, weekly and annual demand cycles which greatly influence how the generation network is operated. The variable nature of hydro inflows are described and the crucial role of New Zealand's limited hydro storage capability in meeting demand. Management of energy resources via the operating plan, merit order and dispatch of individual plant are also described. The implications of Manapouri's high position on the merit order are also explained.

The second section of the report outlines the important characteristics of the generation from Manapouri and its importance to electricity supply in New Zealand. Next follows brief sections on factors which affect the demand for electricity, in addition to the cyclic nature of demand.

The distinction between plant capacity or power (MW), and generation or energy (Gwh), is briefly described, as is the role of the Cook Strait cable (HVDC Link). While New Zealand may have some surplus capacity during times of normal hydrological inflows, there is no surplus of generation. This leads into a discussion of the emerging generation technologies that may contribute to meeting future demand for electricity.

The final section examines the sorts of trade-offs involved in a resource allocation decision like issuing consents for the Manapouri scheme. These range from changes in the local catchment versus higher cost electricity nationally or additional CO_2 and other atmospheric emissions. Local decisions have effects in other regions and nationally and essentially involve balancing different environmental effects.

Recommendation Outline

This report was descriptive in nature and did not contain any recommendations

Relevant Working Party Reports
N2 - Legislation Hierarchy Report: Part A - Summary; Part B - Report

N2 - Legislation Hierarchy Report; Part A - Summary; Part B - Report

August 1994 **:** Author - Hillary Talbot, Roy Summerville, Anne Callaghan

Issue

> *Understanding the inter-relationship between the various legislation which covers the water resource of the Waiau catchment.*

Executive Summary

Manapouri-Te Anau Development Act 1963 - Is a specific code which contains a provision stating it is to override other legislation. Also, there is a principle of statute law that a general statute (ie the Resource Management Act 1991) does not override a specific earlier statute unless there is a clear indication. This indication is given under the RMA in relation to water permits only. The Manapouri-Te Anau Development Act gives ECNZ the authority to carry out activities that are "necessary or requisite" to the operation of the power station.

Resource Management Act 1991 - ECNZ's water rights in respect of the operation of the power station are deemed to be coastal permits, water permits and discharge permits under the RMA. The RMA provides for these deemed permits to expire within 10 years of the date the RMA comes into force (ie 1 October 2001). Therefore a split regime occurs with the water permits being governed by the RMA while the land uses, uses of the beds of lakes and rivers, noise and contaminants to air are governed by the Manapouri-Te Anau Development Act.

National Parks Act 1980 - This Act provides that the provisions of the Manapouri-Te Anau Development Act are unaffected in Fiordland National Park. However for anything not covered by the Manapouri-Te Anau Development Act, RMA consents would be required by the Southland Regional Council and the Minister of Conservation would be involved in terms of the National Parks Act, because the National Parks Act and the RMA appear to be operating in tandem.

Operating Guidelines - The deemed water permits under the RMA include the operating guidelines as conditions. ECNZ is obliged to comply with these except in exceptional circumstances or emergency. By section 401, the Minister's power to promulgate operating guidelines is transferred to the Southland Regional Council. The ability of the Guardians to recommend guidelines, to report to the Minister of Conservation and the right of the Minister of Conservation to be consulted is unaffected, as is ECNZ's responsibility to report to the Minister of Conservation. Nor is the requirement to report details of departure from the guidelines affected.

Recommendation Outline

This report was descriptive in nature and did not contain any recommendations

Relevant Working Party Reports
I1 - Tikanga Maori Cultural, Spiritual and Historical Values of the Waiau River
N1 - The Role of Manapouri Within the ECNZ Generation System

R1 - Report on Tourism and Recreation in the Waiau Catchment

February 1992 : Author - Margaret Anderson

Issue

Knowledge of existing information on the recreational and tourism values/uses of the Waiau catchment.

Executive Summary

The tourism, recreation, scenic and historic values of the Waiau catchment from the mountains of the Divide to the sea are very high and need to be protected. The Waiau River has special significance for the original Maori inhabitants, the Waitaha and Kati Mamoe, and also the later arriving Kai Tahu peoples. The river is part of the identity of these people and their descendants and has a Mauri, or life force that sets it apart as deserving respect. This life force is threatened by any threat to the river, especially any loss of continuity of flow, as may occur at the Mararoa Weir, if some of the water that has flowed from the mountains to Lake Manapouri cannot continue into the Lower Waiau. The identity of the Maori people is part of their cultural and spiritual heritage guaranteed under the Treaty of Waitangi, as is access to and use of traditional food sources and other materials. There are issues here that will need to be considered further, by the appropriate kaumatua and runanga.

Some of the material presented here is based on anecdotal evidence, which is felt important as evidence of how the changes or events have affected people's lives, including feelings and emotions.

Recommendation Outline

The protection of the Waiau River should include looking at the damage that has already occurred and how it can be remedied. Any considerations of the river need to be for the whole river and not individual sections of it.

Relevant Working Party Reports
I1 - Tikanga Maori Cultural, Spiritual and Historical Values of the Waiau River

R2 - Waiau River Historical Review

R2 - Historical Review of the Waiau River and Coastal Area

March 1993 : Author - Delyn Day

Issue

Knowledge on the history of the Waiau catchment with an emphasis on post-European history.

Executive Summary

This review outlines the main historical developments of the Waiau catchment, with particular focus on the lower Waiau and coastal region. The historical pattern that emerges imitates the journey of the river, from the lakes to the sea. European association with the Waiau began as a stream of seafaring explorers and widened into a small lake of sealers and whalers. From this lake, a steady flow of goldminers, explorers, surveyors and runholders, expanded into a second lake of yeoman farmers, flaxmillers and sawmillers.
In this phase European communities grew and settlers built roads, railways, churches, schools, small and large industries. These divergent activities peaked, and them came together as four fast flowing streams of forestry, farming, fishing, and in Manapouri-Te Anau, tourism.

Generally, the history of the Waiau, especially down the river and coastal areas, has been one of loss and adjustment since the 1950s. The loss of indigenous forest to the present population, and the ups and downs of rural wealth have been compounded by the loss of the river Waiau.

Resources, their type and availability, have played an important part in dictating the occupation of the Waiau, for both Maori and Eruopean. The 1990s finds the remaining Waiau population sustained primarily by farming and forestry.

Recommendation Outline

This report was descriptive in nature and did not contain any recommendations

Relevant Working Party Reports
I1 - Tikanga Maori Cultural, Spiritual and Historical Values of the Waiau River

R1 - Report on Tourism and Recreation in the Waiau Catchment

R3 - The Waiau River Recreation Survey

December 1994 : Author - G W Kearsley

Issue

Impact of hydro-electric development on recreation in the Waiau catchment.

Executive Summary

The purpose of this report is to analyse present patterns of recreational use, and where possible, to examine the changes and perceptions on changes in recreation that have come about as a consequence of river control.

Overall, everyone, from all samples, who knew and used the Waiau River prior to control felt that it had been degraded as a recreational resource, and clear and detailed reasons were given as to how and why that was. A variety of remedial actions was suggested, not all of which were entirely practical, but some of which might well be. Nonetheless, the river continues to be a major recreational resource for local people, and, to an extent for the wider region. The Waiau catchment is the context for considerable activity, which revolves around tramping and water based recreation. Scenic values are clearly very important, and the river is a major component part of these.

Recommendation Outline

As tourist activity grows and the lower reaches of the Waiau have the potential to attract more visitors, the protection of water based recreational values, including the enhancement of fishing is important.

Relevant Working Party Reports

R1 - Report on Tourism and Recreation in the Waiau Catchment