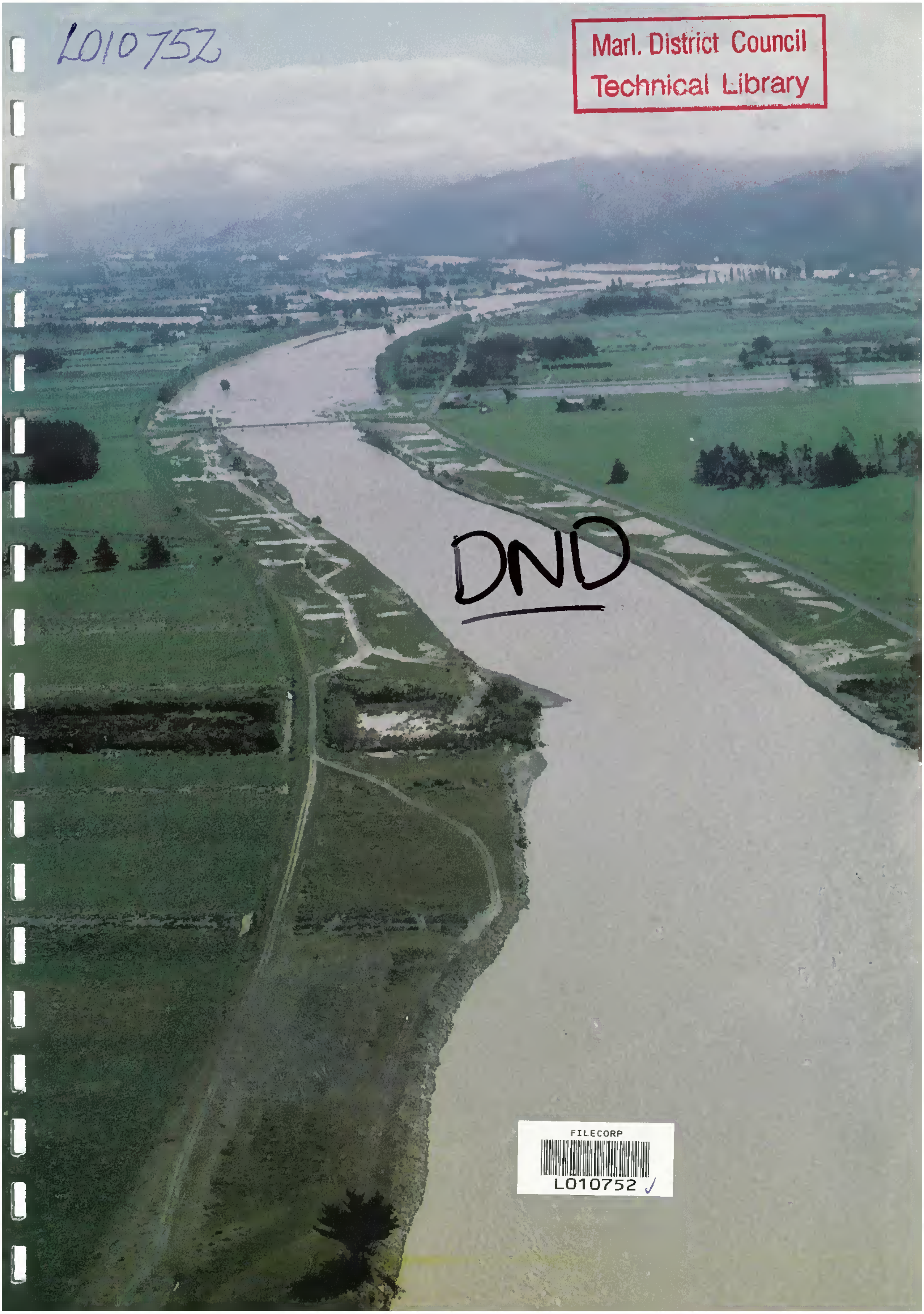


WAIRAU RIVER FLOODWAYS MANAGEMENT PLAN

Marlborough District Council

Operative Date - 25 August 1994

Resource Management Act 1991

Preface

For those living on New Zealand floodplains the control of the large and destructive floodplain rivers is a vital community concern, and no where more so than for the inhabitants of the Wairau floodplain where river works have been planned and promulgated for over 130 years.

This latest review and plan has to take account of the increasing complexity of todays issues, new legislation, the changing development pattern of the Wairau floodplain, and its ever changing rivers.

Unfortunately this plan does not have space to discuss and acknowledge the many successful works carried out by the former river authorities of the Marlborough River Board and Marlborough Catchment Board who looked after the river for nearly 70 years. Marlborough needs to be thankful for the dedicated work of those boards and especially the engineers, CC Davidson, P A Thomson, L N Pascoe and O R Marshall.

This plan has been prepared by the Marlborough District Council, building on, and expediting a review started by the Nelson Marlborough Regional Council (abolished in 1992), and using the considerable database collected by the Marlborough Catchment Board (abolished in 1989).

The plan was put together by a project team of Brin Williman, Robin Carr, Rod Witte and Fraser McRae. Other staff directly involved in preparing support documents were Bill Noell, Sally Neilson, Roger Fitzgerald and Ashley Ticehurst.

A community panel was established to provide informal advice in the plan preparation consisting of Michael Briggs (Chairman of Marlborough District Council Resources and Regulatory Committee), Pat Hammond (Renwick area), Jack Broughan (Tuamarina and Northbank area), David Rudd (Rapaura area), Alex McIntyre (Wairau above Waihopai Confluence area), Phillip MacDonald (lower Wairau area), Alan Scott (Upper Opawa area and grape growers), Liz Davidson (Blenheim and Conservation interests), Tom O'Connor (Spring Creek and Fish and Game Council interests), and Rex Frost (Fish and Game and Recreational interests).

Consultants for some of the required work included Horace Freestone, Grant Webby and Dave Maslin (Works Consultancy Services); Neil Climo (Neil A Climo Consulting Engineer); Charles Pearson and Alastair McKerchar (NIWA); John Trueman and Ian McNabb (Landcorp). Invaluable advice was also given by former Marlborough Catchment Board chief engineers Charles Davidson and Peter Thomson.

The hydrologic and hydraulic survey data collected over many years by Val Wadsworth, Stuart Rae and Frank Bonnington and other staff were essential for this review and plan. The reports and observations of Noel Pascoe (former Senior Rivers Engineer of MCB) were also invaluable.

In the plan preparation considerable interest, enthusiasm and advice was provided by Bob Penington (General Manager), Jim Dovey (Manager, Works and Services) and Dave Olliver (Manager, Resource and Regulatory).

Perspective from the Past

Monday, the 3rd February, will be a day long to be remembered by the inhabitants of the Wairau, as the date on which occurred the highest flood ever known here, submerging Blenheim - with a single exception of the ridge on which stands the Victoria Hotel, the Branch Bank of New Zealand, and the residences of James Sinclair, Esq. - from the Catholic Chapel, in Maxwell Road, to Mr Farmer's in Grove Road. We shall but attempt to describe the circumstances, and if our readers should consider the account too meagre, they must attribute it to the general confusion which has existed in our own premises, in common with others.

. . . At 10 minutes before 6 o'clock looking towards the new Presbyterian Church in course of erection, we saw it move off the brick piles, a distance of several yards, where it remained until about 8 p.m., when the still rising waters floated the structure, and it went *en masse* down the current . . .

. . . At this time cattle, sheep, and pigs came along swimming for dear life - whole stacks of fencing, timber, and firewood, furniture, boxes, &c., all drifting onwards to the great deep . . .

. . . Below Blenheim, the farms seem to have suffered most during Wednesday morning. Mr Macdonald and Mr Harding, it is reported, lost the whole of their stock. A gentleman from the country informed us that on Wednesday when he looked down from the heights the whole plain from above Blenheim to the sea seemed one vast sheet of water . . .

Marlborough Express - February 8, 1868

Cover Photograph: Wairau Diversion in Flood - 22 October 1983. View upstream from mouth

Photograph (Opposite) : Blenheim under flood, Post Office Building, July 1911.


H M CUSTOMS
POST & TELEGRAPH

CONTENTS

Executive Summary

NOTE: This executive summary is not a formal part of the Wairau River Floodways Management Plan, but a brief overview written for more general public reading.

NEED AND SCOPE OF PLAN

1. The Marlborough District Council needs a Wairau River Floodways Management Plan so as to sensibly plan expenditure on river control works, and so as to be able to legally carry out such works under the recently enacted Resource Management Act 1991. The recent cessation of government subsidies under which previous works were carried out is of considerable importance and required that a fundamental river review to be carried out in the preparation of this plan.

2. This Wairau River Floodways Management Plan principally concerns itself with activities that the Council plans to carry out in the riverbeds and floodways. Activities on the floodplain itself will be dealt with by other planning documents, currently in preparation, as will details on controls on what other people may do within riverbeds and floodways.

3. A Community Panel of 10 people representative of differing geographic areas and various interests was established to advise staff in the preparation of this plan.

BACKGROUND

4. A constant battle to control the rivers has been the history and is the legacy for the people of Blenheim and the Wairau floodplain. The Wairau river system has provided the valuable resource of its floodplain, but is also its potential destroyer. The flood control works for the Wairau have to cope with floods larger than any other New Zealand river similarly controlled. The need to maintain, monitor and upgrade river control works will be ongoing.

5. Works have been carried out to control the Wairau river since soon after European settlement nearly 150 years ago by various, and at times opposing, River Boards. The blocking of the Opawa distributary of the Wairau by Conders Groyne in 1914 was the most significant and most contentious work. Here, 3km upstream of the Renwick S H 6 bridge, up to half the Wairau floodwaters rushed down the Opawa river to, and into, Blenheim (or as it was known at one time 'Beavertown'). The construction of Conders groyne blocked this Opawa flow towards Blenheim, but resulted in frequent and larger floods down the main Wairau and Lower Wairau. This caused strong argument between Spring Creek and Blenheim residents.

6. In 1917 the government set up a commission of inquiry, the Wairau River Commission, to sort out this wrangle. The Commission endorsed the construction of the Conders groyne, but on the condition that the Wairau and Lower Wairau rivers be upgraded to carry the full flood flow of the Wairau. The Commission also made many other recommendations.

7. The Wairau River Commission requirement of upgrading the main Wairau as the price Blenheim residents had to pay to block off the Opawa distributary is just as relevant today as when promulgated in 1917. This has placed an ongoing requirement for the residents of Blenheim to maintain the Wairau across the floodplain to a high standard of protection. Nor is it feasible to turn the clock back and re-open the Opawa distributary.

8. A single river board, the Wairau River Board (1921) and its successor the Marlborough Catchment Board (1956) endeavoured to carry out the intentions of the 1917 Wairau River Commission. Despite the many works of these Boards, a satisfactory uniform flood protection standard has not been achieved for the Wairau, nor its southern Lower Opawa/Taylor tributary.

9. The Marlborough Catchment Board carried out works under the 1960 Wairau Valley Scheme. This included the Wairau Diversion and a comprehensive river training and stopbanking programme up to the Waihopai Confluence, to improve the Wairau. The Taylor detention dam has been the major work to improve the Lower Opawa/Taylor system. Many other less major works were carried out over the whole catchment.

WAIRAU : CURRENT SITUATION

10. The Wairau Valley scheme works have increased the waterway capacity of the Wairau from generally 3000m³/sec in 1960 to generally 4400m³/sec today. In some areas the standard is higher and in some isolated areas the standard is less. This has been a great improvement. Between 1921 and 1963 floods in excess of 3000m³/sec occurred on 7 occasions bringing damage and devastation to the surrounding land. Since the Wairau Diversion in 1963, only one flood in 1983 has broken out of the floodway system.

11. The recommended desirable waterway capacity of this report is 5500m³/sec, an increase of 25% on the current capacity. Such a flood has an assessed frequency of a 10% chance of occurring in the next 10 years (Such a frequency is also called a 1 in 100 year return flood). For practical purposes this is effectively the size of the July 1983 flood which has been reassessed as 5800m³/sec.

12. A flood with a 10% chance of occurrence in the next 10 years (1 in 100 year flood) is commonly used in New Zealand as a design flood standard. Furthermore, Conders groyne blocking the Opawa cannot be practically designed to a lesser standard. The

standard of protection at Conders groyne sets the standard for the whole floodplain. The current 4400m³/sec standard has a 30% chance of occurring in the next 10 years.

13. The need to increase Wairau waterway capacity by 25% and more in some places, is due in approximately equal parts to :

- previous under-estimation of flood size.
- previous over-estimation of waterway capacity of the Wairau and Lower Wairau floodways.
- gravel and silt deposition further reducing waterway capacity.

COST OF PROPOSED WORKS

14. The plan provides for capital works at an estimated cost of $13 million dollars to upgrade the river works to the recommended standard, and that this be achieved over a 10 year period. Over the same 10 year period there is also $15 million dollar expenditure required for maintenance and flood damage repair works.

WAIRAU : PROPOSED WORKS

15. The proposed works to achieve the increase in waterway capacity are :

- Improving the channel hydraulic efficiency of the Wairau and Lower Wairau floodways by removal of impeding trees, and removal of internal banking and also other berm shaping improvements. This would be done as far as practical commensurate with the need for bank scour protection works.
- Expediting natural enlargement of the Wairau Diversion by mechanical assistance.
- Raising, or in some places additional, stopbanking over some 20km.
- Significant increase in stopbank protection works in the Conders area by construction of four new rock headed groynes and other rock work.
- A programme of fairway edge willow tree planting as secondary protection, complementary to the expensive rock work.
- Encouraging and directing gravel extraction for the most effective enlargement of waterway capacity.

16. Wairau floodwater backing up Spring Creek is a particular problem that creates one of the weakest points of the whole system. The proposed action is stopbanking off the Spring Creek outlet to the Wairau and with a large floodgated culvert through this stopbank. Fish and Game Council and Department of Conservation would be consulted as to the design of such a works so as to maintain Spring Creek as a valuable fishery.

17. The Tuamarina State Highway 1 bridge appears to constrict very major floods which may lead to overtopping of the stopbanks upstream in floods exceeding 5200m³/sec.

The plan recommends a detailed study of this, before making any decisions on the remedial work required by plan.

WORKS OUTSIDE MAIN WAIRAU FLOODPLAIN

18. The 1960 Wairau Valley Scheme and its subsequent follow up schemes carried out works on all tributaries of the Wairau River. It was a "source to the sea" scheme that included soil conservation works in the hills to reduce erosion and the subsequent deposition of sediment in the floodplain. This work was carried out with considerable government funding.

19. The Wairau Valley Scheme included soil conservation works in the hills and river works on the tributaries in part to reduce sediment supply to the floodplain. While this may have occurred the benefit has not been measurable in the critical section of channel deposition in the main Wairau downstream of Jefferies Road. Without Government funding a more tight fisted approach needs to be taken with regard to fu ding soil conservation and tributary river works. Further works on these tributary rivers should be funded principally by immediately adjacent benefitting landowners at least in the meantime.

20. The Wairau above Waihopai Confluence is the main "tributary" to the main Wairau floodplain. In the 33 years of the Wairau Valley Scheme expenditure has averaged $350,000 per year in todays terms. The total expenditure of $12 million dollars is more than four times the value of the land protected, and approximately 30 times the river works rating income from the benefitting landowners.

21. This situation is untenable. Unfortunately in this powerful river environment it is not possible to devise a lower standard, cheaper river scheme. The reduced expenditure over the last two years with cessation of government subsidy has already resulted in destruction of banks and damage to farmland.

22. This plan proposes to limit the Council programme of works for the Wairau above Waihopai Confluence to clearing willow trees from the main fairway, and further Council involvement would be to provide up to 50% of the cost of river works desired by concerned landowners.

23. Feasible programmes of work can be devised for the many other much smaller tributaries to the main Wairau floodplain, e.g. such as the Onamalutu, Tuamarina, Omaka (upstream of Hawkesbury Road bridge), Wye, Top Valley etc. The cost and benefit of carrying these works will to a large extent be met by the rates of the benefitting landowners. Advice of affected residents would be sought in drawing up annual programmes of work. The annual cost of works on these tributaries is based on present rating levels and a further Council support of up of 50%, would be approx. $100,000.

TRIBUTARIES ON THE WAIRAU FLOODPLAIN

24. The Lower Opawa/Taylor river system is also significantly under standard, despite the construction of the very effective Taylor detention dam. The river system through Blenheim is capable of passing a flood of up to 130m³/sec, the size of the 1980 flood. This size of flood has an assessed 40% chance of occurring in the next 10 years, and is an unacceptable risk for the people of Blenheim. The Lower Opawa stopbanks are also overtopped by such a flood.

25. The recommended design flood is a 170m³/sec. Such a flood has an assessed 10% chance of occurring in the next 10 years (1 in 100 year return period flood).

26. This plan proposes that the hydraulic efficiency of the Lower Opawa floodway be considerably improved by a programme of berm shaping works and removal of thick channel impeding willow and other trees. This work will lower flood levels of the Taylor through Blenheim to a safe level. Material from the berm shaping works of the Lower Opawa would be used to upgrade the under strength and in some places low, Lower Opawa stopbanks.

27. Work is also required to improve the structural integrity of Taylor river stopbanks through Blenheim.

28. The Upper Opawa, Omaka, Riverlands and Wither Stream are also floodplain rivers where the floodways are not uniformly quite to design standard. This plan includes a programme of work to continue to upgrade these to the desired standard. The extent of the work is much less than for the Wairau or Lower Opawa/Taylor.

29. The relatively extensive berm shaping works of the Wairau and Lower Opawa, and the tight degree of vegetation control required on these floodway berms, will generally preclude normal farming use. Council will need to purchase the floodway land that it does not already own or manage. Land purchase is also desirable in parts of the Upper Opawa floodway.

30. The Pukaka, Doctors Creek, Gibsons Creek, Opawa Loop and School Creek (Renwick) are significant floodplain rivers where the Council carries out work. These rivers have broader floodplain issues from a flood hazard or urban stormwater or groundwater recharge issues. Further proposals on these rivers are not covered in this plan but will be dealt with in the Wairau/Awatere Resource Management Plan to be released later.

RECREATIONAL USE OF COUNCIL FLOODWAY LAND

31. Council ownership of floodway land is primarily for flood control reasons. The plan recognises recreational use of Council owned floodway land is a desirable secondary use.

32. This plan makes provision for Council to develop (Council) managements plan for recreational use of Wairau floodways berm land, and in particular to parts of the Lower Opawa, Taylor, Wairau, Wairau Divsion and Spring Creek outlet.

33. Access will also be provided to other Council owned floodway land. Access will be limited to foot access in areas of potential fire danger or conflict with commercial use of the land.

ENVIRONMENTAL CONCERNS AND MONITORING

34. To a large degree the proposed works on the floodways are not a change in direction of flood control of the Wairau river system, and so the plan does not have to address new environmental concerns.

35. The plan recognises that the Wairau is regionally important for brown trout. Evidence to date shows that river control works if anything improve the habitat for these fish.

36. The Wairau (Vernon) lagoons are recognised by the Department of Conservation as of national ecosystem value, and these lagoons are affected by the hydraulics of the Lower Wairau river mouth. The plan proposes to maintain a direct Lower Wairau river mouth opening. The environmental studies to date show the affects of this to be of benefit to the ecology, tidal flushing, water levels, consistent salinity, navigation and general environmental benefit of the Wairau Lagoons and the Lower Wairau estuary area.

37. The plan recognises that the Lower Wairau and its tributaries, especially Rose's Overflow, are valued for whitebait. The plan provides for the replacement of top hung floodgates on strategic culverts with side hung floodgates or fibreglass gates that are less impeding to whitebait passage.

38. A major potential environmental effect is the impact of the Wairau Diversion in reducing flows in the Lower Wairau river. This effects not only the Lower Wairau, but also the Lower Wairau mouth, estuary, Lower Opawa, Spring Creek and Vernon Lagoons. There may be an effect on a wide range of environmental issues including sedimentation, ecological effects, recreational use, water quality, salinity, water level changes. This is a particular concern for the Maori who have strong cultural ties to

the area. Whether this will become a serious problem is not yet clear, and a continuing programme of monitoring is required and consultation with iwi.

39. The plan provides for the development of an Environmental Handbook that will set out rules by which river control activities should be carried out so as to minimise conflict with environmental values.

40. Regular measuring and monitoring of flood events is required to assess the performance effectiveness of the river control works.

41. Monitoring to date has shown that the important groundwater recharge from the Wairau River has been unaffected by recent river control works. This important item also requires regular monitoring. The abstraction of Waihopai water to recharge the aquifer and for other riparian values of Gibsons Creek and the Upper Opawa should continue in recognition of the effect of river control works earlier this century on the area.

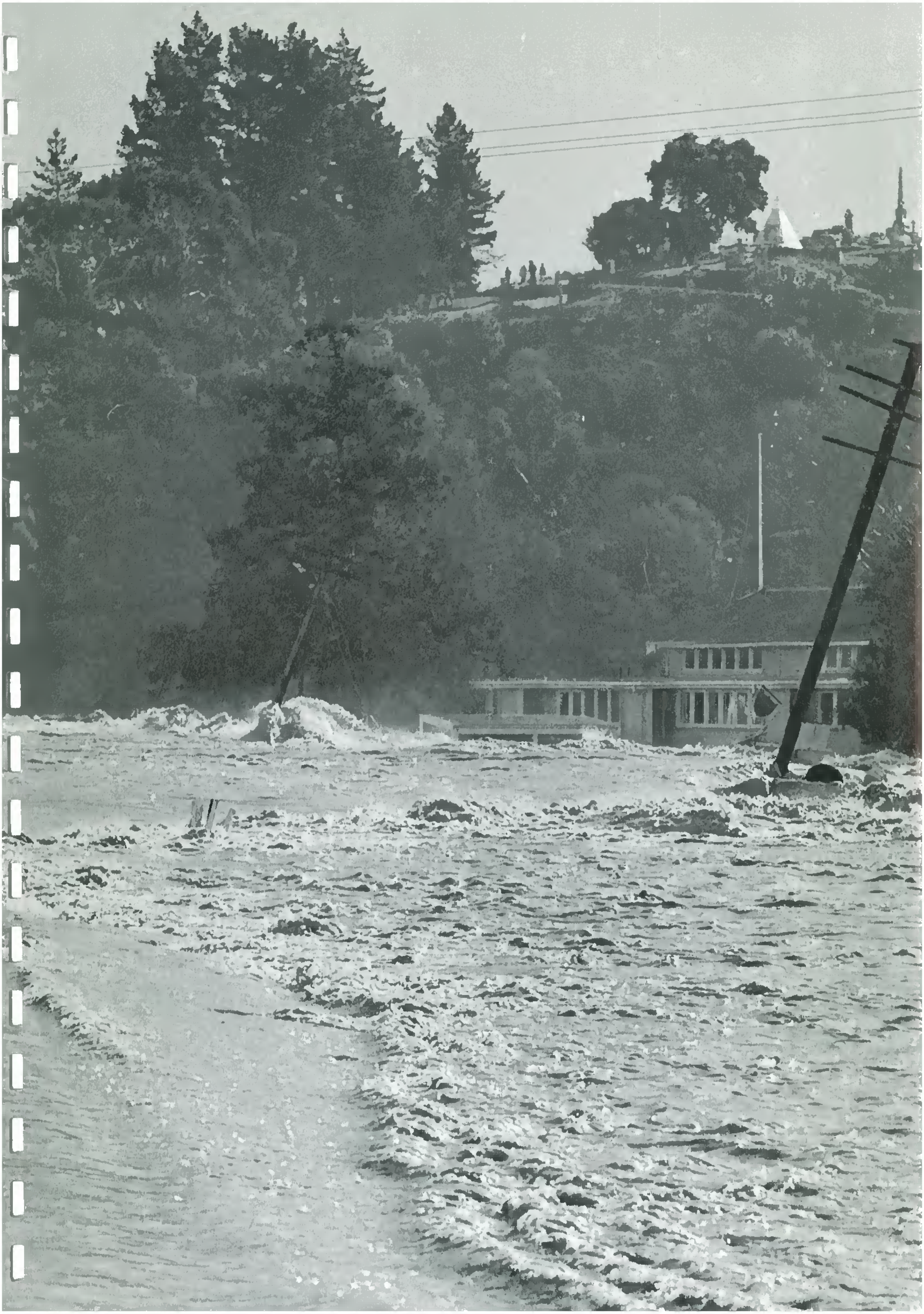
42. Problems that are evident now and potentially serious in the future are :

- Gravel and silt deposition in the Lower Wairau, Wairau downstream of Giffords Road, and in the Wairau Diversion may reduce flood capacity. **Potential solution - deliberate extensive gravel and silt extraction ?**
- The flow division into the Wairau Diversion and Lower Wairau is governed by natural deposition and erosion in the two channels, especially deposition in the Lower Wairau. (Flows of all sizes are shared between the two channels). The reduced low flows in the Lower Wairau may have effects that are undesirable from an ecological, Maori cultural, aesthetic or recreational viewpoint. This situation may worsen in future if left to the natural deposition pattern, **Potential solution - a control structure on the Wairau Diversion ?**

Possible solutions to the above potential problems are complex and expensive, and need regular river cross sectional survey and other monitoring and analysis before future decisions are to be made.

43. While the plan is for a 10 year time period, this regular monitoring and reassessment of the effect and effectiveness of the planned river activities may lead to revision of the implementation procedures.

Photograph : Escaping Floodwaters at Tuamarina - 10 July 1983



Section A : Scope and Outline of Plan

A1 Reasons for the Plan

The plan has been prepared because :

1.1 River control operations are an important and expensive part of Council's overall operations. The Council needs and the community expects, a comprehensive strategic plan outlining the need for future river control activity and setting out a programme of carrying out the works, and ensuring the activities are environmentally friendly.

1.2 The last comprehensive strategic plan for river control works and activities was the 1960 Wairau Valley Scheme report. It is timely to review the effectiveness of the works carried out under that scheme (and its follow-up schemes) in the light of what works in various places have achieved, of the changing economics of doing different works in different places and their effect on the environment. The last Wairau follow-up scheme funding finished in 1991.

It must be noted that the generous Government subsidies under which the 1960 Wairau Valley Scheme (and its follow-up scheme) were carried out are no longer available. This presents quite different criteria for planning river control works than in the past and emphasises the need to review river works activities.

1.3 Under Section 13 of the Resource Management Act 1991 such river control activities can only be carried out in river beds as :

(i) Expressly allowed to do so by a rule in a regional plan; or

(ii) A resource consent granted by a Regional Council.

1.4 The Council, in assessing community expectations, has concluded that a plan prepared under the Resource Management Act is the most appropriate and effective way of exercising its responsibilities in this area. The degree of community wide interest and submissions in the plan preparation process has confirmed the Council's assessment.

1.5 This is such a regional plan through which the Manager of Works and Services can legally maintain, upgrade or build new river control works, and carry out other activities in the Wairau River Floodplain floodways and their tributaries..

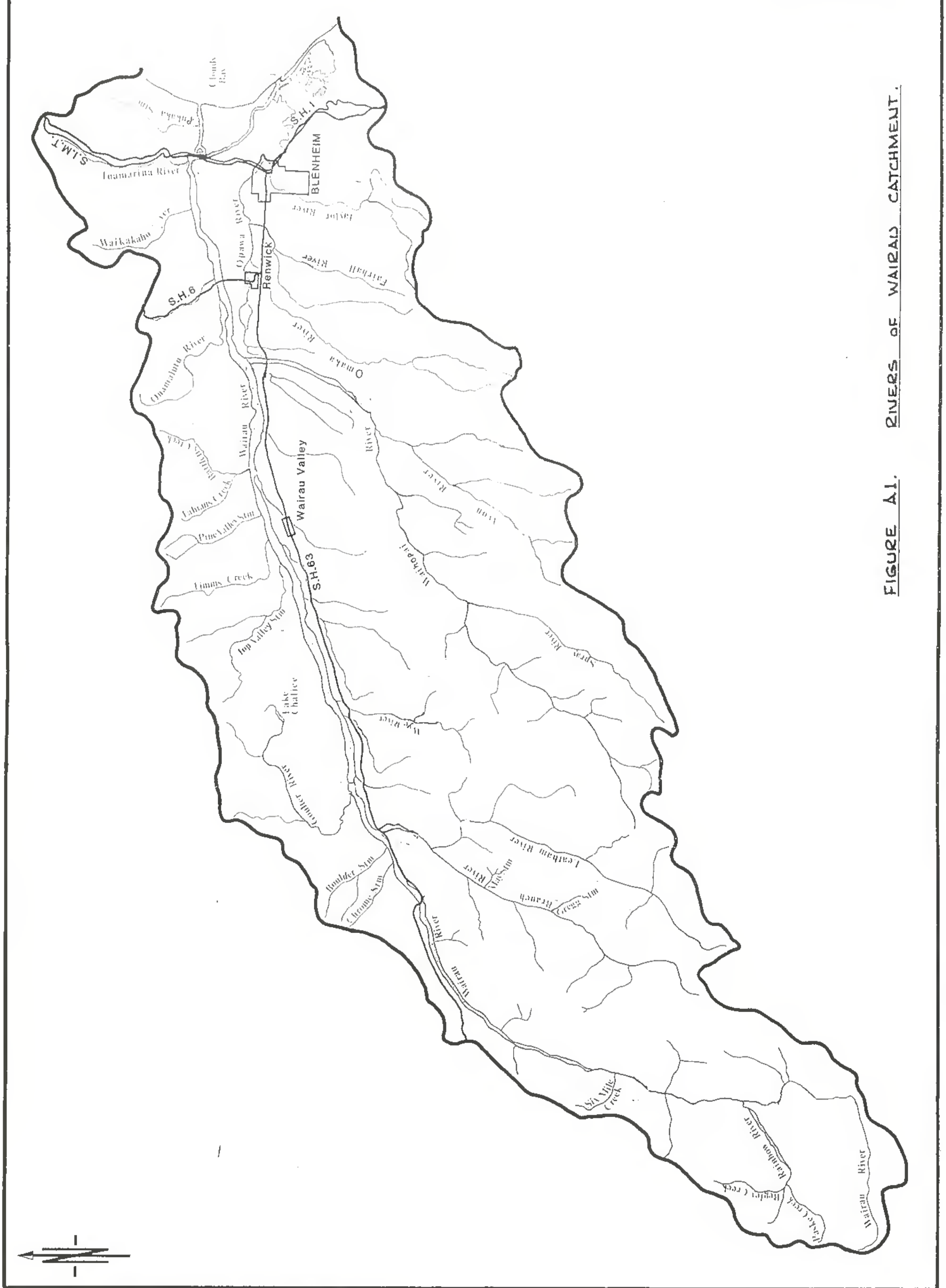


Figure A1 - Wairau Catchment

A2 Scope of Plan

2.1 The Marlborough District Council has responsibility under the Resource Management Act 1991 (Section 65) to prepare a regional plan dealing with the mitigation of the natural flooding and erosion hazard caused by the Wairau River and its tributaries, this being one of its functions under Section 30 of the Act. This plan sets out the Council's objectives and policies, methods and rules and the reasons for them with respect to the Wairau river (and tributaries) floodways. The plan also includes the historical background to the issues involved and some other matters of Council policy concerning the Wairau river floodway system, not strictly required under the Act.

2.2 While the plan deals with all rivers of the Wairau catchment (refer Figure A1), it outlines in detail proposed policies and methods within the river floodways on main Wairau floodplain, viz the Lower Wairau, Wairau Diversion, Wairau, Waihopai, Lower Opawa, Taylor, Upper Opawa, Rose's Overflow, Spring Creek, Omaka, Fairhall, Riverlands and Wither Hills Streams. (Ref Figure A2).

2.3 Because of the importance to the Marlborough District Council of the hazard of the Wairau river and the cost of mitigating against this hazard by floodway works this plan is being produced with urgency by the Council ahead of the Wairau/Awatere Resource Management Plan, which will include water allocation, instream habitat and other broader river management issues. This Wairau River floodways plan will however, be incorporated into the Wairau/Awatere Resource Management Plan which is expected to be notified in 1995. Any potential conflict between managing the Wairau river floodways for flood hazard purposes as opposed to water allocation, instream habitat or other environmental reasons, will be readdressed in the preparation of the Wairau/Awatere Resource Management Plan.

2.4 Further flood hazard mitigation aspects not covered in this plan, but to be included in the Wairau/Awatere Plan are :

- flood overflow paths on the floodplain itself, and flood hazard planning thereof;
- the Pukaka or Doctors Creek that have significant ponding areas on the floodplain itself;
- Gibsons Creek that has a substantial diversion for groundwater recharge and other environmental purposes;
- the Opawa Loop, Fultons Creek, Murphy's Creek, or School Creek (Renwick) which are inter-related with urban stormwater development;
- the predominantly minor drainage watercourses of the lower plains.

2.5 This plan, that focuses on Councils responsibilities for flood control, does <u>not</u> preclude other possible future Council proposals or plans for other river environment works or activities for other purposes.

Figure A2 -

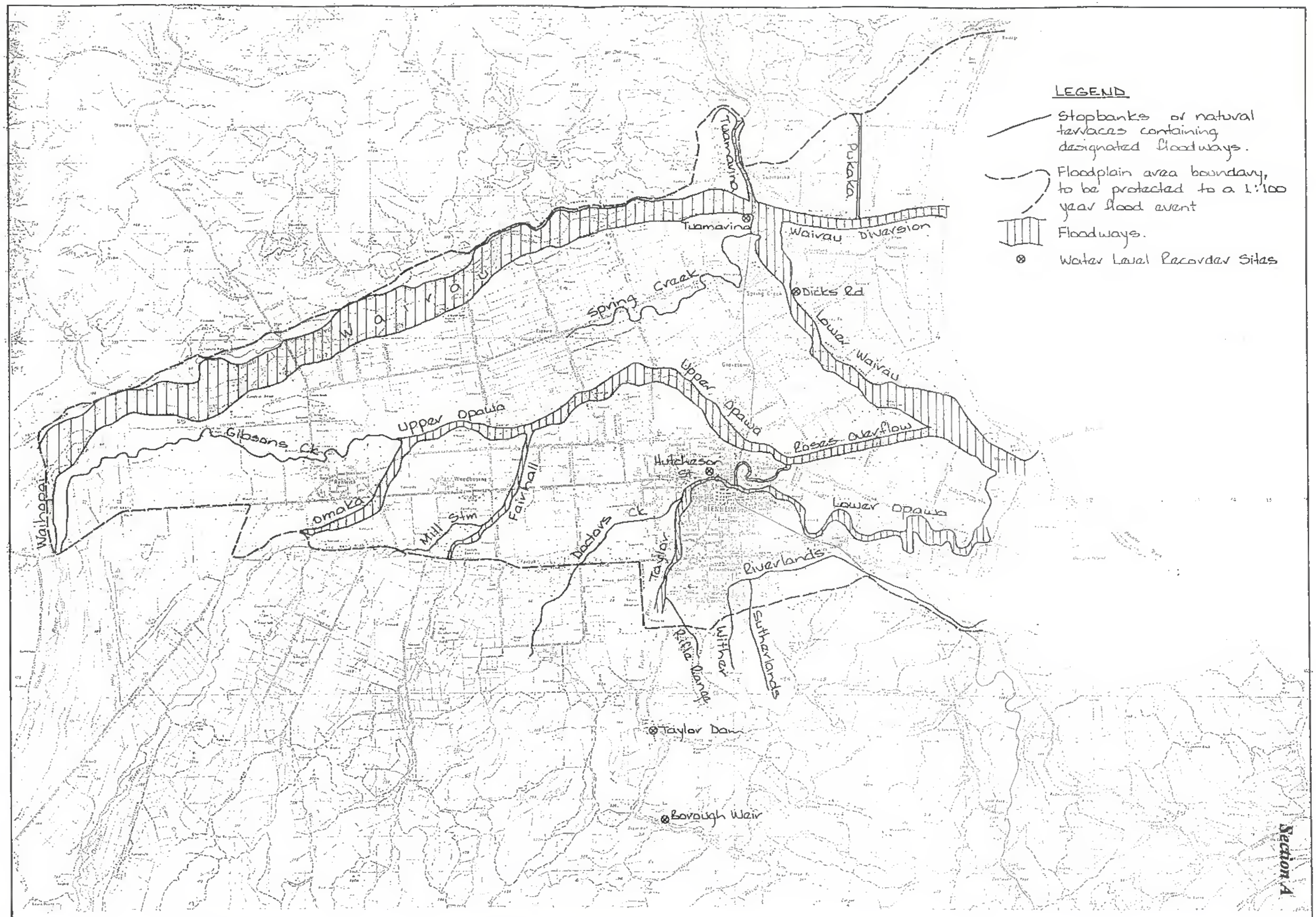


FIGURE A2 WAIRAU FLOODPLAIN RIVERS.

1: 100,000.

2.6 Activities described in this plan are provided for as permitted activities for Council. Activities not detailed in the plan are discretionary activities. Council has retained discretion over all matters for activities included in this plan as discretionary activities.

2.7 The plan concentrates on proposed future activities. Unfortunately there is not space to discuss and acknowledge the many valuable river floodway works carried out for over 100 years to enable Blenheim and the rest of the floodplain to develop as it has.

2.8 The plan identifies significant further river floodway works. The need for further capital works is due to the dynamic changing nature of the river system, different protection standards desired by the community and more knowledge of the rivers behaviour; all these factors having changed since works enacted under the 1960 Wairau Valley Scheme.

2.9 The plan has been prepared for a planning period of ten years. However, the Wairau river system is dynamic, and constantly changing. This plan provides for the constant ongoing monitoring of the rivers and of the effectiveness of the river floodway control works and their effect on the environment. The plan itself and its expected results will also be closely monitored. As a consequence of such monitoring it is likely that parts of the plan will require amendment and review from time to time.

2.10 The plan has been prepared under the Resource Management Act 1991, which requires much broader considerations of the effects on the environment natural ecosystems and Maori cultural values than previous legislation.

2.11 The plan has been prepared by the Marlborough District Council as a high priority task following taking over regional council responsibilities of the former Nelson Marlborough Regional Council.

2.12 A community panel was set up of 10 people representative of different geographic areas and also different spheres of interest. This panel provided informal public consultation and advice in the preparation of this plan. The panel met on 5 occasions during the one year project period and debated four specifically prepared discussion papers. The recommendations of the panel were noted.

A3 Format of Plan

3.1 In terms of the Resource Management Act 1991 this plan is a "Regional Plan" prepared under Section 65 of the Act. In certain matters, notably control of activities on the water surface, the plan is also a "District Plan". As a unitary authority the Marlborough District Council makes no clear distinction in terms of plan preparation or administration between "regional" and "district" responsibilities. The format of this plan is that required by Section 67 and 68 of the Resource Management Act.

3.2 Section A of this plan is a Scope and Outline of the Plan. This part describes and defines the scope of the plan; reasons for it, the geographic area dealt with.

3.3 Section B summarises a condensed history of river control issues and activities over the years to control the Wairau River and its tributaries. Only by understanding the historical river control issues and the effect of river controls works on the river floodway system is it possible to clarify issues and the Council's responsibility to plan future river control activities.

3.4 Section B also addresses whether river control activities in the upper catchment should continue to be considered as integral to the planning of river control activities in the floodplain floodways.

3.5 Section C describes Issues, Options, Objectives and Rules for river control activities in the floodways on the main Wairau Floodplain.

3.6 Section D describes the policies, methods and reasons for methods for the ten identified individual floodplain floodways.

3.7 Section E discusses river control activities for the Wairau tributaries outside the floodplain.

3.8 Section F discusses river control activities for the Wairau above Waihopai Confluence.

3.9 Section G deals with environmental matters that arise out of river control activities and the need to set environmental policies to minimise the impact on the environment of river control activities.

3.10 Section G concludes with a statement of the environmental outcomes anticipated from the implementation of this plan, and monitoring required of expected outcomes.

3.11 Although the plan is an integrated comprehensive document the format, style and cross-referencing is such that the plan can be accessed by :

- objectives and policies
- general issue
- planned actions and controls
- specific section of river where each issue is of importance
- specific property or geographic location (by the accompanying maps).

3.12 A set of aerial photographic maps depicts the stopbanked floodways of the floodplain and proposed river control works and activities.

3.13 Appendix I is a detailed report on the flood sizes and their frequency of the Wairau, Taylor and other floodplain rivers. The flood size is a fundamental parameter on which to base river control works, and a major review of flood frequency was carried out as part of this plan.

3.14 Appendix II is a brief overview of the various hydraulic calculations that have been carried out on the capability of the river floodway systems to pass the recommended design flood flows.

3.15 Appendix III is a copy of the discussion papers presented to, and the resolutions of, the Community Panel that was set up to advise the Council (as outlined in A2.8).

Photograph : Breach in lower Wairau stopbanks near Dicks Road - 2 December 1939

Section B : Background of River Control Issues

Note: This is not a formal part of the plan, but included here because of its importance in discussing the limitation of options available to the Council for flood management. Parts B1 to B5 of this section outline how most of the major issues concerning management of the Wairau River systems go back to the earliest days of settlement and the manner in which the issues have been dealt with by legal and other processes is fundamental to todays situation. Section B6 discusses the relative need and benefit of flood hazard mitigation works to different standards in the various parts of the Wairau catchment. These aspects have relevance under Section 32 of the Act.

B1 The Wairau River and Floodplain System

A constant battle for the control of the Wairau River System has been the history and is the legacy for the people of Blenheim and the Wairau Floodplain.

The Wairau river and its interlinked tributaries have laid down the fertile soils of the Wairau floodplain, provided a separate groundwater resource for agricultural and other uses, but also pose a major and destructive threat in times of flood.

The Wairau River systems delicate interrelationship being the provider of the resource and potential destroyer of the resource is as great as anywhere in New Zealand.

Two other major floodplain systems have strong similarities. The coming together and complex interlinking of rivers on the Hertaunga floodplain in Hawkes Bay, which also provide the groundwater resources, has similarities with the Wairau floodplain. But neither the Ngaruroro, nor the Tuki Tuki nor the Tutaekuri are the size of the Wairau river.

The large Waimakariri river on the outskirts of Christchurch has strong similarities with the Wairau river, but there is not such a complex interlocked river system. Even the Waimakariri flood flows are only three quarters of the size of the Wairau.

The Wairau river has recorded some of the largest floods in any river anywhere in New Zealand. Combined with its steep river slope this makes the Wairau River the most powerful (in flood time) of any river in New Zealand on which a comprehensive river control scheme has been carried out.

The most valuable land is the main floodplain downstream of the confluence with the Waihopai River (Figure B1). This triangular shaped block of land covering the last 33km of the Wairau river covers an area of 20 000 hectares and includes Blenheim, the largest town of the region.

This floodplain was of course built up from sediment carried down by the Wairau and its tributary rivers in flood time. As river channels were filled by deposited sediment the rivers moved across the floodplain building it up. Pakeha settlement has sought to control the rivers to fixed courses across the floodplain so as to utilise the rest of this valuable land.

The main floodwaters that from time to time have inundated this Wairau Floodplain are from the Wairau and its tributaries to the west (Figure A1). Storms sweeping down across Tasman Bay from the North North West (NNW) cause the largest floods. From this direction the 1500m high Richmond Range is the first hill barrier that the water laden winds meet. These hills trigger the rainfall leading to heavy falls in the Goulter, Onamalutu and other Northbank tributaries from the Richmond Range.

This storm path is also directly across the width of the rectangular Wairau catchment. Larger storms carry rainfall across the full width of the Wairau Catchment bringing heavy falls to the large catchments of the Branch, Leatham and Waihopai tributaries on the south bank. The largest NNW storms bring heavy rains to all but the SE corner of the Wairau catchment.

The Wairau is in fact moderately sheltered from the classic Northwesterly (NW) storm of Canterbury fame. The Tasman and Mt Arthur mountain ranges to the west particularly shelter the catchment. The NW storms then have to track the length of the Wairau Valley, and heavy rainfall is confined to the upper quarter of the catchment.

The Opawa River system is a major tributary system that meanders through Blenheim and across the southern part of the floodplain before joining the Wairau near its mouth at the Vernon Lagoons. It includes the Taylor, Fairhall, Doctors Creek and Omaka tributaries which rise in the hills of the south east corner of the Wairau catchment. The catchment is affected most by ESE storms that evade the shadowing effect of the North Island to the north or the high Kaikoura mountain ranges further south. Floods in the Opawa system can total up to a sixth of the main Wairau, which is quite substantial enough to cause widespread disruption if uncontrolled.

The Pukaka and Tuamarina rivers are small tributaries to the north of the Wairau floodplain and can receive heavy rainfall from both NNW and ESE storms. The path of the Tuamarina into the Wairau barely crosses the floodplain but the Pukaka affects large areas of the floodplain to the east of Tuamarina.

The most feared weather pattern is a major NNW storm immediately followed by a major ESE storm (or vice versa) which could bring all the Wairau floodplain rivers in flood simultaneously. Fortunately this storm pattern is rare, but the two occasions when this occurred in February 1868 and May 1923 were dramatic events in Blenheims history.

Marine forces have had a major influence in the formation of the Wairau Floodplain. Much of the apparent "floodplain" land for the 5km east of Blenheim is coastal beach ridges formed over the last 6500 years. The material, swept along the coast from the south, has formed ridges up to 4 metres above current sea level with boulders up to 200mm in diameter. These beach ridge presented a barrier to the Wairau river and were very influential in creating the large area of swamp land present prior to settlement.

The Wairau cuts through these beach ridges at the south eastern corner of the floodplain, somewhat ironically as for most of its course it is on the northern edge. Tectonic forces, created the fault line down of the Wairau Valley, and were influential in the location of the river channel.

River control works to control the Wairau floodplain rivers have a long history. There is evidence of artificial channels in the Vernon Lagoons presumably constructed by the Maori prior to Pakeha settlement. Much more intensive river control works were initiated by the European settlers starting only a few years after the establishment of Blenheim in the 1850's.

Blenheim in those days was called "The Beaver" or "Beavertown" reputedly because the surveyors had to huddle like beavers above the floodwaters as they laid out the township located at the confluence of the Taylor, Fairhall, Omaka and (Upper) Opawa rivers. The Opawa in those days was a distributary of the Wairau that typically carried a third of Wairau flood flows.

River control works on these Wairau floodplain rivers has therefore been a fundamental part of settlement and development of the region since the earliest days. The remaining sections of this Part B are a brief and of necessity, slight simplified summary of historical river control events directly relevant to future river control planning. A much more comprehensive document of the stormy and conducted events is currently being prepared by P A Thomson. This report addresses the continuing river control works that are required.

River control works have also been carried out in the tributaries of the Wairau Floodplain within their more minor and less valuable tributary floodplains. (This includes the main Wairau upstream of the Waihopai confluence). These works have generally only been since 1960. This report also addresses the desirable works on these tributaries.

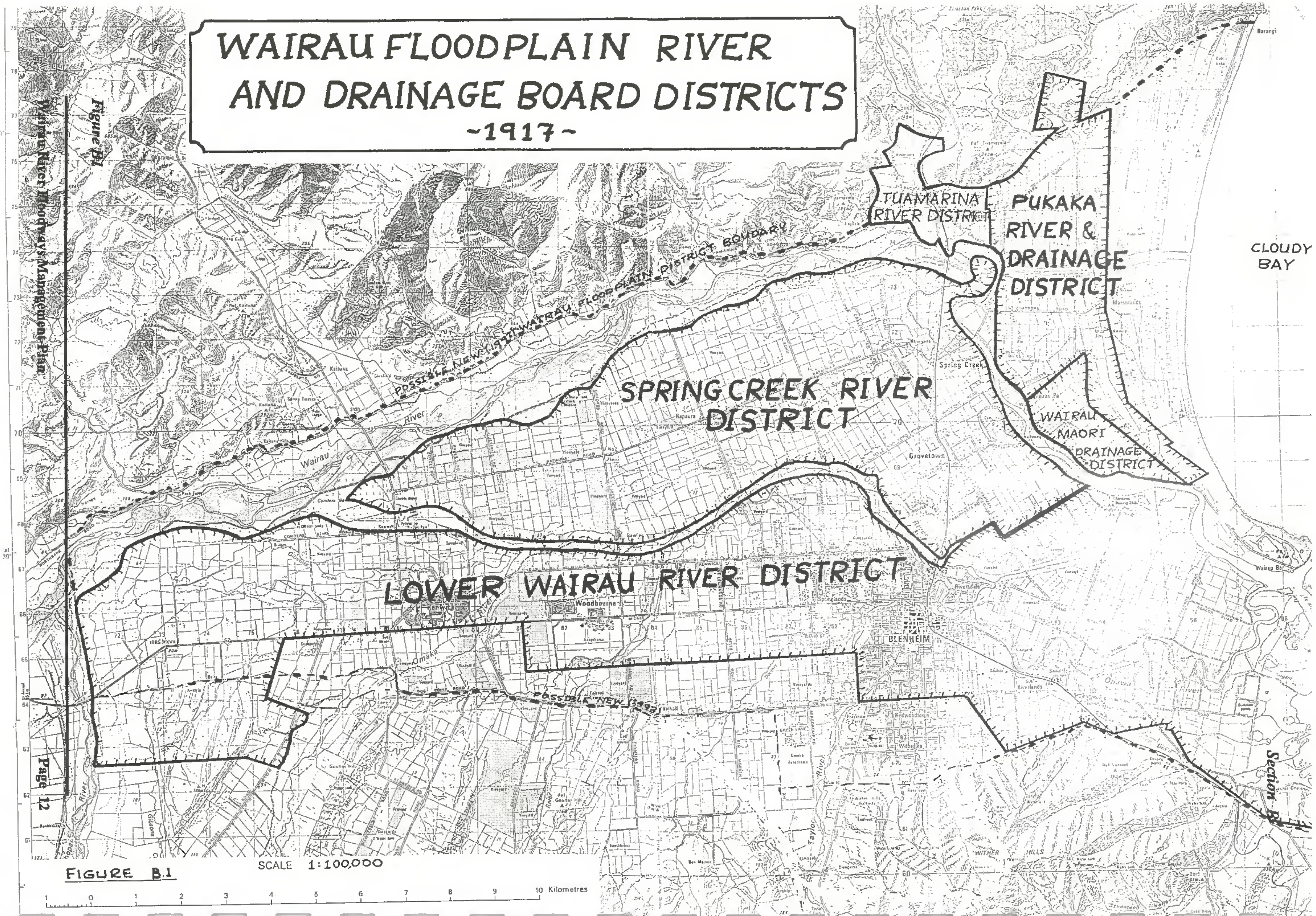

WAIRAU FLOODPLAIN RIVER
AND DRAINAGE BOARD DISTRICTS
~1917~
TUAMARINA RIVER DISTRICT
PUKAKA RIVER & DRAINAGE DISTRICT
CLOUDY BAY
SPRING CREEK RIVER DISTRICT
WAIRAU MAORI DRAINAGE DISTRICT
LOWER WAIRAU RIVER DISTRICT
POSSIBLE NEW (1991) WAIRAU FLOODPLAIN DISTRICT BOUNDARY
POSSIBLE NEW (1991)
BLENHEIM
Spring Creek
Grovetown
Woodbourne
Renwick
WITHER HILLS
Section B
SCALE 1:100,000
1 0 1 2 3 4 5 6 7 8 9 10 Kilometres

FIGURE B.1

B2 River Works Pre 1917.

River works started on the Wairau floodplain almost immediately following European settlement in the 1850's. Flood flows came down the Opawa , a distributary channel of the Wairau and emanating from it some 2km upstream of todays State Highway 6 bridge to Nelson. The Wairau River Commission Report (1917) records at this time most of the flood flows were on a broad front over the wide alluvial flats and such "Opawa" floodwaters could stretch from Blenheim to Grovetown. The Upper Opawa channel itself was quite small at that time. The removal of manuka and flaxes would have helped encourage the enlargement and development of the channel through the 1850's and 1860's.

The first attempt at blocking the entrance to the Opawa distributary channel - called at that time the "Opawa Breach" - was made in 1861 (P A Thomson personal communication). A timber based groyne funded by the Provincial Council was built across the Opawa breach but was swept away by the river. Further works were also unsuccessful with large floods occurring in 1853 and in particular in February 1868. The cost of these works was a massive drain on the Provincial Council's resources (Rae, Thomson et al 1987).

With the demise of the Provincial Council, river boards were set up starting in 1874, to look after the interests of "their" districts. Several river board districts were set up being reflective of perceived communities of interest. Boundaries of the five river boards as at the time of the 1917 Wairau River Commission are shown on Figure B1.

While the various river boards recognised they had a common aim in controlling the rivers, some of their specific objectives were in conflict with each other. Stormy opposition arose between the Lower Wairau River Board whose district included Blenheim; and the Spring Creek River Board, that covered much of the northern part of the floodplain. The Lower Wairau River Board wished to block off the Opawa breach to prevent water heading to Blenheim and the southern part of the floodplain. The Spring Creek Board opposed this action as it would have result in bigger and more frequent floods in their district.

The Spring Creek Board sought a court injunction in 1879 to prevent the Lower Wairau Board blocking the Opawa breach.

This court injunction deterred the Lower Wairau River Board from works to block the Opawa Breach - at least for the next 35 years. The difficulty and cost of such a work may also have been a deterrent.

The Lower Wairau River Board did carry out groynes and stopbanking works in the Conders Bend area immediately upstream of the "Opawa Breach". These works contained Wairau bank overflows in this area and also stopped the "Opawa Breach" from enlarging. These river works apparently did not disobey the court injunction regarding closing the Opawa breach, but they did reduce Wairau flows into the Opawa. Reputedly the works were carried out with shotguns at hand.

Figure B2

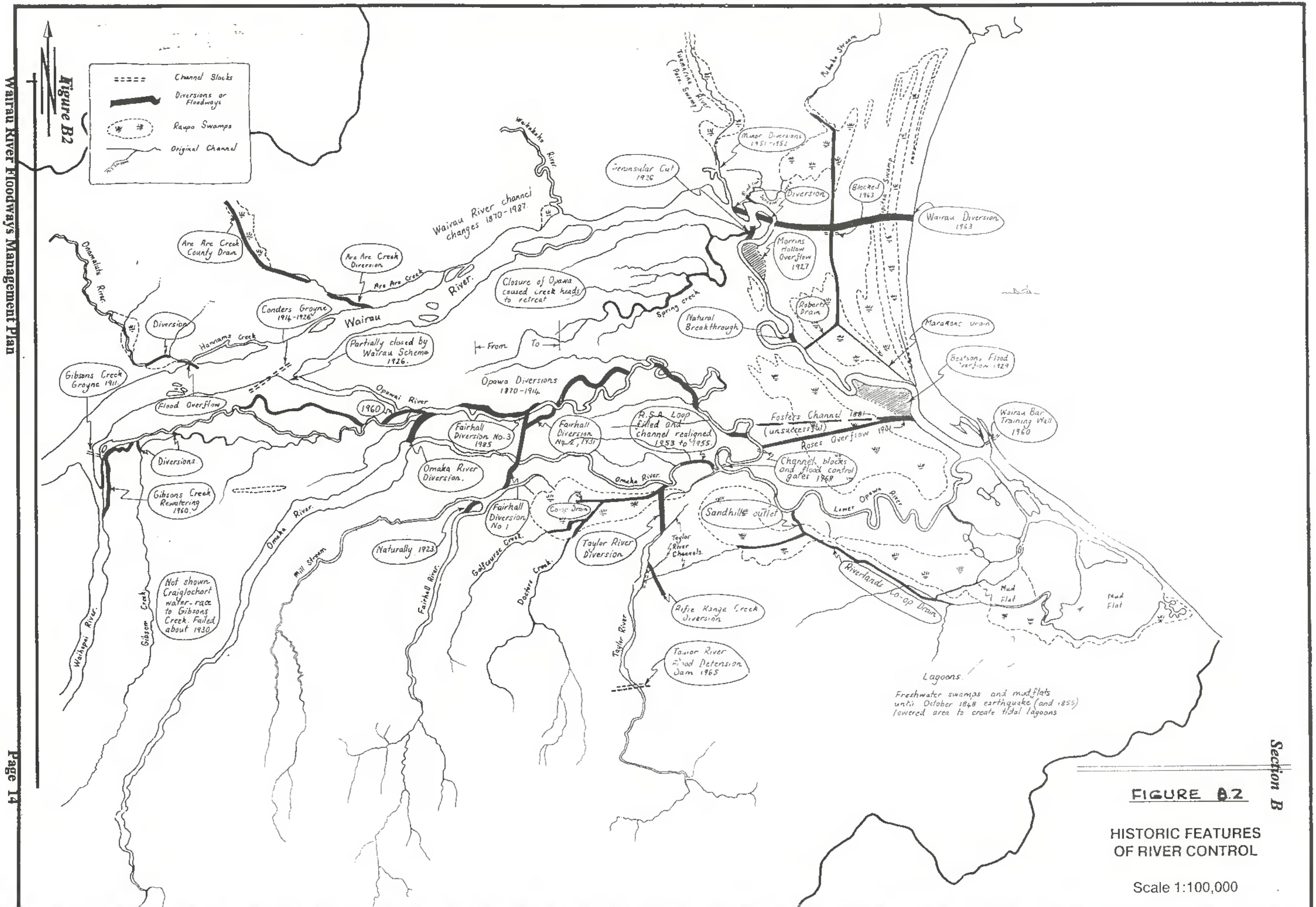


FIGURE B.2

HISTORIC FEATURES OF RIVER CONTROL

Scale 1:100,000

Works were also carried out at Upper Conders to prevent the Waihopai getting into Gibsons Creek and hence the Opawa.

Nevertheless it appears that the Opawa distributary was generally carrying a progressively higher proportion of Wairau flow. Blenheim was reported to have 9 floods in 11 weeks in a period in 1893. Several witnesses to the Wairau Commission Report (1917) attributed this increase in flood proportion to man's interference in the Opawa channel area. This is unlikely. Geomorphic studies by Basher et al (1993) show that the soils down the Upper Opawa floodplain are of recent nature indicates that large erosive floods have been a regular feature of the Opawa for the last few hundred years.

In geological pre European times the Wairau would have alternated to a greater or lesser degree between the northern (mainstem) Wairau and its southern Opawa distributary. It appears that the massive 1868 flood created a scour and deposition pattern that initiated a trend for the river to move back to the southern Opawa channel.

The Lower Wairau River Board concentrated most of its efforts on keeping the upper Opawa River out of Blenheim. (At an early stage, they had diverted the Omaka from its path of joining the Taylor and flowing through Blenheim, and instead routed into the Upper Opawa). Extensive groynes and banking were constructed at "Learys Breach" (north west of St Leonards Road), where the Opawa threatened to cut a new course directly into Blenheim. This banking on the south side of the Opawa was combined together with minor diversions for several kilometres downstream to the east of Blenheim. The main river works carried out both at this time and later are shown in Figure B2.

The Upper Opawa river floodwaters also threatened the Grovetown area, and the Spring Creek River Board responded with stopbanks on the northern side of the Opawa. As the Spring Creek Board also had to deal with the Wairau River to the north and east, it virtually ring banked its district.

The Lower Wairau River Boards culminating work on the Opawa was the construction of Rose's Overflow in 1901. This 4 kilometre diversion took Upper Opawa water from the eastern edge of Blenheim directly to near the mouth of the Wairau.

Any satisfaction at completing this work would have been diminished by the March 1904 flood less than three years later. In this large flood an estimated 2000m^3/sec flowed down the Upper Opawa (Vickerman and Lancaster (1924)), being at least half the flow of the Wairau. This was much greater than the combined lower Opawa and Rose's Overflow capacity of an intended 1250m^3/sec capacity.

The Public Works Department (PWD) also had a significant interest in the matter as they were involved in bridging the rivers and certainly would not have wished to provide for full Wairau flows at both the Opawa river at Grove Road, and the mainstem Wairau. Apparently they wished to have the Opawa distributary channel blocked. (P A Thomson personal communication).

The Lower Wairau River Board clearly reconsidered its options and in 1913 started an operation to put a groyne across the Opawa breach. This action was contrary to the court injunction and detrimental to the Spring Creek River Board, the Pukaka Drainage Board, the Tuamarina River Board and the Maori Land Drainage Board.

The Court of Appeal case that naturally followed found the original Opawa breach injunction to be invalid on a technicality. The high public feeling that this decision aroused, intensified by damaging floods in 1916 lead to the Government setting up a court of inquiry in 1917, called the Wairau Rivers Commission, to report on how the Wairau River should be dealt with.

B3 The Wairau River Commission Report 1917

The Wairau River Commission consisted of F W Furkett a prominent government (PWD) engineer, C R Vickerman a prominent consulting engineer and chaired by F O Loughnan a Blenheim magistrate.

In the brief space of two months they made a close inspection of the Wairau river system and floodplain and conducted a public hearing at which many prominent witnesses who had been involved with the rivers gave evidence.

The recommendations of the Commission were clear cut and far reaching. The major recommendations were :

- "We consider that the channel of the Wairau should be improved so as to carry all the water of the Wairau as no scheme which could be devised within practical limits would ensure proportional division of these waters between the Wairau and the Opawa."
- "Having regard to the necessity of making the Wairau carry all the water there is no valid reason why the (Opawa) breach should be left open."
- "Further, in view of the extreme danger, amounting to disaster, which would ensue if the Wairau changed its course to the Opawa, as it undoubtable might under the influence of a southerly trend, the (Opawa) breach must be closed at all costs."
- "The steps we recommend to improve the main channel are -
. . . The enlarging of the channel to a uniform discharging capacity that should be capable of carrying the largest flood hitherto observed with a reasonable margin of safety."
- "We have no hesitation in recommending that the control of the river be vested in one central authority."

Other recommendations included

- improving the Upper Opawa/Rose's Overflow to safely carry the southern tributary flood flows.
- preventing the Waihopai from breaking into Gibsons Creek.
- diversion of the Fairhall and the Upper Opawa
- stopbanking works on the Tuamarina due to increased Wairau flood levels.
- improving the Pukaka drainage system.
- improving (Riverlands) Co-operative Drainage system
- enlarging Taylor River system if required.
- works at the Wairau mouth to keep it open.

- purchasing all land within the stopbanked Wairau floodway.
- it was unnecessary and uneconomic to construct a diversion of the Wairau from Tuamarina directly to the sea.
- that the single controlling river district be the whole of the Wairau catchment.

The findings of the 1917 Commission were not immediately implemented. A parliamentary Bill (Wairau River Act 1918) for the formation of a single controlling river authority was not passed by parliament.

In 1919 the government set up a further Commission composed predominantly of PWD engineers, to look at eleven different South Island rivers. This "New Zealand Commission to enquire into the Clutha, Orari, Rangitata, Waimakariri, Ashley, Maerewhenua, Waihi, Wairau, Waiau uha, Taieri and Aparima Rivers" finally reported on the Wairau river in March 1921. The report of this 1921 Commission conflicted with that of the 1917 Commission. They recommended that an expensive control structure be built near Conders Groyne to limit flows into the Upper Opawa to $300m^3$/sec; and also that two river authorities be set up - one to control the Wairau and one to control the Opawa and its tributaries. The 1921 Commission report was not accepted.

The recommendations of the 1917 Wairau River Commission prevailed. In July 1921 the Wairau River Board was set up. The works it carried out were very much as outlined by the 1917 Commission. An exception was that the constituted area of the Wairau River Board was limited to that area on the Wairau floodplain of the former adversarial river and drainage boards. In was not till 1956 with the establishment of the Marlborough Catchment Board that the River Commissions' recommendation of a catchment wide district was enacted. With a slight irony one of the first major works of the Marlborough Catchment Board in 1963 was the construction of the Wairau Diversion as a short cut to the sea, - a project not considered economic by the 1917 Commission - but an action that has proved to be very worthwhile.

The enactment of the 1917 Wairau River Commission recommendations in endorsing the blockage of the Opawa breach and the other blockages and diversions of Wairau floodplain channels established the direction of river control works on the floodplain. Blenheim and residents on the south side of the valley got their way in blocking the Opawa breach, but on the understanding of continuing responsibilities for ensuring the adequacy of the Wairau river and other watercourses down the full length of the floodplain. The people of the Wairau floodplain had crossed their Rubicon.

B4 Wairau River Board 1921 - 1955

The Wairau River Board, constituted in 1921, had a baptism by flood.

In May 1923 the southern tributary system of the Lower Opawa - Taylor - Omaka system experienced its largest flood flow on record this century. The Wairau was also in high flood, though less extreme, and its estimated 3500m³/sec flood has an assessed 1 in 10 year return period.

In November 1926 the Wairau was in high flood and its estimated 4500m³/sec flood was not exceeded again until July 1983. Mr Lankow a farmer on the Wairau River just upstream of Tuamarina, suffered serious erosion of his farm land and took the Wairau River Board to court for damage on the basis of the work done in closing the Opawa breach caused his problem. The courts judgement was however against Lankow for they considered that the erosion may have occurred whether or not the Opawa was prevented from taking part of the flood flow, and furthermore that the groyne closing the Opawa breach had been constructed 12 years earlier and so was well outside the 12 month time period set down by legislation for claims.

Both of these floods caused substantial overflows and damage at Tuamarina, Bothams Bend and downstream in the (lower) Wairau. The Board first concentrated its efforts on the Wairau, and in these locations. Downstream of the Tuamarina rail bridge land was bought on both sides of the river so as to enlarge and widen the available floodway. The "Peninsula" cut put through in 1927 is now the channel of the Lower Wairau, and the wider floodway berm created on the left bank at the Ferry bridge area is now known as Morrins Hollow. A widened floodway berm with set back stopbanks was also created by buying land at "Beatsons" Overflow downstream of Jones Road. At that time an ox bow loop in the river there created the need for widening the river. This has since been removed and the river straightened, though the wide floodway berm remains.

The diversion of the Fairhall into the Upper Opawa in 1930 instead of joining the Taylor on the west edge of town was the main effort to relieve flood overflows from that source that had caused so much damage to Blenheim in 1923. Straightening of the Taylor through Blenheim in the 1950's was also carried out.

Much of the Wairau River Boards efforts were directed to the upgrading and repair of stopbanks in the Lower Wairau that were regularly overtopped in flood; and the repair and maintenance of groynes at points of river attack along the south bank of the Wairau above Tuamarina bridge. The need for these works was clearly a result of the mainstem Wairau carrying larger and more frequent floods than it did before the closure of the "Opawa breach".

In carrying out their works the Wairau River Board were advised by Vickerman and Lancaster consulting engineers, who reported to them in 1924, 1926 and 1927. Interestingly enough their 1927 report recommended that 850m³/sec should be designed to escape from the Wairau at the "Opawa breach" by means of a concrete paved gap. This recommendation was in complete contradiction to the recommendation of the impossibility of doing this in the 1917 Wairau River Commission report, and of their own 1924 report.

The justification for this recommendation was based on a review of the flood sizes, and a prediction of smaller floods. It may also have been to do with the difficulties being experienced in upgrading the main Wairau channel downstream to an adequate waterway capacity. In Appendix I of this report the widely different flood ratings of Vickerman and Lancaster 1924 and 1927 are discussed. Todays recommended ratings would be midway between their 1924 and 1927 rating relationship.

The specific provision of a concrete lined gap at the Opawa breach was not enacted by the Wairau River Board, but nor was any further stopbanking carried out in the Opawa breach area to completely seal off that channel. In large floods some water usually spilled out of the Wairau by outflanking the works in the area at the downstream end of the groyne.

The design basis for much of the raising of stopbanks in the lower Wairau appears to have been that the stopbanks be repaired to a higher level than the previous overtopping flood.

Two large floods occurred in June 1954 and February 1955 of estimated sizes of 4200m³/sec and 3400m³/sec (See Appendix I) and assessed return periods of once in 20 years and 10 years respectively. These two floods 8 months apart overtopped stopbanks and caused substantial damage. As a result the residents of Marlborough turned towards replacing the Wairau River Board with the Marlborough Catchment Board allowed for by government initiative through the 1941 Soil Conservation and Rivers Control Act.

B5 Marlborough Catchment Board 1956 - 1989

The Marlborough Catchment Board had wider powers and more government subsidy money support than the previous Wairau River Board. Its district for Wairau works was the whole Wairau catchment. After two years of investigation a comprehensive catchment scheme, the Wairau Valley Scheme was proposed by Davidson (1959), which was approved by Government in 1960. This scheme was for a 15 year period, and some modification to the scheme design developed during the construction period.

The main features of the as constructed Wairau Valley Scheme were

- It was a catchment wide "source to the sea" scheme. This involved carrying out soil conservation works to reduce sediment input from the hillside that source the rivers, stabilisation works in tributary streams through to stopbanking and other river control works in the Wairau floodplain. The area over which works were carried out and paid for was the whole catchment,
- The Wairau Diversion was constructed from Tuamarina direct to the sea near Rarangi to partially divert Wairau water and take pressure off the Lower Wairau. This was expected to enable 5100m³/sec, being a one in 200 year return period event, to be safely conveyed downstream of Tuamarina.
- A Taylor river detention dam was constructed upstream of Blenheim to dampen out the flood peak of the Taylor, and to a size to cope with a May 1923 size event.
- A comprehensive river training scheme was imposed in the partially braided Wairau river between Tuamarina and Waihopai confluence. The expectation was that a deepened single thread channel would result with lower flood levels and less bank protection maintenance requirements.

Other lesser features of the scheme included :

- A diversion of 3m³/sec from the Waihopai into Gibsons Creek so as to recharge the groundwater aquifer that had been depleted since the cutting off of the Upper Opawa.
- A rock lined guide bank to stabilise the position of the Wairau mouth and improve its hydraulic efficiency.
- Extensive and expensive works on the Wairau above the Waihopai confluence with the intention of benefiting local landowners and reducing gravel supply to the Wairau floodplain.
- Significant expense in other tributaries upstream of the floodplain.

- The construction of pumping stations to lift drainage and local floodwaters through the raised river stopbanks.
- An extensive drainage programme for the lower lying areas of the Wairau Floodplain.
- Channel blocks on the Opawa loop through Blenheim which made the Upper Opawa/Rose's Overflow a separate system from the Lower Opawa/Taylor system. This isolated the Opawa loop from flood water from either source and obviated the need for further Opawa loop stopbanking works.

As the 15 year programme of works drew to a conclusion it became apparent that some of the proposed works were inappropriate and/or inadequate to cope with the river problems and further revised programmes of work were required. In 1974 a new 8 year programme of work for the Wairau River upstream of the Waihopai confluence to the Wye confluence was approved. At the same time a follow up programme of works on the Wairau from Tuamarina to Waihopai was approved.

Further catchment wide 5 year followup programmes of work with government subsidies of 70% to 50% were approved in 1980 and 1986; the latter expiring in 1991.

From time to time there have also been government subsidised flood damage repair programmes, notably after the 1983 floods; and also some ad hoc works programmes. This included upgrading stopbanking works in the Omaka and Upper Opawa as the land use intensified to viticulture, and improvements to the Riverlands Co-op drain system.

Conversely works on Doctors Creek were not carried out because of uncertainty as to whether detention dams or a diversion were required, and a lack of political pressure to get this potentially controversial work carried out.

The Marlborough Catchment Board was amalgamated into a Nelson Marlborough Regional Council in 1989 which itself was abolished in 1992 and its responsibilities taken over by the Marlborough District Council. Government subsidies for Wairau catchment works effectively ceased in 1991.

The Resource Management Act was passed in 1991 that required further river works to be approved as part of a plan or as a specific resource consent.

B6 The Wairau Floodplain Community of Interest

B6.1 Wairau Floodplain and Blenheim

On the Wairau Floodplain downstream of the Waihopai confluence the current river pattern has been highly modified by previous River and Catchment Boards works. None of the waterways are carrying their original "natural" flow regimes. These works have been detailed in Section B1 - B5.

A common view expressed by Blenheim residents is that the river control works that protect the town have been completed long ago, and they find difficulty in relating the continuing expense on the Omaka, Opawa and Wairau Rivers, to their situation.

Blenheim - or Beavertown as it was known in earlier days, was at the confluence of a number of river systems - Taylor, Fairhall, Omaka and significantly the upper Opawa that was a distributary channel of the Wairau.

To bypass the town, the original channels were diverted or blocked. Fairhall and Omaka water was diverted north into the Upper Opawa/Rose's Overflow, and the distributary channel of the Wairau - the Opawa breach - was blocked in the Conders area.

All of these activities naturally had reactions, in that areas that previously only had to deal with their natural floodwater were confronted with 'foreign' flood flows that adversely affected their situation and aggravated flooding.

The Authorities of the day, were faced with legal battles to justify the protection of Blenheim, apparently at the expense of such locations as Tuamarina, Renwick, Grovetown and the lower Wairau.

It was accepted - this acceptance forms the basis of the rating principle - that Blenheim could not expect to carry out works to protect itself at the expense of other areas. It was also accepted that the protection of the other areas should be carried out concurrently with or even ahead of, the work to protect Blenheim.

This principle holds as firmly today as when it was first promulgated by the 1917 Wairau River Commission - and as stated forms the basis of the means of raising funds to consolidate and improve flood protection for Blenheim.

Fundamentally, the standard for all river works on the Wairau, derive from blocking the "Opawa breach" in the Conders area, and the standard adopted there to protect Blenheim. This sets the standard for all the floodplain and a commitment on Blenheim ratepayers.

What is not so evident is that the works on the Taylor River through Blenheim are able to be less obtrusive because Fairhall and Omaka water has been diverted to the north of town. The requirements to maintain river works on those river systems are therefore - in the same way as the Wairau - a commitment on the Blenheim ratepayers. The fact that the rivers were diverted many years ago is not an issue, as the river systems take many years to adjust and the Council must continue upgrading and maintaining the system to an appropriate standard.

Later legislation under the 1967 Water and Scil Conservation Act, or the present 1991 Resource Management Act would not allow the type of works that have taken place without legal physical safeguards. Past administrations accepted their responsibilities without the weight of the Resource Management Act to encourage them, and there should be no doubt that those responsibilities still exist.

Improving and maintaining this jigsaw of interlinked modified waterways on the floodplain to an appropriate standard carries with it the responsibility that all river control work on these Wairau floodplain waterways should be planned, promoted and funded as one scheme. If this was not done there would be valid objections under the Resource Management Act to such a floodplain management plan.

Without Blenheim ratepayer input, the river system would fail. Blenheim ratepayers may try to dictate that a lower rate intake should be struck and only used on the Taylor and the Wairau at Conders. Any such move would face strong legal challenge, but if this was achieved, the remainder of the system would collapse. The results of this would without doubt lead to major claims against Council and probable enforced reinstatement of the system to an equitable standard.

The minimum district over which river works should be carried out and funded is therefore 1921 Wairau River Board scheme boundaries.

The maximum possible area is the whole of the Wairau catchment. The current Wairau Valley Scheme covers the whole of the catchment.

A whole catchment control scheme involves carrying out soil conservation works in the rivers sources in the hills, stabilisation works in tributary streams through to river control stopbanking and other works on the floodplain to its outlet into the sea. The 1960 Wairau Valley Scheme (and subsequent follow up works) was such a "source to the sea" scheme. The area over which works were carried out (and paid for) was the whole catchment including all tributaries. This represented a considerable expansion on the earlier Wairau River Board area that only covered the Wairau floodplain below Waihopai.

This whole catchment approach was made feasible by the generous government subsidy money that averaged nearly 3:1. These government subsidy moneys are now no longer available. It is timely to review whether a whole catchment scheme is still practical; or if the old Wairau River Board boundaries are more appropriate; or schemes or various schemes and various scheme boundaries are appropriate.

B6.2 Influence of the river works of the Wairau River above Waihopai Confluence

The most important tributary to the main Wairau floodplain is the Wairau itself above the Waihopai Confluence. The Marlborough Catchment Board spent over $12 million dollars (in 1993 terms) at an average rate of $350,000 per year for over 30 years from 1960 on the Wairau River above the Waihopai confluence.

The work was approved in the 1960 scheme, and when further works were proposed in 1974 these were justified because of the direct benefit to the adjacent farmland. There was also a postulated benefit of reducing gravel supply and thus channel build up in the lower river and floodplain downstream.

The river resurvey information now available indicates that the river bed from Waihopai confluence nearly to Wairau Valley township has remained at much the same level with no indication that river control works in the area are influencing aggradation or degradation of the bed.

The Wairau River is such a wide river that whatever bank works are put in place there are large expanses of gravel bed to supply bedload to the river. Thus there is little evidence to support the contention that bank stabilisation works are useful in reducing gravel supply to the Wairau River downstream. This is supported by observations on other NZ gravel bed rivers, for example, the Ashburton (Keys and Connell (1986)).

The Wairau riverbed on the Wairau Floodplain is aggrading (building up) between Tuamarina bridge and Jefferies Road, but it is eroding and deepening between Renwick bridge and Waihopai confluence. Thus, even if river control works up stream have been successful in a reducing gravel supply to the main floodplain reach of the river, the river has adjusted to this by eroding its own bed in the Conders area and still depositing and building up the river channel in the important Tuamarina to Giffords Road area.

Thus, the aggradation problem mid-valley on the Wairau floodplain area may well be much the same irrespective of whether works in the Wairau above Waihopai are having any effect on gravel supply (which is doubtful).

The river control works upstream of the Waihopai confluence at present have no clear benefit for those living downstream on the main Wairau floodplain. River work done in this area affect a different community of interest. These river works should be promoted and funded in a different manner from the main Wairau floodplain area. The economies of carrying out river works in the area would then be more readily be assessed on its merits.

B6.3 Influence of other Wairau Tributaries River Works.

Other tributaries also flow on to the main Wairau floodplain. Considerable expenditure has also taken place on the many tributaries of the Wairau, eg the Tuamarina, Onamalutu, Are Are, Mill Stream, Omaka etc that flow directly on to the floodplain from the north or south; or Hillersden, Bartletts, Wye etc that join the Wairau above Waihopai first.

The work done has mainly been channel clearing and bank stabilisation. Similar arguments regarding the effect of these river works in reducing sediment supply to the Wairau floodplain apply to these rivers as to the Wairau above Waihopai Confluence. Again there is little evidence of benefit to ratepayers living on the main Wairau floodplain.

As for the Wairau above Waihopai these different tributaries further river works should be funded differently from the main Wairau floodplain river works.

The last step of a "sea to the source" scheme is the soil conservation work in the upper catchment. Soil conservation works to reduce sediment input to the river system have been carried out on the Northbank Streams, Upper Wairau, Wye, Waihopai and Wither Hills.

B6.4 Influence of Soil Conservation Works on the floodplain.

The soil conservation works on the Wither Hills clearly have a direct and valuable benefit for the waterways at the base of the hills directly affect the intensive development of Blenheim. Should the waterways at the base of the hills be suddenly filled and blocked by sediment eroded from the hills in a major storm, considerable damage would result immediately to adjacent houses. The existing soil conservation works on the Wither Hills are clearly valuable and important works. As a separate exercise and funded separately, a management plan has been published for the Wither Hills by Council (Landcorp Property (1993)). This management plan sets out proposed future soil conservation works and maintenance strategies and also outlines other community service requirements.

The effectiveness of continuing soil conservation works in other parts of the catchment is much less clear. The work that was practical to be done has been done, especially on the Northbank. Much further work could be carried out in the Waihopai which is a major sediment source, especially of the suspended sediments. (It is such fine sediment size that is silting up the lower Wairau). The value and effectiveness of carrying out such soil conservation in the rugged Waihopai catchment is however, uncertain. The arguments regarding the degree to which sediment supply actually affects the floodplain discussed above apply to a large degree for soil conservation works also. There is little evidence to judge whether soil conservation works to reduce fine sediment erosion have been cost effective. Interpretation of results is also made more difficult by construction of the Benhopai dam in 1928, that filled with 4.5 million m³ of sediment within 20 years, but now may be still catching gravel sized sediment. In todays tighter financial times soil conservation works in the hills needs to be shown to be cost effective to obtain funding from floodplain residents.

Further soil conservation works may be needed in the longer term but Council has no plans to carry out further such soil conservation work in the near future. Decisions have already been made to discontinue a "source to the sea" whole catchment works scheme, at least for the present.

B6.5 Public Discussion

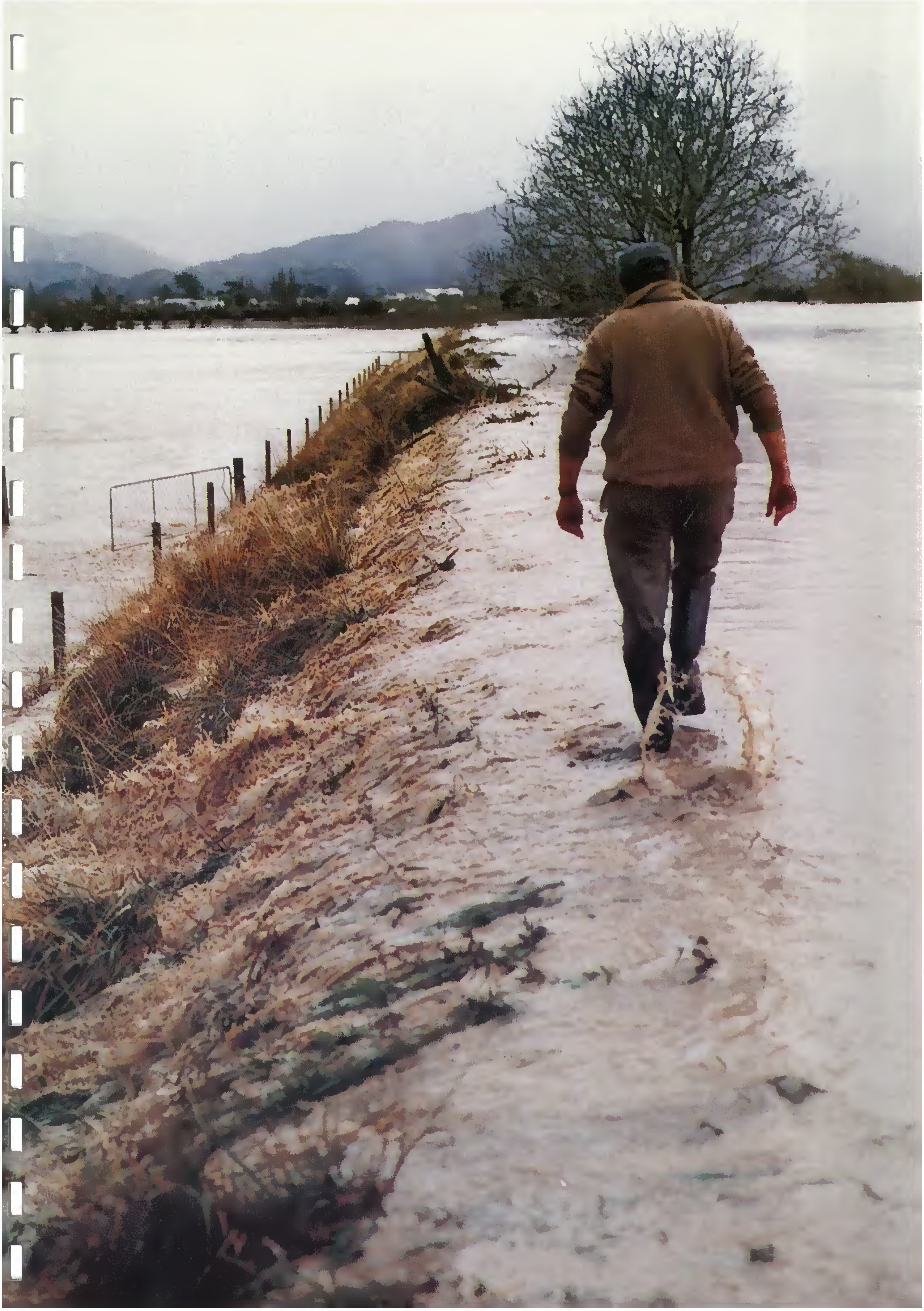
Currently the Wairau Valley Scheme district embraces the whole catchment. The community panel that was set up (refer section A1.2) to advise on river issues with was specifically asked if they wished to see the scheme district area reduced to the extent of only the main Wairau floodplain.

They recommended that they preferred to see works still being carried out and paid for on a whole catchment wide district, but they recognised that the standard of works on the tributaries outside the main Wairau floodplain and the mechanism of funding of these works may have to be different. (Refer to Appendix III regarding discussion papers and minutes of Community Panel meetings).

B6.6 Summary

Further river control works in the Wairau catchment should be over a district that covers the whole catchment. Within this district two sub areas are defined. Firstly, the main Wairau floodplain area on which a stopbanked river floodway system to a defined standard is appropriate; and secondly, the tributaries where a lesser imprecise standard is more appropriate. The recommended main Wairau floodplain rivers area is similar but slightly larger than the 1921 Wairau River Board district, and is shown on figure A2. Discussion on setting appropriate standards for each sub area is in following sections.

Photo: Lower Wairau overtopping stopbanks near Grovetown - 10 July 1983



Section C : Wairau River Floodways on the Main Floodplain

C1 Maintaining the Current River Floodway Locations and Flow Regimes

C1.1 Description of Issue and Reasons for Objective

Over the 100 years or so since river works were commenced on the Wairau Floodplain, vast amounts of money have been spent to create the present river system for the prime purpose of flood control. Since the 1950's alone, over $80 million in present terms has been spent - mostly with a high degree of success and benefit in the prevention of catastrophic flooding. There is no doubt that in some cases there are also environmental and physical effects that are not to everyones advantage.

The feasibility of whether it is possible to return to the original "natural" river system before the various public authorities carried out the substantial river modifications must be discussed.

If it is not possible to reverse these works then the Marlborough District Council and its ratepayers have a responsibility to at least maintain the current "artificial" river pattern; or indeed improve it to an appropriate standard.

The river works that have been carried out have been largely outlined in Section B1-5.

In particular the location of rivers has been changed by construction of diversions, or by blocking off alternative outlet channels. These diversions and blockages have meant that **every** river channel or floodway on the Wairau floodplain is carrying a different flow regime or in a different position (or both), and usually substantially different from what it did prior to European settlement.

The most significant of these is the blockage of the Opawa distributary channel from the Wairau. This has increased flood flows down the mainstream Wairau by typically 50%. This has subsequently required substantial river control works on the mainstream Wairau - including the Wairau Diversion - to cope with these increased flood flows.

It has also allowed development of Blenheim to go ahead without the regular flooding from the Wairau. More recently it has also allowed much of the land of the Upper Opawa channel to be developed for viticulture within a narrowed floodway. To attempt to restore the original river pattern would require a mammoth physical effort, be legally extremely difficult if not impossible, and be of enormous cost. Clearly there is no option but to accept the blocking of the "Opawa Breach".

The same argument applies to a lesser degree to practically every significant diversion and blockage that has been carried out. It could be asserted that no river channel on the Wairau Floodplain is natural. The Wairau Diversion, Fairhall Diversion, Roses Overflow, Pukaka floodway and the concrete lined Wither Stream are probably 'artifical watercourse' rather than 'rivers'. It is only since the 1967 Water and Soil Conservation Act, and more recently the 1991 Resource Management Act that specific legal safeguards are required.

Summary

The river works and floodways that have been imposed in the past on the Wairau floodplain rivers have completely altered them from their 'natural' state. The rivers are impossible to return to their former state. The Marlborough District Council, as river authority, now have the responsibility of maintaining the current river pattern, not only in terms of maintaining the existing river floodways to enable them to pass flood flows safely, but also to carry out ameliorating action on a wide variety of environmental issues. There is no "do nothing" option, and the economics of doing river control works on the main Wairau floodplain is a secondary issue.

For this reason, this plan is the appropriate instrument under Section 32 of the Resource Management Act 1991, for the Council to carry out its duties under Section 30 of the Act.

C1.2 Objective

To maintain and upgrade to a uniform high standard the existing highly modified floodway systems on the Wairau floodplain as the primary mechanism of mitigating against the flood hazard. The Wairau floodplain and its floodways are shown on Figure A2.

Note: This is the fundamental objective of this plan.

C1.3 Policies, Methods and Rules

These will be discussed in Sections C2, C3 and D.

C2 Appropriate Flood Capacity Standard of Floodways

C2.1 Description of Issue and Reasons for Objective

The cost of river floodway works is usually strongly dependent on the size of flood it is required to contain. A fundamental question is how big a flood should be contained within the stopbanked floodway system.

Prior to 1960 stopbanks on the Wairau floodplain were constructed a bit higher than the last big flood, with little knowledge of actual flood sizes. This approach has an advantage of political expediency; but it does not address the following matters:

(a) Flood levels (and the stopbank heights) for similar floods are affected by channel changes - especially diversions upstream or stopbanking on the opposite side of the river, or gravel deposition.

(b) Intensive land development with high capital investment, requires a clearer identification of risk.

The preferred method of determining stopbank heights is a detailed study of the size of floods likely to occur and computer aided hydraulic analysis of the waterway capacity required for such a flood flow. This approach is considered more appropriate for todays planning of river works on the Wairau River and tributaries on its floodplain.

The question arises as to what size flood should the stopbanked river floodway systems be designed to cope with; ie the design flood. This size of flood can be described in terms of how commonly it occurs.

Theoretically economic cost benefit studies can be done to examine the optimum capacity of a floodway system. Such a major study requires assumptions as to how much landowners will develop if provided with flood protection. Initial scheme studies usually assume with or without flood protection scenarios.

The assumptions become particularly speculative when trying to examine alternative levels of protection and/or how quickly river control works would deteriorate if not maintained.

It is considered that the margin of error of such assumptions is so great as to render dubious any detailed economic study to evaluate the optimum protection standard for the Wairau system. (Nevertheless it is to be noted that such an economic study be Le Page (1986) showed that maintaining the Wairau Valley Scheme to be a very economic proposition with a rate of return of 19%).

Williman and Smart (1988) have catalogued all the major river control schemes in New Zealand. They found that the river control schemes that protect urban areas typically have a standard of protection up to a flood size with a 10% chance of occurring within the next 10 years. A less clear, but more succinct description of this flood frequency is "a 100 year return period event" - its frequency, on average over a long period of time, is once every 100 years.

Some urban areas have designed for flood events ever rarer than this. For example:

Town	River	Return Period
Christchurch	Waimakariri	200 year
Dunedin	Leith	500 year
Opotiki	Waioeka	250 year
Palmerston North	Manawatu	140 year
Invercargill	Waihopai and Kingswell	125 year

Most rural based river floodway systems usually have adopted a lower flood capacity standard - commonly up to a 20% chance of occurring within the next 10 years (or a 50 year return period flood.)

The Wairau floodplain has the urban areas of Blenheim, Tuamarina, Spring Creek and Renwick at risk from flooding from the Wairau, Taylor, Opawa, Omaka and Fairhall. Furthermore, the rural land of the Wairau floodplain is also rapidly intensifying with viticultural, horticultural and lifestyle block development. The desirable design flood size for these rivers is recommended to be for a flood with a 10% chance of occurring in the next 10 years (or a "100 year return period flood").

It should be noted that the Wairau River Commission (1917) recommended "the largest flood hitherto observed", Davidson (1959) that the Wairau Valley Scheme be to 1 in 200 year standard, Thomson and Pascoe (1985) recommend a 100 year return period flood.

A flood with 10% chance of occurring in the next 10 years (100 year return period) is therefore a suitable flood size for design of the river floodway systems of the Wairau floodplain. As discussed in Section C2.1 it should also be uniform over the whole floodplain.

Currently, the river floodways are not up to this standard for most of the Wairau Floodplain. For both the main floodways on the floodplain - the Wairau and the Lower Opawa/Taylor - the actual flood standard is currently assessed as typically capable of passing a 30 year return period flood, and this standard is relatively uniform over much of the river reaches. Such a flood has a 30% chance of occurring in the next 10 years. There are some areas with a lower standard than this where intended river works would have a higher priority. (See Appendix I and II) and some areas that it is higher. This is detailed in later sections.

C2.2 Objective

To achieve a floodway capacity and standard of protection for a flood size of up to a 100 year return period event (ie, with a 10% chance of occurring in the next ten years) for all works on the main Wairau Floodplain rivers downstream of the Waihopai Confluence. This Wairau floodplain area and its rivers are shown in Figure B1.

Note: Following the ten year period of this plan it may be desirable to increase the design standard.

C2.3 Policy

To maintain and upgrade the floodways using the blend of methods most appropriate for each particular floodway. The plan identifies nine separate floodways on the floodplain. The methods to be adopted for each individual floodway, and the reasons for the choice of methods are detailed in Section D.

C2.4 Methods

The methods to improve floodway capacity are categorised as follows :

(i) Gravel and Sediment removal to deepen the channel

This may only be a temporary remedy as further gravel and sediment is brought down by the river as it re-establishes its regime. It should also be noted that river channels naturally change as the river waters move sediment, eroding from upstream reaches of the river to deposit it downstream. Deposition is normal for most rivers and indeed it is the normal floodplain building process.

This insidious deposition of gravel, sand and silt in the river channel reduces the floodway waterway capacity. As a result stopbanking works capable of passing the design flood at the time of construction can become inadequate in later years.

It should be noted that excess gravel or sediment removal can encourage the undermining and collapse of banks and stopbanks. The amount of sediment being deposited in the river system will influence if this is likely to be a problem.

(iii) Increasing the waterway capacity

(a) This can be achieved by **increasing the width of the floodway** by relocating the stopbanks further landward so as to increase the waterway area.

(b) **Raising the stopbank levels** so as to increase waterway area.

(c) **Increasing the channel efficiency** by removal of impeding vegetation or banking or other obstructions within the floodway. This vegetation removal can be carried out both within a defined active main fairway/main channel and/or on the normally vegetated berms.

(iii) Stopbank erosion protection

To prevent the stopbank being eroded and scoured away during floods.

The stopbanks need to be protected from fast flowing water attack that can erode them. This particularly applies to the large and powerful fast flowing Wairau, and also the Omaka and Waihopai. Stopbank erosion protection works on the Wairau are much more expensive than the stopbanks themselves. The stopbanks are set back from the fairway/main channel and so as to keep the fast water well away. Bank edge protection is then established on the fairway/main channel. This edge protection is rock work for the more severe river attack and tree based protection for gentler situations. Trees are usually willow or poplar and at times anchored by driven rails or wires. The berm between the fairway/main channel and the stopbanks usually have sufficient tree planting and grassing so as to inhibit erosion and prevent channels forming on the berms. The stopbanks are grass covered.

Stopbank erosion protection rock work can be placed proactively in a predetermined location in anticipation of bank attack, or reactively following bank attack and erosion during a flood event. It is usually not economic to proactively place the highest standard of rock protection over the full length of both banks especially in braided rivers that can attack at virtually any location along the banks. A blend of proactive and reactive methods is usual.

(iv) Adequacy of Stopbank Structural Integrity

Stopbanks are dams that hold back water. Stopbanks have to be built sufficiently soundly so that they do not fail due to the hydraulic forces of the water held back by them. Aspects of thickness of bank, type of material used for construction, degree of compaction, foundations of stopbank are of relevance. Stopbank failure can occur by undermining, slumping etc.

(v) Modifying Flow Control Mechanisms

Natural features or man made structures within a river channel often control the amount of flow in a channel and/or the level of floodwater. This is a similar but related issue to waterway capacity.

The Lower Wairau mouth bar is such a natural flow mechanism in which the varying configuration of a spit to the north in effect partially blocks the mouth, from time to time. This effects flood levels upstream, tidal flushing and lower flow water levels that effect environmental aspects in the Vernon Lagoons as well as the Lower Wairau and Lower Opawa rivers. Opening of a direct mouth by bulldozer is a method that benefits flood and drainage considerations and also appears to provide environmental benefit.

The low soffitt and relatively short length of the bridge over the Wairau river at Tuamarina is a man made flow control mechanism that may detrimentally affect flood levels upstream. The Taylor Dam is a flow control mechanism that reduces the design flood downstream.

(vi) Maintenance and Flood Damage Repair

These are activities that maintain existing river control structures and works. Maintenance and flood damage activity includes :

- Rock replacement on training banks.
- Rock extension of training banks.
- Isolated rock work.
- Gravel or sediment removal above water level.
- Tree, scrub and other vegetation removal and control
- Tree Planting and maintenance
- Grass and Lucerne planting and maintenance
- Noxious plant control
- Diversions in fairway
- Placement of rock, concrete or masonry rubble, gabions etc.
- Rock recovery
- Piled or anchored retards
- Grazing control
- Aquatic weed control
- Stopbank maintenance and reconstruction
- Culverts through stopbanks maintenance and replacement
- Floodgates (flapgates) and other culvert gates repair and replacement.

C3 Priorities for Policies and Methods

C3.1 Description of Issue

The plan has as a major objective the containment of floodwaters in the floodplain floodways to a standard of a 100 year return period flood, and to achieve this over a 10 year time frame. The timing and priorities in which the improvement activities will be carried out is a valid issue; and for the Wairau this is an issue of considerable local concern.

If improvements are carried out from the upstream end of the floodway first before any downstream improvements, in the meantime the downstream area could receive greater floods and suffer worse flood breakouts compared to the situation of before any works were done. Conversely if improvements are carried out at the downstream end of the floodway first before upstream improvements, in the meantime the upstream area could suffer flood breakout while the downstream area flood control improvements are unutilised.

This plan proposes that priority for works be based on 3 factors:

(i) Current standard of protection.

(ii) Engineering practicality.

(iii) Consequences of failure.

For the Wairau, factor (i) the current standard of protection, will be the most important, and work would be prioritised in the Spring Creek area, or the Conders area, or wherever, based primarily on the area with the lowest current assessed standard of protection.

For the Taylor/Lower Opawa the consequence of failure is the most important factor. Thus for the Taylor/Lower Opawa floodway the improvement works will be from Blenheim working downstream as this will be to the greatest benefit to Blenheim residents.

C3.2 Objective

To prioritise floodway activities over the 10 year plan period.

C3.3 Policy for Determining Priority

To use assessed current standard of protection together with assessments of engineering practicality and consequences of failure as a guide for listing activities into priority classes.

C3.4 Methods

Activities that have a high priority and are expected to be carried out within the next two years will be listed as category (a).

Activities of medium term priority will be of category (b)

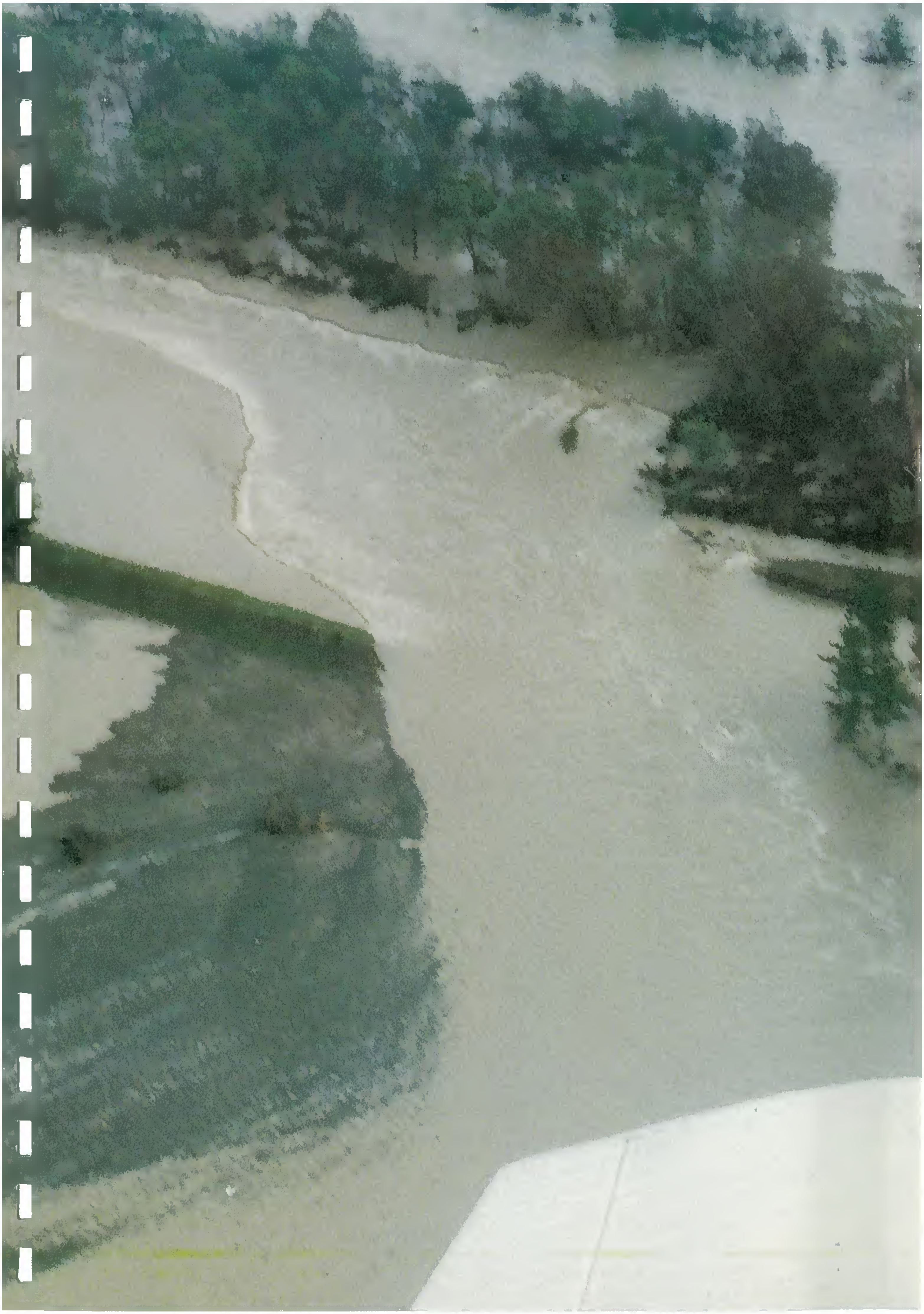
Activities of less priority, expected to be carried out towards the end of the 10 year period will be listed as category (c).

Activities that will be carried out on an annual regular basis will be listed as category (r).

Activities likely to be required outside the 10 year time frame of the plan will be listed as category (x).

These priority categories are listed for each individual river floodway in Section D.

Photograph : Breach of stopbank into old Opawa channel at Conders Groyne - 10 July 1983



Section D : Individual Analysis of Wairau Floodplain Floodways and the Proposed Policies, Methods, Rules and Reasons

This includes

1. Lower Wairau
2. Wairau Diversion
3. Flow Division area of Diversion and Lower Wairau including Spring Creek outlet
4. Wairau from Tuamarina to Waihopai Confluence
5. Waihopai
6. Lower Opawa/Taylor
7. Upper Opawa/Roses Overflow
8. Omaka
9. Riverlands and Wither Stream
10. Other floodplain rivers not examined in detail (Pukaka, Gibsons, Doctors Creek, Opawa Loop, School Creek).

D1 Lower Wairau (River mouth to Ferry Bridge) Floodway

Reference Map 1

Channel characteristics (typical)

Type	:	Deep narrow silt bed river
Length	:	9 km
Channel Width	:	120m
Floodway Width	:	350m
Slope	:	Tidal, flood slope 0.05% (1 in 2000)
Design Flood	:	2500m³/sec Design Freeboard 0.5m

D1.1 Policy for Lower Wairau (Mouth to Ferry Bridge)

REFERENCE	POLICY	APPROXIMATE PRIORITY CATEGORY
	DESCRIPTION OF PROGRAMMED METHOD	
D1.2.1.	Deliberate strategic sediment removal	(r)
D1.2.2 (a) + (b)(ii)	Stopbank raising Ferry Road to Watsons Road	(b)
D1.2.2 (a)+(b)(iii)	Willow tree removal	(a)
D1.2.4 (a)+(b)(i)	Stopbank upgrading above Jones Road	(a)
D1.2.4 (a)+(b)(ii)	Stopbank relocation below Jones Road	(c)
D1.2.4 (a)+(b)(iii)	Stopbank upgrading downstream of Eckfords Road	(b)
D1.2.5 (a)+(b)(i)	Pilot cut excavation of new mouth. Extension of rock guide bank.	(r) + (x)
	Flood damage repair	(r)
	Maintenance	(r)

D1.2 Reasons for Methods and Policy for Lower Wairau

1.2.1 Issue : Sedimentation

(a) Situation.

(i) River channel cross sectional survey has been carried out in 1957, 1963, 1969 and 1989 and is discussed by Williman (1992). Between 1957 and 1967 a minor amount of siltation occurred over the whole river reach. The bed level at Ferry Bridge in 1957 was also similar to a 1938 bed level measured from a flow gaugings, and slightly lower by 0.2 metres than a survey in 1927 by the Wairau River Board.

From 1969 to 1989 considerable siltation of the channel took place, with a total of 1.3 million cubic metres being deposited at a rate of 60 000 m³/year. This has resulted in the main channel bed typically aggrading by 1.0 metre and reducing in width from 140 to 120 metres. Deposition at the bottom end is less than 1 metre. Above the Ferry Bridge area it is nearly 1.5 metres, and this includes gravel deposition. An example of the silt deposition is shown in Figure D1, at Dicks Road, just downstream of Ferry Bridge.

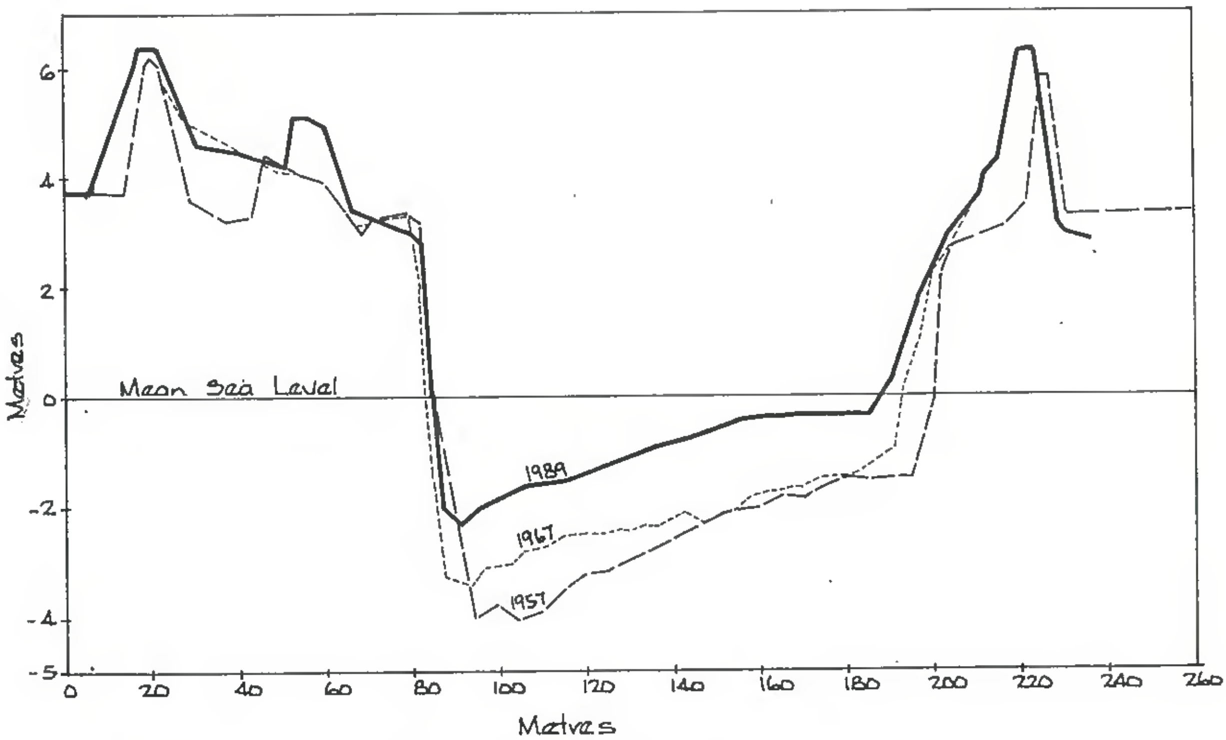


FIGURE D1 LOWER WAIRAU AT DICKS RD.

Figure D1 CROSS SECTION CHANGES 1957-1989.

(ii) This silt deposition is due to the reduction in flows with the construction of the Diversion in 1963 and its increasing development particularly since 1972. The reduction in the sediment transporting capability of the freshes and floods is proportionally greater than the reduction in flow. The silt deposition will reduce the waterway capacity of the lower Wairau.

This siltation will continue until the river channel reaches a new balance of transporting capacity and sediment level. Further regular river bed cross sectional survey is required to ascertain the degree to which the channel is reaching this new regime.

The sandy silt material that is being deposited is material that is carried in suspension in the fast more turbulent river system upstream of Tuamarina. The main cause of its deposition is the lesser velocities associated with the lesser flood flows in the lower Wairau since Wairau Diversion construction.

(iii) The deposition of gravel upstream of Ferry bridge is by a slightly different mechanism. The gravel is carried as bedload that moves along the bottom of the bed, and this gravel front is now moving past the Ferry bridge and downstream. It is more of a problem concerning the division reach of the lower Wairau between Ferry bridge and Tuamarina, and will be discussed in Section D.3.

(b) Methods and Reason for Adoption

(ii) **Siltation:**

- Dredging. This is very expensive.
- A flow control structure at the head of the Lower Wairau to increase the size of moderate floods in the Lower Wairau to help transport silt through the river. During major floods however this flow control structure would ensure that the Wairau Diversion carries the larger part of the flow. Also very expensive.
- Do nothing.

Both dredging and a sophisticated flow control structure are very expensive. In the short to medium term the problem of adequate waterway can be met (as will be discussed in Section D2) by increased Diversion capacity.

For this 10 year plan period the "do nothing" option is generally advocated, though of course, further monitoring of bed levels and measurement of suspended sediment concentration of flood flows is required. A trial of strategic sediment removal by deliberation Council excavation is also appropriate.

1.2.2 Issue : Adequacy of Floodway Capacity

(a) Situation

(i) The lack of waterway capacity of the Lower Wairau has been a major issue in Wairau river control works. Stopbanking was constructed around the turn of the century, but once the Opawa distributary was blocked at Conders groyne in 1914, the Lower Wairau capacity of approx 2800m³/sec was regularly overtopped at approx 6 year intervals until the Wairau Diversion Construction in 1963. (Refer Appendix I and II for flood hydrology and hydraulics).

The stopbanks are new to a fairly consistent capacity for the lower Wairau, and this is the basis for selecting 2500m³/sec as the design flood size. The Wairau Diversion is planned to be increased in capacity to 3000 m³/sec so as to carry the remaining full Wairau design flow of 5500m³/sec.

(ii) An exception is a 500m length on the right bank from downstream of Ferry Road bridge to Watson's Road where the stopbank is 300mm low.

(iii) On the 5km reach from Ferry Bridge down to Jones' road some 85% of the banks have thick willows with limbs that overhang approximately 5 metres into the channel. These overhanging limbs impede the flow, and this impeding effect spreads across the full waterway of the channel. Aerial photographs show this degree of willow growth has increased from 35% in 1947 and 55% in 1972.

The affect is to increase the channel "Mannings 'n'" hydraulic roughness from a measured 0.021 (at water level below overhanging trees) to an estimated 0.026 at peak flood levels.

The reduction in maximum waterway capacity since stopbank raising was carried out following the Jan 1962 flood, is estimated as 700m³/sec or some 25% of the design flood. Of this, approx 15% is attributable to siltation and the other 10% to the willow tree growth.

(iv) For the final 3 kilometres to the sea on the left bank there is no stopbank. This is a peninsular of land 3 km long by typically 0.8 km wide of quite elevated old beach ridges. The land is of poor productivity with two houses. The positioning of the Wairau bar road is just outside the edge of land that is not usually flooded (though it was in July 1983). With the Wairau Diversion carrying more water now this land is even less likely to flood, and natural high ground marks the edge of the floodway.

(b) Methods and reasons for adoption

(ii) **Ferry Road to Watson's Road Stopbank** - Raising the stopbank by 300mm for the low 500 metres **is a clearly preferred option here**.

(iii) **Impeding Willow Trees** - The removal of overhanging willows on the inside of bends or straight river reaches where they are not required for bank erosion protection **is a practical option**.

Trees on the outside of bends need to be left to provide erosion protection. This would also help preserve cover for fish habitat and general river aesthetics. The overhanging limbs from these trees should desirably be trimmed back.

(iv) **Left bank for 3km from Lower Wairau river mouth**.

- **The do nothing option is preferred** until if and when the natural ground is shown to be too low.

1.2.3 Issue : Stopbank Erosion Protection

(a) Situation

(i) Channel bank erosion is limited to the outside of bends. Willow trees are useful in inhibiting such erosion. Bank erosion has occurred only in major floods in excess of 2500m³/sec. This has resulted in restoration works using very large quantities of rock to hold the bends where water depths can be up to 12 metres. Severe bank erosion of the soft bank material could eventually lead to ox bow bends, two of which were present on the river at the time of European settlement. This needs to be avoided.

(ii) Wave lap erosion also occurs in the lower reaches of the river where the saline environment inhibits protective tree growth, and rock rubble has been used for protection. Such wave lap erosion is occurring in the 500 metres downstream of Eckfords Road.

(b) Methods and reason for adoption

(i) **Channel bank erosion prevention measures.**

- Maintaining willow trees on the outside of bends.
- Preventative placement of rock rip rap in probable locations of bank attack is not justified because stopbanks are set back from the active bank so that one damaging flood is very unlikely to erode to and through a stopbank, and there is time for repair measures.
- Repair with rock rip rap following erosion damage as necessary. This is a preferred option. However, it should be noted that channel bank erosion may not be potentially damaging to the stopbank, especially if it is tens of metres away. Rock rip rap is not justified for berm protection only and the stopbank itself is not at risk. The decision to hold the bank line with rock riprap protection should be made carefully.
- Relocation of stopbank inland. This is a possible option if very severe bank attack occurs. The area involved is likely to be limited in extent.

Overall, no preventative bank protection measures other than maintaining the willow trees on the outside of the bends is advocated. Rock rip rap work would be used as necessary for repair following large damaging floods. Even then, the option of "do nothing" because the stopbanks themselves are not under threat, or moving back the stopbanks must also be considered by each situation on its merits following flood attack.

(ii) **Wave lap bank erosion downstream of Eckfords Road**

- Do nothing. **This generally is a preferred option** until if and when, wave lap erosion comes to within 15 metres of the stopbank.
- Place rock rubble bank protection.

- Relocate stopbank further back from the river. This is an attractive option as the current stopbank needs upgrading for reasons of structural inadequacy.

1.2.4 Issue : Stopbank Structural Integrity

(a) Situation

(i) A 300 metre length of stopbank on the right bank shortly upstream of Jones Road is "original bank" constructed perhaps 80 years ago with a top width of 1.2 metres and up to 1.2:1 batters. A study by Climo (1993) indicates that such narrow sections stopbank are unlikely to meet desired stability standards. These dimensions also lead to stock damage of the banks, and this bank is only just to adequate height.

(ii) A 1 kilometre length of stopbank downstream of Jones Road, is similarly "original bank" of narrow dimensions.

(iii) In the vicinity of Eckfords Road there is 600 metres of original narrow bank much of which has been damaged by stock.

(iv) Many of the drainage and pump culvert pipes under the stopbanks are short, and these are potential failure paths. There are several such culverts not of adequate length. (NB Upgrading of pumping stations and enlargement of culverts to increase disposal of drainage and local floodwaters is also being proposed and will be discussed separately in a later document).

(v) Fences on the top of stopbanks have led to animal tracking on the stopbanks with stopbank damage. This applies to considerable lengths of stopbanks, especially the left stopbank.

(b) Methods and reason for adoption

(i) **Stopbank above Jones Road - The preferred option** to upgrade this stopbank is to widen it to a top width of 3.5 m and batters of 2:1.

(ii) **The 1 km reach of stopbank downstream of Jones Road**. A completely new stopbank typically 200m closer to the river **is a feasible option** that may not be much more expensive than upgrading the old bank. It would also release some 15 hectares out of the floodway including Jones Road that serves several houses which are cut off in flood time.

It may appear that this option would then direct floodwater across on to the opposite left bank to the detriment of landowners there. This is in fact no different the current situation where quite high guide banks on the right bank berm inhibit the berm from carrying floodwater and direct water across to the left bank.

The stopbank would only be relocated following the removal of these guide banks to the extent of actually increasing the overall effective floodway capacity.

(iii) **Stopbank in the vicinity of Eckfords Road.**

- Reconstruction of this stopbank and re-sowing down with grass **is the practical option**.
- Do nothing is contrary to this plans objectives, though the risk of failure and the consequence of failure are less than in other areas of inadequate stopbanks.

(iv) **Inadequate Culverts under Stopbanks**.

- Lengthening these culverts and also close attention paid to ensuring back filling is impermeable **is the practical option** for those potentially weak points. Damaged culverts also need replacing.
- A 'do nothing' option is not acceptable. Any failure is likely to be rapid and potentially very damaging and would occur at floods significantly less than design flood.

(v) **Fences** should be relocated to the bottom of stopbanks and damage patched up and sewn down in grass, where this has occurred.

1.2.5 Issue : Flow Control Mechanisms

(a) Situation

(i) The Wairau river mouth bar is a natural feature that has a dominating effect in normal river flows on Wairau estuary levels, the Wairau lagoons, the lower Wairau to upstream of Ferry bridge, and the lower Opawa. Even in flood flows a poor configuration of the bar has resulted in raising flood levels as far as Jones Road.

The bar is formed by a combination of marine forces, tidal flows into the Vernon Lagoons and river flows from the lower Wairau and to a lesser extent the lower Opawa.

The marine storm wave forces are very important. In times past they formed a bar typically extending a kilometre to the north. When such a bar formed there would be significant water friction loss down this extra distance of coarse gravel bed channel. In these situations the water level in the whole lower Wairau upstream is kept at virtual high tide levels with little or no tidal variation.

This has a significant environmental effect on the Lower Wairau, lower Opawa and Vernon Lagoons. With this partially closed bar the water there may stay almost completely devoid of saline water, or conversely stay with an extensive saline wedge (Cawthron (1992)).

Gravity drainage of the extensive areas of flat lower plains into the lower Wairau is also prevented and expensive drainage pumping required.

With a direct open mouth there is twice daily flushing of saline water, tidal water level variation in the lower Opawa and lower Wairau and good gravity drainage.

Boat access across the bar is also much better with a direct mouth outlet and was a concern of Harbour authorities when the Wairau and lower Opawa were important for shipping.

The Wairau bar is typically built by waves to a height of 2.3 m above sea level. It can be overtopped by floods that occur from time to time and when this occurs a direct mouth is then scoured out. This scouring takes some time to achieve, and in a fast rising flood the flood water levels upstream may be much higher for some period. This can lead to overtopping of stopbanks. This is reported to have occurred in the 1929 flood when flood levels in the lower river were recorded as higher than the much larger 1926 flood.

Once a direct new mouth is formed the cycle begins to repeat itself with sea forces gradually extending the bar further north.

The tidal flushing flows into the lower Wairau and Vernon Lagoons are reported as up to $300m^3$/sec at spring tides (Davidson (1959)), some three times the median combined river flows. The size of this tidal flushing flow is important in keeping a direct mouth open for longer.

The 1848 earthquakes Eiby (1982) reports as causing 1.5 metres subsidence of the Vernon Lagoons by consolidation of the silt bed through shaking. This led to a consequent enlargement of the lagoons and greater tidal flushing flows. These increased flushing flows may have been instrumental in improving navigability over the bar and hence the recorded subsequent boat access up the Opawa and to the establishment of Blenheim.

These combined tidal flushing flows and river flows can be concentrated by a guide bank to inhibit the development of the bar. At least 3 such guide banks or jetties have been built by river or harbour authorities over the last 85 years starting with the Harbour Authority of the day in 1097. The last, a rock bank some 500 metres long, was built as part of the Wairau Valley Scheme in 1961.

Figure D2

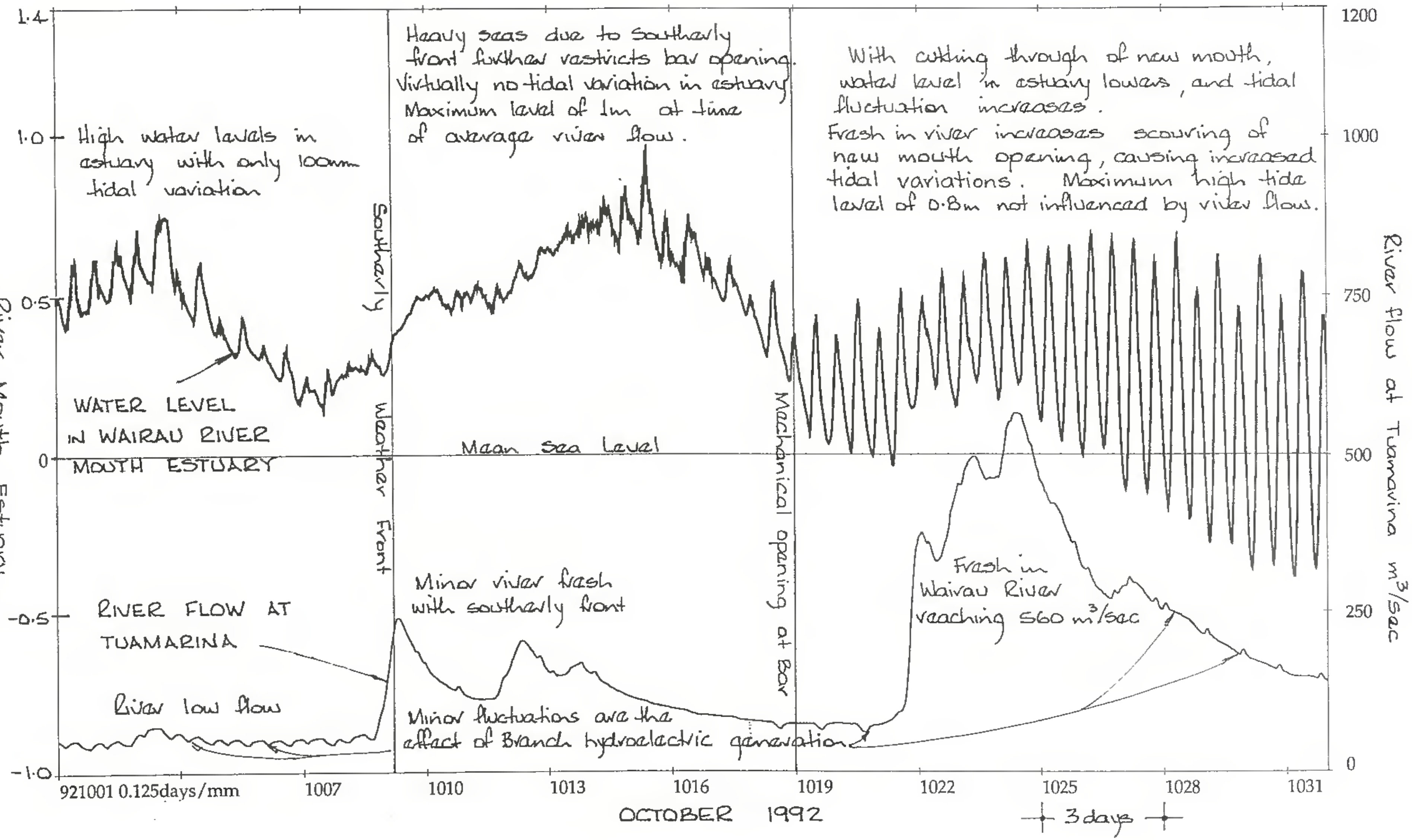


FIGURE D2 WAIRAU RIVER MOUTH.
WATER LEVEL RECORDED IN ESTUARY.
October 1992 - Mechanical opening of partially blocked Bar in this period.

This 1961 rock guide bank, at a cost of $1 million in todays terms has been very effective at keeping a direct open river mouth. Since its construction only twice, in 1974 and 1992, has the mouth partially blocked. In both occasions reopening of a direct mouth was helped by mechanical excavation which enabled a new mouth to open and scour out in a relative small fresh in the river.

This partial mouth blocking may be getting progressively worse but evidence to support this is inconclusive. It may simply be due to an uncommon pattern of wave forces in 1974 and 1992. It is to be noted that in 1974 and 1992 the beach bar had prograded 100 metres on the upstream side and 200 metres on the downstream side compared to 1960 when the guide wall was constructed. Aerial photographs show that there is little difference between 1972 and 1992 conditions.

Figure D2 shows water levels recorded in the Wairau river estuary 500 metres upstream of the mouth, and the effect of the degree of mouth opening on these water levels, and also the effect of changing river flow.

Figure D3 is an aerial photograph of the river mouth in November 1991, superimposed on which is the 1948 coast line and river bank line.

(ii) Tributary inflows of drainage and local floodwater into the lower Wairau are by culvert pipes through the stopbanks. Simple floodgates (or flap valves) are constructed on the outlet of these culverts to prevent water flowing back from the river. The floodgates are open at low to average flows, and/or at low tide for natural outflows. These floodgates, while essential for preventing the backflow of floodwater, are claimed to adversely effect movement of whitebait and other fish into the drainage network.

The floodgates need repair, maintenance and renewal from time to time.

Scale: 1:15000

Metres
0 100 200 300 400 500

FIGURE D3. WAIRAU RIVER MOUTH - BAR.

Comparison of 1948 and 1992 Conditions.

Aerial Photograph at 30/11/91

Solid line - Coast & Riverbank line 1948

Figure D3

(b) Methods and reason for adoption

(i) **Wairau mouth.**

- The "do nothing" option which would allow the bar to partially close for periods of time is not acceptable.

- A direct open mouth has considerable benefit for flood control and drainage. It also has benefit for a wide range of other environmental issues. This direct open mouth can be achieved by :-

  - ♦ an extension of the rock lined guide bank to more permanently keep a direct mouth open;

  - ♦ or to excavate a pilot cut through the bar as and when required, so that a moderate fresh will readily scour out a new direct mouth.

  The choice between the two is primarily financial.

An extension to the existing rock guide wall would be approximately 100 metres long. The last 100 metres of existing bank would also be slightly realigned so that the new bank would extend directly out to sea. The cost would be approximately $250,000.

Mechanical excavation to assist self opening during a minor fresh would typically cost $15,000 each time.

The mechanical excavation will be the cheaper option provided that opening is required less frequently than on an annual basis. At present the need to assist opening of the bar is less frequent than once a year so that the mechanical pilot cut excavation **is the preferred option** for the time being. An extension to the existing guide bank may be required within the 10 years plan period.

A specific resource consent for excavation of a pilot cut on an as and when necessary basis has been applied for and recently approved (subject to conditions).

(ii) **Floodgates.**

- The continuing use of floodgates on culverts including repair and renewal as necessary **is the only practical option** to prevent backflow of flood flows through drainage and local floodwater culverts. Replacement of floodgates for culverts in strategic locations with side hung floodgates easier for fish passage, will be part of a staged programme. (Refer also to C3.17)

- It would be irresponsible to remove these floodgates or allow them to fail through lack of maintenance.
- Any other gate or valve system would be very expensive to construct and operate and would be potentially unreliable in flood situations.

D2 Wairau Diversion (Sea to Bothams Bend)

Reference Map 2

Channel characteristics (typical)

Type	:	Gently curving artificial channel through beach gravels
Length	:	4.2 km
Slope	:	0.07% (1 in 1500)
Channel Width	:	150 m
Floodway Width	:	300 m
Design Flood	:	3000m³/sec Design Freeboard 0.6m.

D2.1 Policy for Wairau Diversion (Mouth to Bothams Bend)

REFERENCE MAP 2

REFERENCE	POLICY	APPROXIMATE PRIORITY CATEGORY
	DESCRIPTION OF PROGRAMME METHOD	
D2.2.2 (a)+(b)(i)	Removal of paving gravels	(r)
D2.2.2	Deliberate strategic sediment removal	(r)
D2.2.2 (a)+(b)(i)	Widening of active rock lined channel	(x)
	Flood damage repair	(r)
	Maintenance	(r)

D2.2 Reasons for Methods and Policy for Wairau Diversion

2.2.1 Issue : Sedimentation

(a) Situation.

(i) Enlargement by erosion was a key design intention of the Wairau Diversion. It was initially constructed as a 10 metre wide pilot channel within a 300 metre wide floodway from Bothams Bend to the sea, with only enough material excavated from the pilot channel so as to construct the stopbanks. Erosion of this pilot cut to a deeper and wider channel was intended to occur during floods with time. Trenches of rock running down the full length of the floodway were constructed to limit the eroded channel to 150 m wide.

The highest beach ridges were closest to the sea. The natural ground slope was thus generally uphill until the final coastal beach ridges were reached. The pilot cut was of course put in on a downhill sloping gradient.

Neilson (1993) has analysed the regular cross sectional surveys of the floodway. Some 15 re-surveys have been carried out on each of the 14 cross sections since the Diversion opening 30 years ago. The major findings were :

* There has been erosion of 1,600,000m³ of material, while conversely 400,000m³ has deposited. The erosion has been of the main channel and it has eroded out to the rock trenches for some of its length. Deposition has been of silt on the berms.

* Erosion has been predominantly in the lower half downstream of Rarangi Bridge where 1,100,000m³ of material has eroded. Above the bridge the 500,000m³ of erosion has been nearly matched by 400,000m³ of deposition.

* Figure D4 depicts some resurveys at cross section 10 midway between Rarangi bridge and Bothams Bend, showing the deposition and erosion pattern.

* Erosion started at the mouth and has worked upstream. Until 1983 the erosion upstream of Rarangi bridge was limited, and also counter balanced by deposition on the berms. It is this reach above Rarangi bridge that is dominant in controlling the inflow

into the Diversion. Thus prior to 1983 there was only a small increase in the flood flow capacity into the Diversion.

* The floods of 1983 moved large quantities of the heavy beach gravels in the reach downstream of Rarangi bridge, which had been stable since 1976.

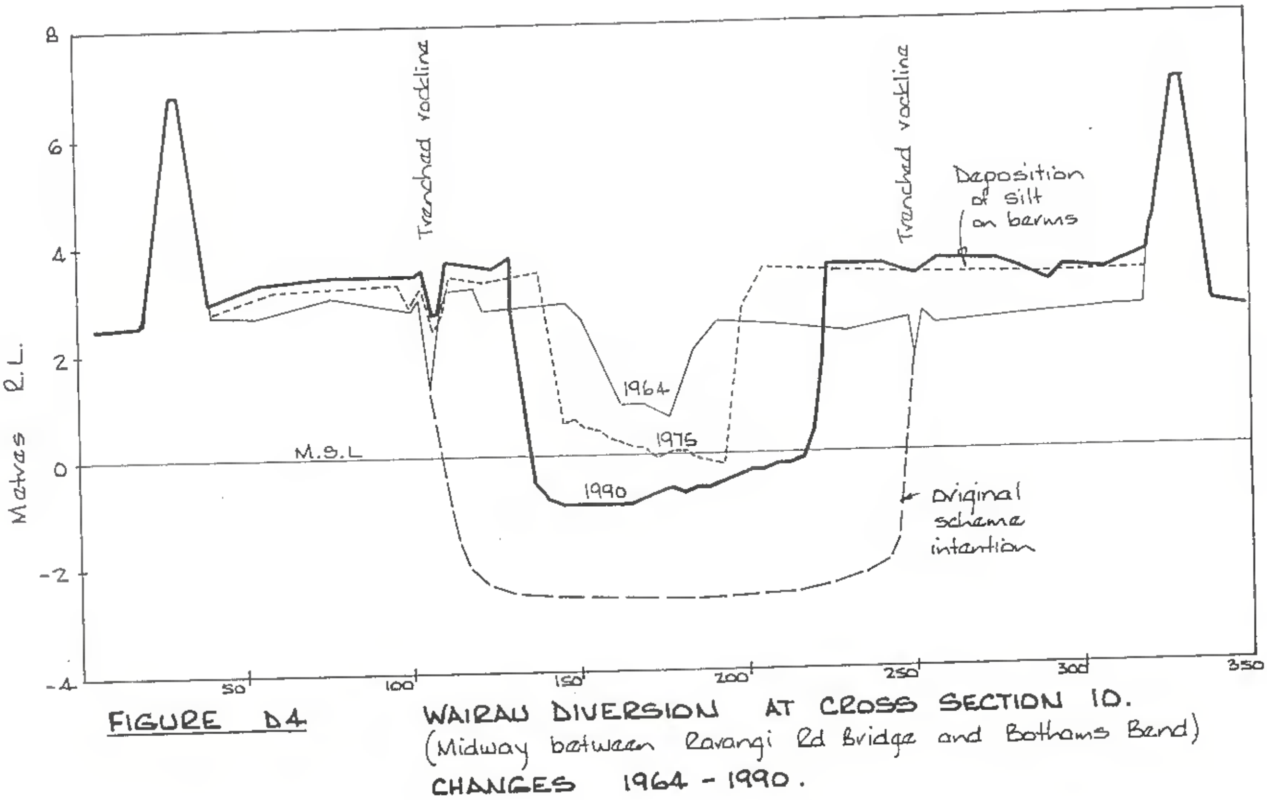
* This removal of gravel downstream of Rarangi bridge in the 1983 floods created steeper hydraulic conditions upstream. This has subsequently resulted in steady erosion of the finer beach gravels in the upstream reach above Rarangi bridge. This has therefore steadily increased the Diversion capacity over the last ten years.

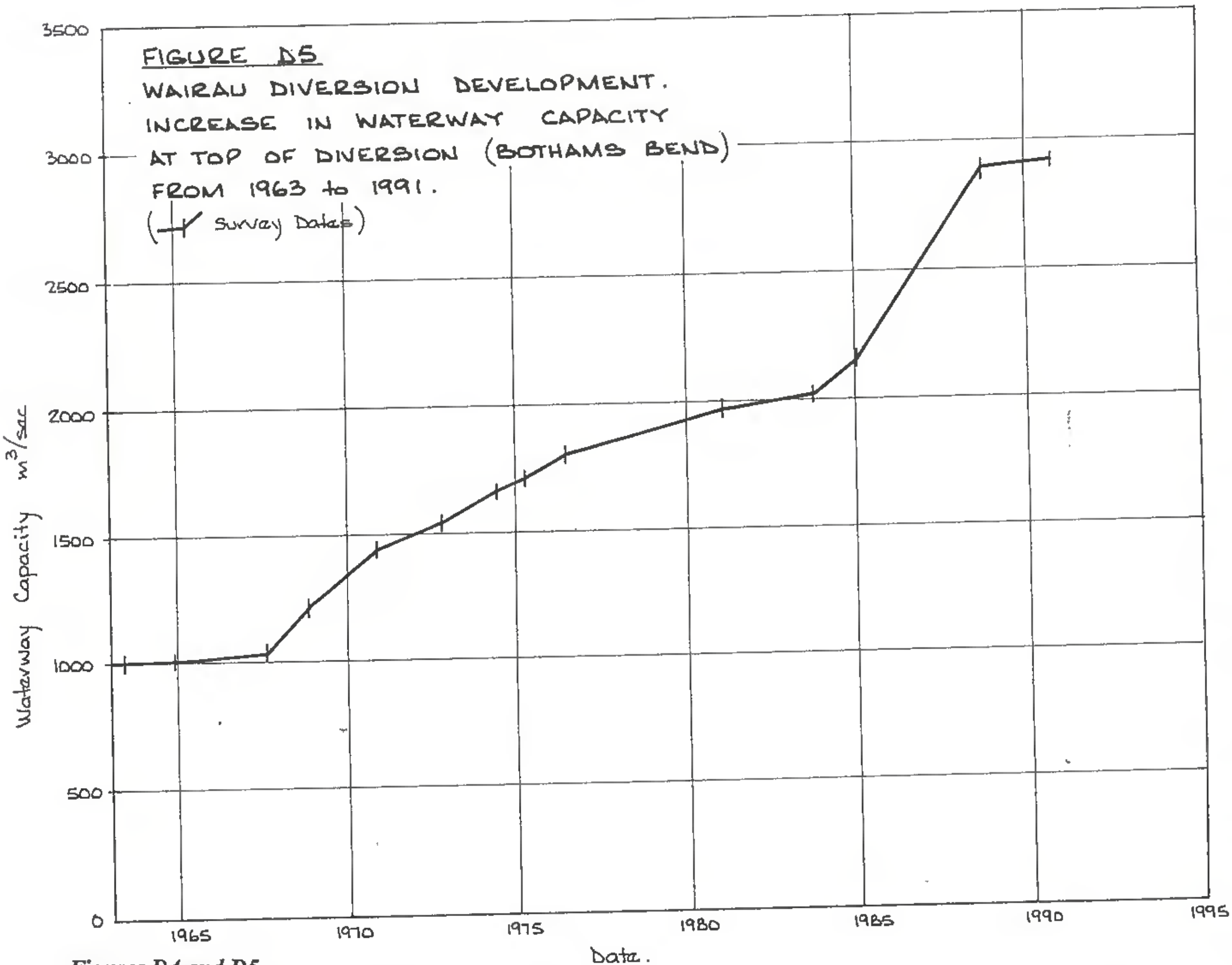
* A plot of estimated Diversion waterway capacity with time is shown on Figure D5, based on work by Noell (1992).

* The increase in the Wairau Diversion capacity is as much related to where the erosion is taking place, as to the total amount eroded. The recent steady increase in capacity is with the overall erosion rate less than earlier years.

* Apart from during the 1983 floods little erosion has occurred in the reach of heavy beach gravels downstream of Rarangi bridge. The channel bed in the 500 metres downstream of the bridge stands out as a high point, or submerged weir, in the channel long section, inhibiting erosion upstream.

* Figure D6 depicts a long section of the average bed level of the "channel" between the rock trenches for some surveys. This "channel" is now almost entirely full width, but at earlier times it had significant area of berm within an enlarging pilot cut channel. Noticeable is the high point at cross section 6 just downstream of Rarangi bridge.





Figures D4 and D5

* It is suggested that possible maximum diversion development would be a steady channel bed slope of 1:1500 for the full length of the Diversion.

* After this "possible maximum development" state is reached, reduction of the Diversion capacity could occur due to deposition of alluvial gravel from upstream. This has already started to occur in the top 800 metres of the Diversion.

(ii) **Summary:**

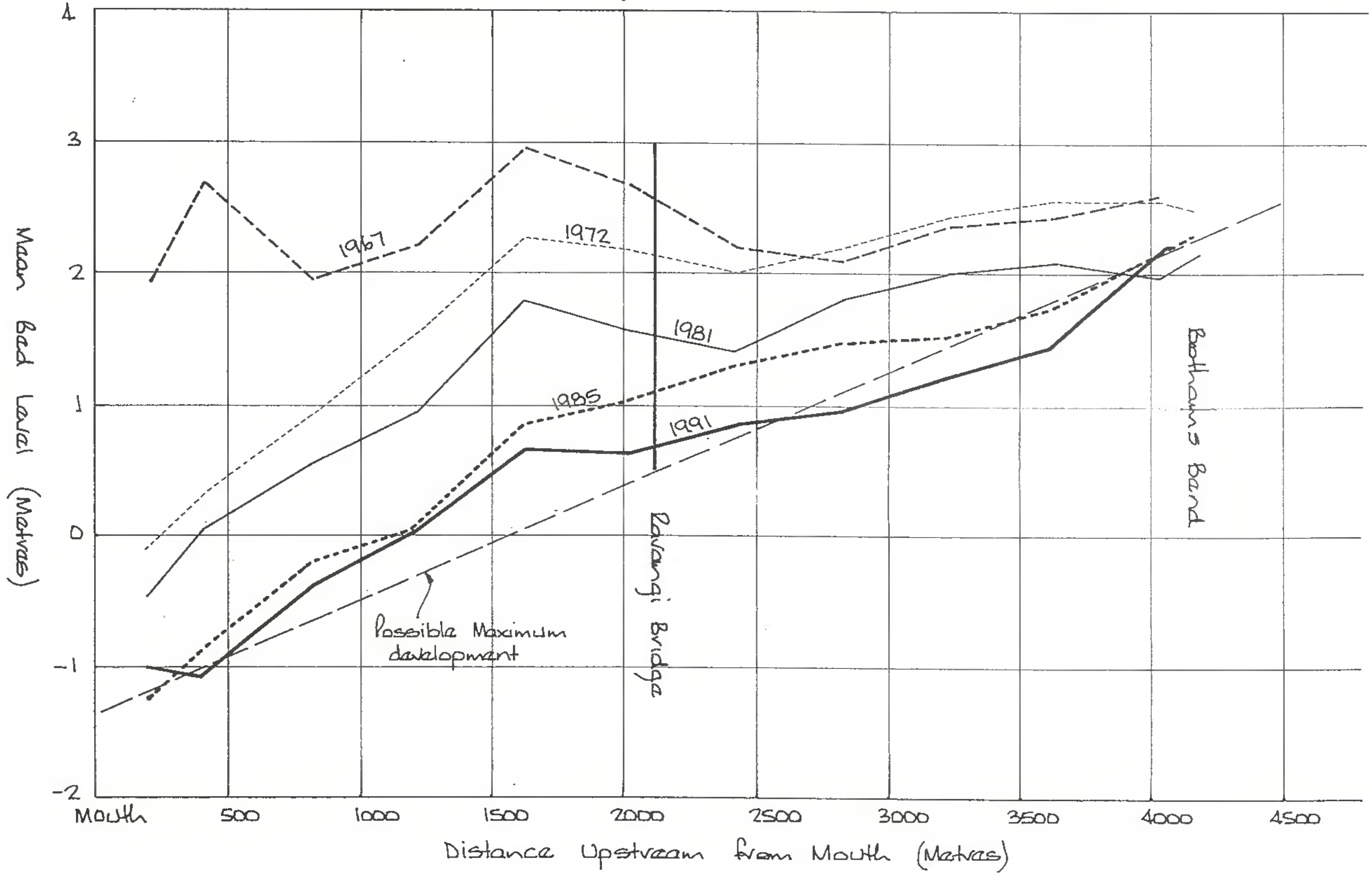
The Diversion has not and will not enlarge to provide as much waterway capacity as contemplated by the Wairau Valley Scheme. Further enlargement is partly inhibited by the large paving gravels in the 1 kilometre downstream of Rarangi bridge. In the longer term gravel deposition by alluvial gravels from upstream will occur.

(b) Methods and reasons for adoption

Will be discussed under D2.2.2 Waterway Capacity.

FIGURE D6. WAIRAU DIVERSION.

Reduction in mean bed level between rock tranches, with channel enlargement. 1963 - 1991



2.2.2 Issue : Waterway Capacity

(a) Situation

(i) The current capacity at the top end of the Diversion is estimated at 2800^3/sec. This needs increasing to at least 3000m^3/sec to achieve scheme objectives. Further downstream, especially below Rarangi bridge, the waterway capacity is already in excess of 3000m^3/sec.

The current capacity of the Diversion may only be of secondary relevance unless the control mechanism which determines the flow split into the Diversion and Lower Wairau allows this amount into the Diversion. This will be discussed more in Section D3, where it is shown that the capacity of the Diversion influences to some degree the flow split. Thus, as the Diversion increases in capacity, it will also attract a greater flow.

It will be therefore be desirable to increase the capacity of the Diversion to greater than 3000m^3/sec in order to help ensure that 3000m^3/sec gets into the Diversion and that the lower Wairau is limited to 2500m^3/sec in design flood conditions.

(b) Methods and reason for adoption

(i) **Increased Waterway Capacity**

- The Diversion, with its straight channel, uniform cross section and grassed berms is already very hydraulically efficient and no increase of channel efficiency can be obtained.

- The only sensible option is increasing the waterway capacity by main channel deepening or widening. This can be through natural erosion with time, or deliberate excavation, or a combination of these.

  Natural channel erosion is now at a slow pace, and it may take many years for the channel to enlarge to the desired capacity.

  Immediate excavation to design capacity would require removal of approximately 500,000 cubic metres of material, most of it from the bottom of the main channel which is continuously carrying water. The cost would be at least $2 million dollars.

- Removal of the large 200mm diameter boulders that pave the channel in the 1 kilometre downstream of Rarangi bridge will encourage further natural erosion of the finer material over the whole length of the Diversion. This is seen as the preferred option.

  The most practical removal of the large paving gravels is by scraping the top 300mm of gravels from the bars above the low tide waters edge and removing from the channel. Subsequent floods if above 1500m³/sec (approx twice a year) then erode the exposed finer material until such time as a new paving layer is formed and the process repeated. In total some approximately 50,000m³ of material would be removed in this way over the next few years.

- In the longer term waterway capacity may become compromised again as larger alluvial gravels are transported in from upstream by the river and deposited. Options to deal with this include the possibilities of digging this gravel out and/or widening the active channel by moving back the trenched rock lines. These are both expensive options that are unlikely to be required in the next 10 years of this plan.

2.2.3 Issue : Stopbank Erosion Protection

(a) Situation

Trenches of rock were initially dug in over a central 150m width, leaving some 75m as berm to each stopbank. Although this rock trench was limited as to quantity of rock and to depth of rock placement it has generally proved adequate to hold erosion when attacked.

With a flat gradient of 1:1500 the erosive power of the river is low and so only moderate bank protection works are required.

(b) Methods and reasons for adoption

- Trees have the disadvantage of impeding the waterway, and the height of bank required to be protected would also present difficulties.
- Continuous trenches of rock lines have already been constructed. These can be easily maintained with rubble available in large quantities readily at hand at the Pukaka quarry. **This is the preferred option.**

2.2.4 Issue : Stopbank Structural Integrity

(a) Situation

The stopbanks were built fairly recently to a high standard and finished with an outer layer of impermeable silt. The berms have a thick layer of impermeable silt and the main channel is 75 metres away so that the potential seepage path under the stopbank foundation is long. The stopbanks are therefore considered to be sound.

2.2.5 Issue : Flow Control Mechanisms

(a) Situation

(i) The Wairau Diversion bar has on a minor scale the problems that the Lower Wairau mouth bar has.

There is **not** a longshore drift to build up an extensive bar of marine sediment and prograde the coast at the mouth. The flanking rock lined banks keep the flow going straight out to sea. Oddly enough the weak longshore drift that is present runs from north to south contrary to the strong south to north longshore drift at the Wairau mouth.

The mouth does block completely at times and flows of up to approx. $10m^3/sec$ can seep throughout the 2.3 metre high barrier. Flows greater than this will overtop this barrier and scour out a new mouth. This backing up effect of a mouth bar blockage is limited to 2km due to the steepness of the channel upstream, and is of fairly short duration. In these situations drainage of the area is impaired and fish access into the Diversion prevented.

(ii) The issue of the flow control mechanism that determines the flow into the Diversion, is discussed in Section D3.

(b) Methods and reasons for adoption

(i) **Blocked Bar** - A pilot channel through the beach bar can readily be cut by bulldozer, and then even moderate flows scour a gooa channel out. **This is the preferred activity.**

D3 Flow Division Area of Diversion and Lower Wairau, and Spring Creek

Reference Map 3

Channel Characteristics

This area is a transition area as the Wairau divides into two channels, and the slope flattens considerably. At Tuamarina the channel slope is 0.15% (1 in 700), and this flattens down the gravel "Diversion" channel to 0.07% (1 in 1500) over a 1.2 km distance.

The convoluted 2.5km "Lower Wairau" channel flattens to a 0.05% (1 in 2000) slope by Ferry bridge and changes from a gravel bed to a silt/gravel bed. The even flowing groundwater supplied Spring Creek joins midway down this "Lower Wairau" channel.

D3.1 Policy for Flow Division area of Diversion and Lower Wairau, and Spring Creek

REFERENCE	POLICY	APPROXIMATE PRIORITY CATEGORY
	DESCRIPTION OF PROGRAMMED METHOD	
D3.2.2(a)+(b)(i)	Deliberate strategic gravel and sediment removal	(a) + (r)
D3.2.2 (a)+(b)(ii)	Spring Creek floodgated culvert and stopbanking	(a)
D3.2.2 (a)+(b)(iii)	'Diversion' channel stopbanking raising	(c)
	Encourage commercial gravel extraction	(r)
D3.2.2 (a)+(b)(iv)	Removal of constricting knob in floodway	(a)
D3.3.4	Investigation of need for flow division control structure	(r)
	Flow division structure	(x)
	Flood damage repair	(r)
	Maintenance	(r)

D3.2 Reasons for Methods and Policies for Flow Division Area of Diversion and Lower Wairau, and Spring Creek

3.2.1 Issue : Sedimentation

(a) Situation

Sedimentation is the major issue in this area. Erosion and deposition in the two channels controls the flow division between them. It also affects flood water levels and the need for stopbanking a long way up Spring Creek.

Bed level cross sectional information is limited to only 2 sets for the "Lower Wairau" channel, in 1957 and 1992. The "Diversion" channel has seven sets of cross sections taken from 1972 to 1992.

(i) The Wairau Valley Scheme anticipated that the effect of the Wairau Diversion development downstream would also induce bed erosion of the 'Diversion' channel in this division area. The bed of the 'Diversion' channel from Tuamarina to Bothams Bend was predicted to erode and lower by over 2 metres.

This has not occurred, for the bed levels have stayed very constant and indeed deposition of 0.3m would have occurred if the counterbalancing excavation for stopbank construction is discounted (Neilson (1993)).

The bed material is coarse alluvial gravels deposited by the river in previous times when in fact this channel was the main channel of the river carrying greater flood flows than as for 'Diversion' channel today.

The channel slope, bed material size and flow are in balance with each other and it is not surprising that the bed has not eroded.

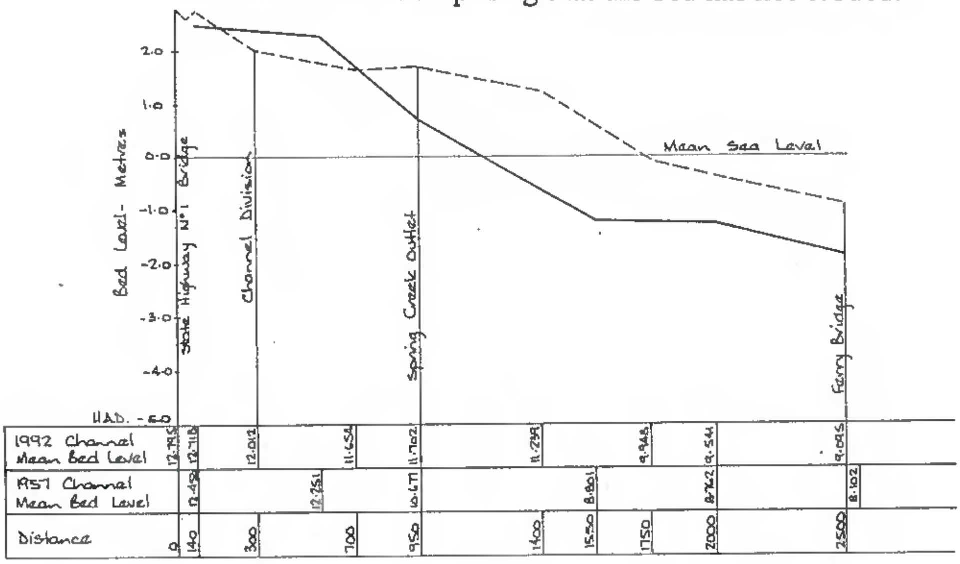


FIGURE D7. LOWER WAIRAU CHANNEL COMPARISON 1957-1992.
Mean Bed Levels - Tuamarina Bridge to Ferry Bridge

(ii) Considerable deposition has occurred in the "Lower Wairau" channel. Between 1957 and 1992 the channel mean bed level aggraded by 1 metre at the Spring Creek outlet, up to 2 metres downstream of Spring Creek outlet, and reducing again to 1 metre at Ferry Bridge. Upstream of Spring Creek outlet to Tuamarina bridge gravel extraction has balanced the deposition. This long section of bed levels is shown on Figure D7. Without the Wairau Diversion this aggradation of gravel material would have been shared between the "Lower Wairau" and "Diversion" channels.

(iii) There is no man made control structure to proportion the flow down each channel. The natural bed levels are the control mechanism. The deposition and erosion pattern in this division area is the predominant factor in determining the flow split.

In major floods the percentage of flow carried by the Wairau Diversion has been recorded as :

1967	:	25%
1970	:	30%
1975	:	35%
1983	:	42%
1993	:	53%

(The percentage of flow carried by the Diversion increases as flood size increases. At lesser flows the Diversion carries proportionally less.)

The hydraulic analysis carried out by Works Consultancy Services (1992) together with the bed level survey dates indicates :

- The build up of sediment in the 'Lower Wairau' channel is the primary mechanism that has changed the flow split proportions.

- Development of the Wairau Diversion 1km downstream of the division has been important, but a secondary influence on the flow split proportions.

The build up of sediment in the 'Lower Wairau' channel to date has been to advantage in forcing more water down the 'Diversion' channel and reducing flood flows down the lower Wairau. The future sedimentation pattern may or may not be so advantageous.

From a flood control viewpoint it is important that the total flood flow is divided to limit both the lower Wairau and the Wairau Diversion to below their design capacities. Unless a specific flow control structure is installed, control of the flow split will be by sediment deposition, and/or gravel extraction.

Removal of the sediment by controlled commercial gravel extraction, and deliberate dredging of the silt/gravel sediment material of little commercial value will be important.

(iv) The sediment build up also affects flood levels in the river, and is of particular relevance with regard to a weakness of the system - the Spring Creek tributary. Stopbanks go back up Spring Creek for 3 km past Spring Creek township to Rapaura Road. These stopbanks are to hold Wairau water that backs up Spring Creek.

Spring Creek itself is groundwater fed and has no significant flood flows. The Spring Creek stopbanks are 0.9m lower than the Wairau stopbanks. This is also the level of the railway line.

(Should a Wairau flood breakout upstream Spring Creek is a pathway for these floodwaters to get back into the Wairau once flood levels have dropped.)

In July 1983 flood levels were 0.3m higher than the Spring Creek stopbanks. Overtopping and damage occurred. Flood levels were similar in 1962.

The predicted design flood levels in todays situation is 0.1m higher than for July 1983. This can be attributed to channel sedimentation.

The build up of sediment in the channel, especially between Ferry Road bridge and Spring Creek outlet, has been detrimental to flood levels backing up Spring Creek. Significant development of Spring Creek township has occurred since 1983, so that there are more people and property at risk from Wairau floods.

(b) Methods and reasons for adoption

This will be discussed specifically in the following sections.

3.2.2 Issue : Waterway Capacity

(a) Situation

(i) The 'Lower Wairau' channel is just up to capacity to carry the 2500m³/sec design flood as for the Lower Wairau downstream. This includes the left bank stopbank needing to be higher because flood levels across the Morrins Hollow left berm are 0.4m higher than in the main channel. Further sediment build up of the channel will reduce waterway capacity.

(ii) The Spring Creek stopbanks are 0.7m lower than appropriate - allowing for 0.3m freeboard compared to 0.5m for the lower Wairau. The standard protection afforded is therefore has a 40% chance of being exceeded in the next 10 years (a 20 year return period flood). Further sediment build up in the river would reduce this standard still further.

(iii) The 'Diversion' channel has two stopbanks on its left bank. The 'original' river stopbank, some 350 metres away from the channel, was effectively duplicated in 1972 by a bank only 50 metres from the main channel. The 'original' bank, while of adequate height, was narrow and steep sided and of doubtful structural integrity. This inner straight stopbank is however, 0.8m low. It was overtopped by the July 1983 flood.

There are therefore two stopbanks in this area, neither of them to a satisfactory standard. Sandwiched in between is productive but relatively low lying land, that is not protected to design flood standard.

(iv) There is a constriction on the right berm of the 'Diversion' channel just upstream of Bothams Bend. This constriction is a 1 hectare knob of high ground on the right berm that affects flood flows. Removal of this knob of high ground will have an effect on the flow division and will increase the proportion going into the Wairau Diversion.

(b) Methods and reasons for adoption

(i) **Future sediment deposition raising flood levels**

- Raise stopbanks - expensive and undesirable from a flood hazard safety viewpoint.

- Force more water down the Wairau Diversion - this may require the expense of a control structure, and it may also require enlargement of the Wairau Diversion.

- Encourage commercial gravel extraction. **This is a desirable option** that will be embarked on. Nevertheless, in the immediate future it is unlikely that commercial extraction can remove the required amount of sediment desired.

- Deliberate Council sediment removal - expensive and may affect fish habitat and angling if carried out underwater.

- Do nothing - this is contrary to scheme objectives.

Further sedimentation is expected, but its extent is not known, and no major decisions should be made until the extent of the problem is clearer. Regular river cross sectional survey, suspended sediment sampling, and development of mathematical model of sediment deposition mechanisms is one part of the investigation into the need for a flow control structure at the top of the Diversion. Examination of the environmental and ecological effects of the changed flow pattern on the lower Wairau and Vernon Lagoons is another part of the investigation. This is discussed further in D4.2.3.4.

Deliberate strategic excavation as well as commercial gravel extraction of the river bed is required.. In the meantime, the most important reach is the 800m upstream of Ferry Road bridge, especially the bend area. Excavation to widen and deepen this reach will have the most effect on flood levels over the whole reach while having the least effect on the flow division mechanism into the Diversion at the top end of the reach. This channel excavation would be carried out on the inside of the bend (north eastern) on an annual basis and its effect monitored.

Much of this channel excavation work can be done above water level as a significant beach has been formed. However, it will also be desirable to excavate under water level. This will disturb sediments and detract from angling and other recreational use of the river. Nevertheless its advantage is so desirable that the work should be carried out. Consultation with Fish and Game Council and DOC will be desirable to ascertain preferred timing and other conditions for the work.

(ii) **Spring Creek stopbank level.**

- The channel excavation described immediately above [D8.3.2(i)] is principally expected to prevent the current unsatisfactory condition from worsening. Improvements to the Spring Creek system are required to bring this area to the design standard.

- The 'do nothing' option is contrary to plan objectives. There is considerable urban and commercial development in the Spring Creek township that is not protected to a 100 year return period event.

- Raising the Spring Creek stopbanks for approximately 3km length in 0.7m is a difficult, disruptive and expensive operation due to proximity to houses and roads. In some places concrete walls would be required to minimise space requirements.

  The Spring Creek rail bridge and state highway bridge are also underheight. Raising these bridges would be expensive. The alternative of sand bagging the bridges in flood times would be quite feasible, but does have the disadvantage of road and rail closure.

  The stopbanking system would also have to be extended through the motorcamp and across Hillocks Road and upstream.

  The overall option is likely to cost several hundred thousand dollars and be opposed by landowners affected by the works. It is not a desirable solution.

- Hydraulic computer modelling of the river has been used to calculate the flood levels in this reach of the river, which are in good agreement with bed levels shown in figure D9. Design Lower Wairau flood levels 400 metres downstream of the present Spring outlet are 0.5m lower than at the current outlet itself.

  A diversion of the bottom 400 metres of Spring Creek and new stopbanking between the Wairau and Spring Creek in association with this diversion will prevent Wairau floodwater getting into Spring Creek until its new outlet confluence.This diversion and stopbanking off of Spring Creek to outlet 400 metres downstream will therefore lower flood levels backing up Spring Creek by 0.5 metres.

  The new outlet position would also be where the recommended Lower Wairau channel excavation and deepening (D3.2(ii)) has the most effect. A total lowering of flood levels by 0.7 metres is expected to be achieved by the combined works.

This is a feasible option and has the advantage of providing for any extra large flood discharge down the Spring Creek that breaks out from the Wairau further upstream and gets into Spring Creek as a secondary floodplain flow path.

- Build a (Wairau) stopbank across the mouth of Spring Creek at its confluence with the Wairau. A culvert would be built through the stopbank to pass Spring Creek flow and this culvert to have floodgates that prevent Wairau backflow. This option will achieve the most positive prevention of Wairau flood flows back up Spring Creek.

The culvert would have to be large enough to provide for flood flows from Spring Creek itself of an assessed $10m^3$/sec. More importantly, the culvert size would need to keep water velocities sufficiently low to provide fish passage for the normal Spring Creek flows of $4.5m^3$/sec.

A twin 2.1 metre diameter concrete culvert will provide adequately for flood flows and keep normal average water velocities to an average of approx 0.65m/sec, with even lower velocities on the bottom where artificial roughness stones will be glued to the culvert pipes. These velocity criteria are similar to existing stretches of the final reaches of Spring Creek before it joins the Wairau.

This size of culvert also is commensurate with the Spring Creek depth near its Wairau confluence, and the pipe invert level will be approx. normal existing bed level, and a free water surface level would be achieved below the soffitt of the pipe. The floodgates would be side hung gates, and the hydraulics of the site are such that they would be open for over 99% of the time.

Preliminary discussion with Department of Conservation staff indicates this is likely to be acceptable for fish passage, but specific consent is required under the Fish Passage Regulations for which detailed design of the structure is required.

The 30 hectares flood berm area of the lower reaches of the stopbanked Spring Creek will provide storage for 900,000 cubic metres of Spring Creek water before stopbanks are overtopped. This is amply adequate for Spring Creek flows without overtopping stopbanks.

Should Wairau water breakout and get into Spring Creek some provision needs to be provided for this to get into the Wairau. The maximum sensible flows to be designed for is assessed as $50m^3/sec$.

This is a conservative estimate of the maximum capacity of the unstopbanked reaches of Spring Creek before overtopping occurs with overland flows towards Grovetown, and also appropriate for draining the Spring Creek catchment in approx 2 days in the case of any Wairau breakouts.

This flow would be provided for by a 50 metre length of stopbank that was set 1.2 metres less than design stopbank height, with appropriate flapgates (or floodgates) that only permitted flow from Spring Creek into the lower Wairau.

This is the preferred option. The cost will be similar to that for the diversion proposal, but it is more certain in operation. Detailed design is required to obtain fish passage consent from the Minister of Conservation, also appropriate to get specific resource consent.

(iii) **Low 'Diversion' channel stopbanks.**

- The 'do nothing' option has the implication that the original stopbank is still the official stopbank and should be kept maintained. Its doubtful structural integrity would need a more detailed examination.

- Raising the stopbank by 0.8m is a straightforward option that will clearly define the floodway boundary and give full flood protection to 30 hectares of land. **It is the preferred option.**

(iv) **High Constricting knob.**

- Removal of this knob is a straightforward option, and the material can be used for the stopbank upgrading on the opposite bank discussed in 8.3.2(b)(iii) above, or to be deposited outside the floodway.

3.2.3 Issue : Stopbank Erosion Protection

(a) Situation

The bed slope and water velocities in this area are not high. Erosive conditions are limited to the outside of the bends. Bank protection is by a combination of willow trees, and on the more erosive outside of sharper bends, by rock riprap. Bank protection measures are not required on the inside of bends.

(b) Methods and reasons for adoption

Maintenance and repair of existing tree and rock bank protection, is the preferred option. . Works will be required from time to time following flood damage. No specific proactive bank protection measures are needed.

3.2.4 Issue : Flow Control Mechanisms

(a) Situation

Flow Division into Wairau Diversion and Lower Wairau.

This has been discussed to some degree in D3.1. The current flow split into the Diversion is now close on being the desired flow split in flood times. The planned continued increase in Diversion development discussed in Section D1 and further sediment build up in the flow division area should soon reach the desired flow split. The Diversion should also soon be up to desired capacity with the proposals outlined in D2

Once this has occurred further Wairau Diversion development will not be wanted, As the Diversion develops and captures a greater proportion of moderate floods, the lesser flood flows down the lower Wairau would increase its siltation there. This will reduce its flood capacity.

The reduced flows down the lower Wairau especially at normal flows may affect the salt water/fresh water balance in the Lower Wairau and Vernon Lagoons, and be detrimental to the ecology of the area. The induced increased sedimentation could also be having a detrimental effect.

Some other rivers in New Zealand have flood diversion systems with control gates on to control the amount of flow in the diversion channel. Such diversion gates are usually open only in times of large floods.

Perhaps ideally a flow split of 75% : 25% in the favour of the Lower Wairau is required up to a flows of 2000m³/sec, and once above 2000m³/sec the flow split to reverse to 25% : 75%. Such a flow split would have the bulk of minor floods using the Lower Wairau, but the Diversion carrying an increasing amount during major floods.

(b) Methods and reasons for adoption

Control Structure

The tighter the degree of operational rules desired the more sophisticated a control structure is required. A structural gate system would be very expensive, but at the other end of the scale leaving things to nature has little control.

There may be some opportunity for intermediately costed control mechanisms such as using shingle banks that would fail on overtopping. This would have a continuing maintenance and restoration cost. The reliability of these operations is also an important factor.

The need for any control mechanism in future is not proven. Perhaps adequate control can be provided by manipulation of sediment extraction in the reach. A major reason for flow control could be environmental conditions in the Lower Wairau and/or the desire to inhibit further siltation there.

Further investigation **is the preferred** option. This investigation will include sediment investigation as outlined in D1 as well as environmental and ecological monitoring of the Lower Wairau and Vernon Lagoons. This is seen as a longer term investigation and monitoring exercise. The design and location of a control structure would be the last part of the investigation. It is unlikely that a control structure could be demonstrated as necessary to be constructed within the ten year time frame of this plan.

D4 Wairau (Tuamarina to Waihopai Confluence)

Reference Map 3, 4, and 5

Channel characteristics (typical)

Type	:	Semi braided gravel bed river
Length	:	22 km
Floodway Width	:	800 m (reduced from 1000m in 1958)
Fairway Width	:	400 m (reduced from 600m in 1958)
Slope	:	0.3% (1 in 300), but steepens from 1 in 700 at Tuamarina to 1 in 200 at Waihopai Confluence.
Design Flood	:	5500m³/sec Design Freeboard 0.9m.

D4.1 Policy for Wairau (Tuamarina to Waihopai Confluence)

REFERENCE MAPS 3, 4, AND 5

REFERENCE	POLICY	APPROXIMATE PRIORITY CATEGORY
	DESCRIPTION OF PROGRAMMED METHOD	
	Encourage commercial gravel extraction	(a) + (r)
D4.2.1 (a)+(b)(i)	Deliberate strategic sediment removal	(r)
D4.2.1	Develop Gravel Extraction Infrastructure (Council) Plan	(b)
D4.2 (a)+(b)(i)	Cleared fairway of typically 400m width	(a)
D4.2.2 (a)+(b)(i)	Lowering and partial removal of downstream end of fairway banks and spur banks. - On northbank at Rock Ferry, - opposite Giffords Road, - upstream of Selmes Road. - on southbank at Jefferies Road, - upstream of Wratts Road, - upstream of Selmes Road	 (a) (b) (c) (c) (a) (b)
D4.2.2 (a)+(b)(i)	Raising of 8km of stopbanks on southbank. Hillocks Road to Cravens Cravens to Selmes Selmes to Wratts Wratts to Giffords	 (b) (a) (b) (a)
D4.2.2 (a)+(b)(ii)	Raising lower Conders groyne bank and upper Conders stopbank..	(c)
D4.2.2(a)+(b)(i)	3km new stopbank from lower to upper Conders	(b)

REFERENCE	DESCRIPTION OF PROGRAMMED METHOD	APPROXIMATE PRIORITY CATEGORY
D4.2.2 (a)+(b)(iii)	Raising northbank open ended stopbanks at : Barnetts : Mahers : Norths : Huddlestones	 (a) (c) (c) (c)
D4.2.3 (a)+(b)(ii)	Flood damage repair at two north bank training banks.	(a)
D4.2.3 (a)+(b)(ii)	Willow tree fairway edge plantings. Pilot retards to strengthen tree planting.	(r)
D4.2.3 (a)+(b)(iii)	Two rock headed cross banks groynes at middle Conders. Two rock headed cross bank groynes at Upper Conders Extension of continuous rock protection at lower Conders. Tree planting between cross bank groynes. Northbank training bank opposite Waihopai confluence return banking.	(a) (b) (a) (b) (c)
D4.2.3 (a)+(b)(vi)	Berm Shaping Works Shrubby willow protection tree planting. Spaced commercial tree planting.	(a) + (b) (r) (c) + (x)
D4.2.3 (a)+(b)(ii)	Land purchase for berm shaping, tree planting work.	(a) + (b) + (c)
D4.2.4	Stopbank filter toe drain at Hillocks Road and other sites.	(c)
D4.2.5 (a)+(b)(i)	Tuamarina pocket stopbank raising	(c) + (b/c)
	Wairau-Tuamarina stopbank raising of 200m immediately upstream of bridge	(a)
D4.2.5 (a)+(b)(iii)	S H 1 bridge works constriction - investigation - remedial work	 (a) (b/c)
	Flood damage repair	(r)
	Maintenance	(r)

D4.2 Reasons for Methods and Policies

4.2.1 Issue : Sedimentation

(a) Situation

(i) The prospect of gravel build up in this reach of the Wairau river has been a major concern for a long time. The Marlborough Catchment Board established a set of 30 river cross sections over the reach for survey which has been carried out in 1958, 1963, 1969, 1984 and 1991. A partial survey was also carried out in 1978.

Comparative analysis of these cross sectional surveys is not easy. In this wide braided river changes to the bed are occurring all the time with the formation and moving of braids, riffles and bars. A new braid can form and deepen on one side of the river, while a bar is building up on the other side of the up to 1km wide floodway.

It is the relatively recent computer availability that has enabled a detailed analysis to be carried out and this was done by Noell and Williman (1992). This was more detailed than the analysis by Wadsworth (1986).

A major difficulty in carrying out analysis is that the river control works since 1958 have reduced the width of the floodway and have also altered the position and width of the active channel within the floodway. The 1958 cross sectional survey could not therefore be directly compared to the 1991 survey.

This was overcome by dividing the analysis into two time spans. The period 1958 to 1969, and from 1969 to 1991. The cross sectional survey of 1969 is representative of when the river control works had imposed a new river pattern. Two different channel positions were defined for the 1969 survey - one for comparison with the 1958 (+1963) survey, (representing pre-scheme conditions), and the other for comparison with the 1991 (+1978+1984) surveys (representing post scheme conditions).

The 1969 - 91 analysis is the more definitive and represents the channel deposition/erosion pattern since river training works have been imposed. The channel was much more stable in position so the floodway could be divided into an active gravel channel, and berm areas of silt deposition. Some gravel extraction records were also available for this time period.

The main findings of Noell and Williman report in the 1969-1991 post scheme conditions were :

* Within the floodway between 1969 and 1991 there has been an average annual deposition of 142,000m³/year of sediment between Tuamarina and the Renwick Bridge. The sediment comprises of silt and gravel and these figures also include an estimated 47,000m³/year of gravel extraction.

* Within the relatively stable main channel in the same 1969-1991 time period, there was an estimated annual gravel deposition of 81,000m³/year between Tuamarina and the Renwick Bridge (including gravel extraction), with a further 8,500m³/year of gravel being deposited in the Diversion, and in the Lower Wairau below Tuamarina. This gives a total of 90,000m³/year of gravel deposited below the Renwick bridge.

* For the 7 km reach between Renwick Bridge and the Waihopai confluence there was an overall net loss of 12,000m³/year of sediment. In the upper half of this reach, erosion of the active channel occurred to be nearly matched in the lower half by deposition both in the channel and on the berm.

* The pattern of deposition is shown in Figure D8. It can be seen that the 4 kilometres upstream of Wratts Road is an area of significant deposition; the 4km reach downstream of Waihopai confluence an area of erosion; and that gravel extraction in the Tuamarina bridge area is of significance. Without this gravel extraction much more sediment deposition would have occurred, and this gravel extraction has altered the deposition pattern for some distance upstream.

* This deposition/erosion is not at a constant rate but is in pulses related to the pattern of flood flows.

* These deposition rates are only 1/3 of the Waimakariri river deposition rates (Griffiths (1989)). This suggests that lack of availability of sediment to pick up and transport is the limiting factor rather than the transporting capability of the Wairau River.

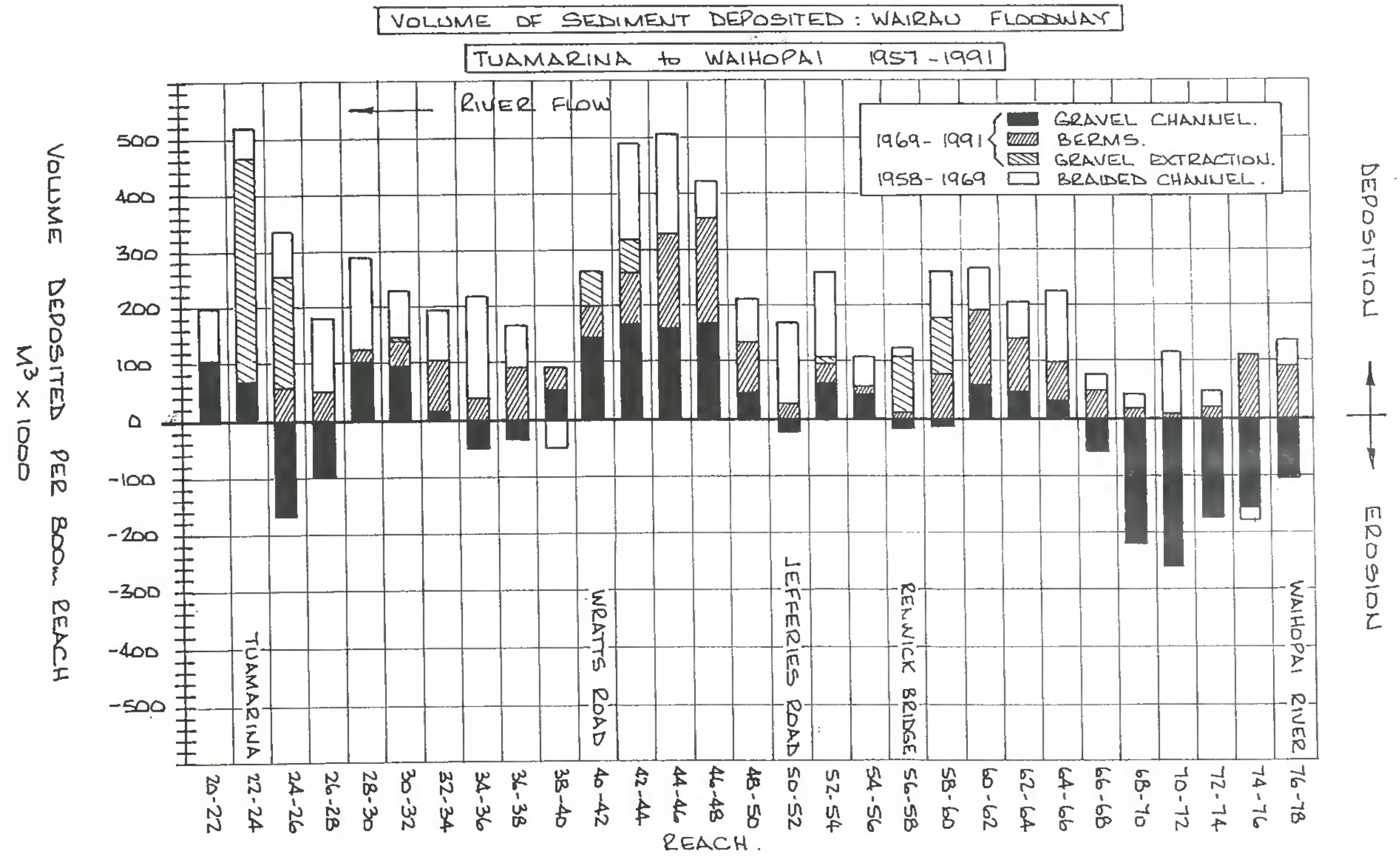


FIGURE D8. WAIRAU SEDIMENTATION PATTERNS.

The less accurate analysis of the 1958-1969 pre scheme conditions was limited to the then typically 600m wide active braided channel. Here 164,000m^3/year of sediment was deposited between Tuamarina and Renwick bridge, and 43,000m^3/year between Renwick bridge and Waihopai confluence. These deposition rates are larger than for the 1969-1991 period, though this could be attributed to margins of error in the analysis.

The sites of deposition are where the river has a significant reduction of slope, and it is this flattening of slope that is considered to be the major factor determining the location of deposition.

The most significant areas of berm deposition are similar to those areas of gravel (channel) deposition and appears to be infilling of low lying channels on the berms. This appears to have been occurring largely irrespective of the amount or type of vegetation present.

The results in terms of changes in mean bed level are shown on the below table, and divided in reaches of relative similarity.

	Average deposition rate in mm/year		**Approx bed level change**
Reach	**1958-1969 pre scheme situation**	**1969-1991 post scheme situation**	**1958-1991**
Tuamarina to Wratts Road (6km)	*20 mm/year	* 8 mm/year	+0.4m
Wratts Road to below Jefferies Road (4km)	25 mm/year	22 mm/year	+0.7m
Below Jefferies Road to Conders Groyne (8km)	10 mm/year	3 mm/year	+0.2m
Conders Groyne to Waihopai Confluence (4km)	10 mm/year	-12 mm/year	-0.15m

Over the 33 year period deposition has occurred in the floodway between Tuamarina and Conders Groyne. It is particularly severe in the 4km reach upstream from Wratts Road to 800 metres below Jefferies Road, where deposition of 0.7m has occurred.

* This would rise to 25 mm/year and 15 mm without gravel extraction respectively

Within measurement accuracy the amount and pattern of deposition is similar for the 1969-1991 post scheme situation as the 1958-1969 pre scheme situation.

This rise in bed level will result in similar rises in expected flood levels.

(ii) The deposition of sediment from Tuamarina to just downstream of Jefferies Road is very likely significantly influenced by the blocking of the Opawa distributary channel by the Conders Groyne in 1914. Gravel and other sediment is no longer being carried into the Opawa and deposited there. The increased flows in the mainstream Wairau are probably carrying gravel and sediment further downstream than the Renwick bridge area where deposition may have occurred in the past. The current deposition pattern is likely to vary slightly in the future as slopes readjust due to the deposition. In the longer term the Tuamarina area may be of the most concern for sediment deposition.

(iii) River works on this reach of the Wairau river were intended to train this braided river into a single thread channel, as discussed by Pascoe (1974). The advantages of training a braided river into a single thread channel were outlined in a paper by Nevins (1969). One of the anticipated advantages was the formation of a concentrated main channel which would then deepen by scouring its bed. This could be expected to reduce bed levels, confine the 2000m^3/sec mean annual flood into this main channel, and lower flood levels.

Equations based on Laceys work (Pascoe (1974)) indicated that a single thread Wairau channel should be 220 metres wide, and the hope may have been that this would carry the 2000m^3/sec mean annual Wairau flood.

This "single thread" channel has only been achieved to a very limited degree at low and average flows. There is no clear cut 220m wide channel. At 220m width the flow is typically 150m^3/sec. This is a little bit greater than the 120m^3/sec that typically occurred previously, but much less than 2000m^3/sec "dominant discharge" contemplated as possibly occurring. At flood flows of 2000m^3/sec the river is stopbank to stopbank, typically 800m wide.

As has been shown in the previous section there is little, if any, difference in the deposition pattern with the implementation of the river training works based on single thread channel principles.

Other NZ gravel bed braided rivers have also not responded to this single thread training method, most notably the North Ashburton (Keys and Connell (1986)).

(iv) The reduced width of the floodway and active gravel channel reduces the area available for deposition and consequently deposition causes greater rises in bed level and greater rises in flood levels.

(b) Methods and reasons for adoption

(i) **Sediment Build Up**

- Attempts to reduce sediment input by soil conservation and river control works upstream have been expensive and with little proof of effectiveness. As discussed previously, further upper catchment works are not currently justified on the basis of trying to reduce sediment from upstream.

- Commercial Gravel extraction can play a valuable role in combating sediment build up and maintaining adequate waterway capacity of the Wairau River. Gravel extraction could beneficially proceed in the Tuamarina Bridge to Renwick Bridge reach at a sustainable rate in the order of approximately 100,000m^3/year, over double the current extraction rate. An initial rate to clear the build up to date would be greater than this.

  In the Tuamarina Bridge and just upstream the current extraction rate of approximately 40,000m^3/year is about right. In the Wratts Road to Jefferies Road reach, considerably more gravel extraction would be desirable.

  Commercial Gravel extraction from this section of the river should be encouraged **as the most preferred option**. However, at present there is not the demand for as much gravel from the river as could be desirably supplied; and -

- Deliberate Council gravel and sediment removal is an option that needs to be examined. In the long term it may be the option (in association with commercial gravel extraction) to maintain the floodway to its required capacity. At the moment the floodway is substantially below capacity because of the combination of

  - Sediment deposition over the last 35 years or more.

- Hydraulic efficiency of channel found to be approx 10% less than previously assessed.
- Design flood increased by 8% in this plan.

While the current deposition patterns may change in the future, there is a need to address the lack of waterway capacity as of now. This is discussed in more detail in C4.4.2.2.

- Gravel extraction upstream of Jefferies Road is not desirable.
- The impact of gravel extraction by commercial or Council procedures is significant. The increased gravel and sediment extraction proposed **will require Council to develop a broad ranging plan** dealing with locations cf extraction, stockpiling, processing, placing of reject material, access to the sites both within the floodway and from public roads, the effect on the State Highway network and other nuisance effects.

(ii) **Opawa distributary no longer carrying away sediment** - As discussed in Section B it is not possible to turn back the clock and re direct Wairau waters and sediment into the Opawa at lower Conders groyne (Opawa breach).

(iii) **River Training Methods** - River training methods have been found to have little effect on changing the transporting and deposition of gravel and other sediments. There appears no advantage of continuing the single thread channel river training method of the 1960 Wairau Valley Scheme for the hoped purpose of attempting to change the deposition/erosion pattern.

The effect of sediment build up on reduced waterway capacity and options to deal with this problem, will be discussed in the next section.

4.2.2 Issue : Waterway Capacity

(a) Situation

Analysis of flood sizes is detailed in Appendix I with a recommendation of a design flood size of 5500m³/sec, being a 1 in 100 year return period flood. The capability of this reach of river to carry the recommended 5500m³/sec design flood is reviewed in Appendix II.

(i) For a 8km reach from Hillocks Road to Giffords Road the floodway does not have adequate waterway capacity.

It should be noted that the present day floodway waterway capacity is significantly less than in 1983. This is due in part to sediment deposition in the channel, and also in part due to the presence of high rock lined guide banks that impede the floodway. Some 8 rock lined guide banks or spur banks were partially washed away by the 1983 flood and this enabled the floodway to be more fully utilised during that flood. These banks have since been repaired and replaced in a stronger form. It is less likely that these guide banks will fail in future, and stopbanks will be more likely to overtop instead.

Much of the floodway is just capable of carrying a flood of 4400m³/sec - October 1983 size - which has a 30% chance of occurrence in the next ten years. Between Giffords Road to Wratts Road reach has a waterway capacity of less than 4000m³/sec - which has a 40% chance of occurring in the next ten years.

(ii) The 6km "Conders area" reach is also not up to design waterway capacity. This reach is where historically water can and did break out and/or spill out into the Upper Opawa. The 500m long lower Conders groyne blocking the "Opawa breach" and the 2 km upper Conders stopbank have not been completed to design flood standard height. The programmed 3km of stopbanking between lower Conders Groyne and upper Conders proposed under the Wairau Valley Scheme was also not completed.

This stopbanking work in the Conders area had been programmed for completion in the early 1970's under the Wairau Valley Scheme. The 1970 flood showed that the Wairau Diversion had developed very little at that time and that the combined capacity of the Wairau Diversion and Lower Wairau was still well short of full desired design standard.

The Marlborough Catchment Board therefore resolved in 1972 <u>not</u> to complete the stopbanking in the Conders area until the Wairau Diversion had developed.

Overflows in the Conders area were considered as reducing the flood flow going down the main river to Tuamarina, Spring Creek and the Lower Wairau. In this way a relatively equitable standard of flood protection was intended to be provided for Blenheim/Renwick residents (affected by breakouts into the Upper Opawa system) and Spring

Creek/Tuamarina/Lower Wairau residents affected by the Wairau and Lower Wairau.

This is the same bitterly fought argument that goes back over 100 years and was addressed by the 1917 Wairau River Commission as discussed in Section B.

The Marlborough Catchment Boards fears and expectations were reinforced by the July 1983 flood that broke out and caused considerable damage in the Tuamarina/Spring Creek/Lower Wairau area. But the flood down the Wairau had been reduced by flood overflow and a stopbank break in the Conders area into the Opawa system.

Following the 1983 floods the Marlborough Catchment Board refined its previous viewpoint with this resolution in 1985 :-

(a) "That a stopbank constructed to design freeboard be provided in the Upper Conders area when the development of the diversion has achieved full design freeboard downstream of Tuamarina; and in the meantime an equitable standard of protection be provided relative to that in Spring Creek area by a low stopbank which can be safely overtopped without scouring."

(b) That a "fuse plug" section of stopbank with a freeboard of 600mm above the design flood be prepared at Lower Conders."

This resolution has not been superseded. A low stopbank was built in the Conders area in 1991, Lower Conders groyne is not to full design height, and there is no stopbanking between lower and upper Conders.

The protection standard provided at the lower Conders groyne may be less than for a 4000m³/sec (20 year return period) flood. The protection standard is slightly higher at Upper Conders. The standard cannot be defined with precision, as significant freeboard is required in this area of variable flood levels. Flood levels depend on whether the main channel braid is on the northern or southern side of the fairway, and can vary by approximately 1 metre for the same size flood.

(iii) There are four significant open ended stopbanks on the north bank.

A difficulty in analysing the waterway capacity on the north bank is that does not have a continuous stopbank system. The floodway is confined by a combination of hillside, natural terraces, and lengths of open ended stopbank/training banks. Floodway berm land can be considered to extend up to the Tuamarina track Road in places. Partial flood protection is given by training banks. Flood waters will back up from the open downstream end, but at a lower level and a very low velocity.

Open ended training banks in excess of 1km long are called stopbanks because backflow around the downstream will not reach right back up behind the bank and so total flood protection is offered at the upper end of the bank.

- The 2.5km open ended stopbank (Barnett's bank) reconstructed in 1984 on the north bank immediately upstream of Tuamarina has the important role of directing floodwater away from the Wairau-Tuamarina stopbank that runs back up the Tuamarina stream and protects Tuamarina township. This training bank is not quite to its design height for its upper 1km and needs raising by up to 0.8m.
- The 1.5km open ended stopbank (North's) on the north bank of the river immediately downstream of Renwick bridge is less than design height.
- The 1km training bank/stopbank (Maher's) from Rock Ferry opposite Conders Groyne may not be up to design height from flood levels observed in the June 1993 flood.
- The 2km open ended stopbank (Huddlestone's) on the north bank opposite and upstream of Giffords Road also may not to be design height from flood levels observed in the June 1993 flood.

(b) Methods and reasons for adoption

(i) **Waterway capacity increase Hillocks Road to Giffords Road**

- Do nothing. This is contrary to a main objective of the plan and is not acceptable.
- Deliberate Council gravel and sediment removal. The waterway capacity for the 8km from Hillocks Road can be increased by raising stopbanks by typically 0.8m, or conversely deepening the channel over its width also by 0.8m. Thus to achieve the desired increase in waterway capacity would require approx 2,500,000 cubic metres of sediment removal in the 8km reach from Hillocks to Giffords Road. This would cost approx $10 million and

further require the purchase cost of land outside the floodway on which to store the excavated material.

Furthermore, it must be understood that river bed levels re-establish so as to be in balance with the river flow and transported sediment. The removal of gravel and sediment from the floodway may encourage further deposition in the same place. Thus the solution is likely to commit a continuing future gravel and sediment removal cost.

Deepening the channel by gravel extraction may also lessen the stability of the banks through undermining. As is discussed in D4.2.3 stopbank erosion protection costs are very high. Deepening the channel by gravel extraction is likely to cause an increased cost of stopbank erosion protection works.

- Encourage commercial gravel extraction. **This is the most desirable option**. As discussed in D4.2.1 it is an option that may in the future be appropriate to maintain an adequate waterway capacity. It is not adequate to achieve the required increase in waterway capacity for the reasons described above.

- Strategic gravel and Sediment Removal
Where bed levels are particularly high it may be possible to carry out limited deliberate Council gravel and sediment removal. This may have limited success, but is likely to be the forerunner to deliberate sediment removal to maintain waterway capacity once it is achieved. A system of deliberate Council sediment removal together with encouraged commercial extraction need be started now, and the results carefully monitored. The excavated material will be placed on Council land on the landward side of stopbanks, or in backwater areas in the toe of guide banks within the floodway. In the longer term, probably outside the ten year period of the plan, it will have to be transported and deposited outside the floodway.

- Improve the floodway efficiency. This is also a preferred option, but in itself will not be adequate to achieve the required increase in waterway capacity. Improvement of efficiency can be carried out by :

- * Clearing and maintaining free of vegetation an active channel fairway of typically 400m width. Improving the channel efficiency is a practical and logical option by clearing and maintaining a cleared fairway. Improving channel efficiency has the additional advantage of keeping flood levels lower, and thus potentially less dangerous should a breakout occur. Most but not all of the proposed fairway has been cleared, but four main areas remain. These are all on the north bank opposite Pauls Road, opposite and downstream of Giffords Road, just upstream of Waikakaho Stream and in the Conders area.

- * Lowering of training banks and spur banks within the floodway. This lowering of the training banks would be typically the downstream 200-300m of bank thus to the minimum required for holding a fairway meander pattern for stopbank erosion protection purposes. This is another practical and economic option that should be carried out as far as practical. The training banks and spur banks that are most beneficial to lower at the downstream ends are :

  - * Rock Ferry training bank 2.5 km upstream of Renwick bridge on northbank.

  - * Northbank open ended stopbank opposite Giffords Road.

  - * South bank training bank 0.8 km upstream of Wratts Road.

  - * Jefferies Road training bank on southbank.

  - * Spur bank 0.5 km upstream of Cravens Road.

These training banks currently serve an important purpose for stopbank erosion protection. Willow tree planting, supported as necessary by rail iron retards, will be required to replace the lowering and partial removal of these training banks. Such tree planting will be much more permeable than a bank, and allow water through to utilise the berm waterway capacity while still provide similar stopbank erosion protection. The tree planting and rail iron retard work will need to be carried out before or at least simultaneous to the lowering/shortening of the training banks. Berm shaping works may also be required before or simultaneously to guide bank lowering.

- Other training banks or spur banks that it may be desirable to lower and/or shorten pending further examination are :

  * The training bank and several spur banks between Selmes Road and Wratts Road.

  * The open ended stopbank on the north bank on this reach.

- Removal of berm vegetation as far as practical while ensuring there is adequate suitable vegetation to prevent erosion of berm and stopbanks.

  Some of the land on the northbanks is former braided river bed covered in thick growth of self seeded wattle and willow. Significant flow capacity improvement of this "berm land" could be made by partial removal of these trees, or by complete removal of the trees and replacement with spaced commercial value tree planting. More detailed studies are required to define the full benefit of the tree removal of such berm areas and its replacement with spaced tree planting. An area of 20 hectares between and opposite Wratts and Giffords Roads is a definite benefit area.

- **Raising Stopbanks.** Even with all practical improvements to floodway efficiency the waterway capacity is inadequate for 8km from Hillocks Road to Giffords Road stopbanks would need to be raised by typically 0.8m to provide design waterway capacity. This includes some freeboard provisions to allow for floodway sediment deposition over the next 20 years. In the shorter term it would provide adequate waterway capacity for a 5800m^3/sec (July 83 size) flood event, and much less than deliberate sediment removal. **It is a preferred option.**

  Raising of stopbanks here will only be approx 1/3 the cost of the option of moving and relocating stopbanks to enlarge the floodway.

- Relocating stopbanks to widen the floodway. This is an expensive option. It could only be embarked on if the longer term degree and location of river bed build up through sedimentation could be forecast with confidence. This is not the case, and within the 10 year time span of this plan the need for moving back stopbanks is not required.

Furthermore, the hydraulics of the river channel is very complex and the benefits obtained by improving channel efficiency as outlined in D8.4.2(b)(i) cannot be predicted accurately on our current knowledge. The result from the channel improvement work needs to be monitored during flood events and modelled by sophisticated computer analysis programmes.

It is premature to recommend that relocation of stopbanks to widen the floodway is required at this stage.

(ii) **Conders Groyne to Waihopai Confluence area**

- The do nothing option needs serious consideration. This option in effect was adopted by the Marlborough Catchment Board, as discussion in (a), so as to try and provide an equitable standard of protection for Spring Creek/Tuamarina/Lower Wairau as for Renwick/Blenheim. The 'do nothing' option was of course only expected to be an interim measure as the Wairau Diversion developed and would then be expected to provide full design standard at Tuamarina/Spring Creek/Lower Wairau. At that stage improvement of Conders was contemplated.

  This plan herein proposes works in the Diversion/Tuamarina/ Spring Creek/Lower Wairau area to bring that area up to full design standard. That being the case, the Conders area should also be brought up to full design standard.

  Furthermore a 'safety valve' or flood overspill area will not reliably work in this Conders area. Flood levels have been measured to be up to a metre different on each side of the river depending on the position of the main channel braid (Noel (1992)). Flood levels on the lower Conders groyne or upper Conders stopbank will vary depending on the position of the main channel braid. This was also observed by witnesses to the Wairau River Commission, and is also implicit in the observation that at upper Conders the 1923 flood levels for a 3500m^3/sec flood were very similar as for the 5800m^3/sec flood of July 1983. Plans show the main channel hard against the upper Conders area in the 1920's.

Any 'safety valve' or 'overspill' system relies on a flood level to be reached before coming into operation. If the flood level is inconsistent with actual flood flows so too will be the performance of the 'safety valve'.

Thus overtopping of the lower Conders groyne could occur in a moderate flood if the main channel braid was on the south bank. In this situation flooding would not occurr at Tuamarina/ Spring Creek/Lower Wairau.

Conversely overtopping of the lower Conders groyne may not occur even in a very major flood if the main channel is on the north bank. In such a flood damage could occur at Tuamarina/Spring Creek/Lower Wairau.

Simply, it is not feasible to have a structure here that would reliably divert a proportion of water towards the upper Opawa. Even a very expensive gate system may not be reliable. This is the same conclusion as the Wairau River Commission made in 1917 (or described in Section B3).

It should also be pointed out that there is a considerable area of land that would flood and be damaged between the Conders area and the upper Opawa floodway. In July 1983 some two thirds of the 1500 hectare of land between the Upper Opawa floodway and upper Conders was flooded.

Trueman (1993) has found this land has risen considerably in value over the last 10 years, doubling its capital value from $7.4 to $15.9 million dollars between 1981 and 1991. Much of this increased valuation was in improvements to the land, that would be more at risk from flooding. This land is not zoned as floodway and cannot be considered any longer as floodway.

The "do nothing" option is no longer acceptable even as an interim measure.

- Raising the existing stopbanks by typically 0.8m at lower Conders groyne and upper Conders **is the logical option** for these locations.

- For the 3 kilometres of the reach between lower Conders groynes and upper Conders there is either no stopbank, or old narrow poor quality low stopbanks. **In this reach a new stopbank is required**. The preferred alignment is typically 100m further towards the river from the existing natural terrace or old stopbank. The cost of the stopbank would be much the same for either alignment, but the relocation of the stopbank will enable approx 30 hectares of land to be excluded from the floodway.

(iii) **Northbank open end stopbanks** - The "Barnetts", North's, Maher's and Huddelstone's open ended stopbanks on the northbank to a lower standard is not acceptable. Where they seriously impede the flow they need removal, otherwise they should be raised to the defined standard, so that the land protected can be used for clear purposes. The "Barnetts" bank is in a category of its own as it protects Tuamarina township, and not just farmland.

4.2.3 Issue : Stopbank Erosion Protection

(a) Situation

Stopbank erosion protection is a very important issue because of its very high expense.

(i) Prior to the Wairau Valley Scheme bank protection works was by strong points of wire mesh and stone crates with heavy willow boughs built as and where river attack occurred on the south bank, and often very close to the stopbanks themselves. The 600m width of the braided channel allowed the main channel braid to develop at very oblique angles with strong cross river flows and heavy direct attack on the banks. Considerable expenditure was required on these stone netting and willow free based groyne structures.

The Wairau Valley Scheme sought to impose a single thread channel training pattern on the river, as outlined in D4.2.2(a)(iv). The major advantage of this single thread channel was the expected stable meander pattern that was achieved. Rock bank protection work would then only be required on the outside of the defined bends. The length of bank requiring such heavy bank protection would only be approx. 1/3 the total length of stopbanks. In the Wairau Valley Scheme report Davidson (1959) stated :

"It is recognised that considerable difficulties will be experienced in training this channel to (single thread) regime conditions. However, the advantage in lower flood levels, sediment discharge capacity, easier lateral protection and greater safety generally, are so considerable as to warrant considerable expenditure and effort to obtain conditions as closely approaching the ideal as possible."

Laceys empirical equations (based on sand bed even flowing Indian rivers) were used to set this intended single thread channel width at 220 metres, the radius of curvature of the meander as 900 metres, the meander wavelength as 2000 metres and the meander amplitude as 700 metres.

Curved rock line training banks on the outside of intended bends were used to create this predetermined channel alignment. Construction started in 1966.

By 1974 shortcomings of the design were noted. Realignment of training banks was carried out so as to achieve a longer meander wavelength and longer radius curvature. (Thomson and Pascoe (1974). This was a major exercise. In some areas a new training bank was constructed directly on the opposite side of the river, in other areas significant removal of already placed rock was required to be replaced on a preferred flatter curve alignment.

The degree to which these training banks could be relocated was limited by existing physical features such as bridges, hillsides, stopbanks and other river control works. The finally constructed rock training banks in place today have an overall meander pattern that differs from site to site with regard to meander length, amplitude and radius. The river naturally tended to self clear a vegetation free channel of typically 400 metres in width. This is significantly more than the 220m "Lacey" width, but significantly less than the 600m original braided active channel width.

(ii) For 16km of the reach from Tuamarina to lower Conders groyne this single thread training pattern approach has been partially successful. The advantages have been :

- The main river braid has usually flowed along and been directed by these outside of bend training banks.
- The main channel has been kept away from attacking the stopbanks.

*	Oblique angle cross river flows have been significantly reduced as the reduced width of the active channel inhibits their development.

The disadvantages have been :

*	Rock lined training banks, built to berm level were often washed out from behind once overtopped. A solution to this of building full stopbank height training banks. These then had the disadvantage of blocking flow on to the berms and reducing floodway capacity (Discussed in D4.2(b)(ii).).

*	The meander pattern is not stable and the river regularly threatens to outflank the training banks at the upstream or downstream end. This has resulted in training banks being extended further upstream or downstream with the by product result of reducing floodway capacity.

*	Initial construction of the rock lined training bank edge in good conditions typically requires 15 tonnes of rock per metre length of bank, at a cost of approx $250 per metre. Repair or extension of the bank to the precise alignment required can require more than twice as much rock if construction has to be carried out in deep swift water - as it often is in flood repair times.

(iii) For the 6km reach from Conders groyne to the Waihopai confluence the single thread training pattern is less successful. This is not surprising as the slope has steepened to 1 in 260. The equation of Leopold and Wolman (1960) indicate that the Wairau should be naturally braided at slopes steeper than 1:2000, and that it becomes progressively more difficult to force a braided river into a single thread pattern at steeper slopes. At a slope of 1:260 it has become very difficult.

A stable meander pattern on the intended alignment has not developed.

There is one section of stable meander pattern in this section of the river. This is a natural curve against the natural bed rock of the north bank at Rocks Ferry. Unfortunately this is on the directly opposite side of the river than the intended meander pattern. For approximately 80% of the time since 1923 this had been a natural 1 kilometre meander curve of a main braid of the river. The attempted training works to alter this since 1970 have had no influence on changing this position. The rock lined training bank on the opposite side has never had a channel develop against it since its 1967 construction.

Since the 1990 flood the river has been threatening to erode a new alignment and outflank the rock lined bank at lower Conders that protects the entry to the old Opawa channel. This is a vital area to protect and substantial further works are required.

(iv) The upper Conders area immediately downstream of Waihopai Confluence received heavy bank attack in the 1910's and 1920's. The river has not attacked heavily since, and few protection works have been constructed there. River attack could readily occur in the future, and further works are required.

(v) At lower Conders there is a length of 200 metres of stopbank where the main channel flows directly against the rock lined stopbanks. Should this rock be eroded away the stopbank would quickly fail and immediately allow large amounts of main channel flood waters into the breakout path towards the upper Opawa and Blenheim.

(vi) While it is important that the floodway berms carry a significant proportion of major floods, it is also important that these vegetated berms do not scour and develop channels. This in turn could lead to stopbank erosion and failure.

Grassed berms provide good waterway capacity. In major Wairau floods grassed berms have seriously scoured where close to the main fairway channel or if the berms is low lying old channel. Where such old low lying channels lead towards or are close against stopbanks this is particularly dangerous.

This was the situation where bank failure occurred at lower Conders in 1983, and where bank failure nearly occurred at Wratts Road. Berm scour has also occurred on both sides of the river in the Cravens Road area, and at Selmes Road.

(b) Methods and reasons for adoption

(ii) **Training Pattern between Tuamarina and lower Conders groyne -** The imposed single thread meander pattern approach has been reasonably successful. The difficulty and cost of adopting a completely different stopbank erosion protection system would be enormous. Improvements can be made to lessen the current disadvantages.

Willow trees are not strong enough to hold direct attack of the Wairau river. They are very valuable as back up to training bank rock lines and can prevent washing out of the rock line by overtopping flows. Tree plantings can therefore be used instead of full height banks behind rock training curves, and have the advantage of letting reasonable amounts of water through to utilise the floodway capacity of the berms. Trees would be used to replace high training banks that jutted out into the floodway, (and the banks removed as discussed in D8.4.2).

Trees, when developed, are also capable of resisting river attack of lesser river braids. Piled retards with willow or other tree limbs lashed on are used to strengthen the tree plantings. These have been in the form of driven rail iron piles, or willow limbs constructed as a cruciform shape. These retards are particularly useful in strengthening tree planting during early years of tree growth.

If greater river attack is later experienced, rock lined bank can be constructed in the front of the trees, with the advantage of developed trees in place to prevent scouring out of the rock from behind.

A band of predominantly willow trees flanking both sides of a defined cleared fairway will be complementary to the rock lined training banks. Behind the rock lines the willow trees should be predominantly a multi stem shrubby osier willow; as first line bank edge protection a tree willow of Matsudana hybrid is required. The band of trees should be up to 30 metres in width.

It must be recognised that there will be a continuing high cost in maintaining the 10 rock lined training banks. The training banks on the south bank have been upgraded to a high standard over the last few years and a lesser degree of maintenance is anticipated.

The training banks on the north bank appear currently to be a lower standard. Flood damage repairs and realignment are required at "Stedmans" training bank (opposite Wratts Road) and "Dodson Bush" (opposite downstream of Selmes Road).

It is difficult to assess the standard of rock work in many of the banks, as substantial lengths are covered by shingle or intermeshed with willow trees. Although the standard of some banks is likely to be reasonable, upgrading of the banks could not be done short of a virtual rebuild. Preventative works to upgrade these banks to a higher standard is an undesirable expenditure option. Repair of banks, following flood damage, is a more practical proposition. Often flood damage is limited in extent and some eroded rock recovered for re use.

The training banks are outflanked from time to time as the semi braided river moves channels. In future, the willow tree plantings could reduce the damage of this threat. Nevertheless, decisions will commonly need to be made to :

* extend training bank upstream or downstream, usually on a less than preferred alignment.

* strengthen the tree plantings with piled retards.

* carry out a diversion to realign the main channel in the floodway to the desired alignment of the training banks.

* do nothing in the hope that the situation is temporary and the main channel braid will move to the preferred alignment on its own accord.

Depending on the situation the choice of action would be taken on a case by case situation on its merits. Any of the alternatives may be preferred. It should be noted that it is particularly important to establish the desired meander pattern at the top of the reach in the Renwick bridge area.

Often, following flood damage, rapid action is needed by way of rock replacement or channel diversion, to prevent the damage escalating.

(iii) **Training pattern between lower Conders groyne and Waihopai** - For this 6km reach the single thread meander training approach is not providing reliable protection for the very important potential breakout path towards Renwick, the Upper Opawa and eventually Blenheim.

Instead, some form of continuous protection for the **south bank** is required as discussed by Williman (1991).

There are two main alternatives for providing continuous protection.

* A continuous rock lined guide or training bank, parallel with the river, and backed up with a band of willow trees. Apart from the lower Conders training bank there is also a 1.5km training bank further upstream. These therefore cover much of the south bank of the river. There is still a 2.5 kilometre gap between these two

training banks and there is also a further 1 km in the upper Conders are without a rocked bank.

* Rock headed groynes at right angles to the river, use considerably less rock and are therefore cheaper. Such groynes have been used extensively on the similar Waimakariri. Again, three planting in between the groynes is useful back up and will inhibit turbulent eddying flows between the groynes. One rock headed groyne was built in 1972 at the Waihopai Confluence, and another in the reach between the two training banks following the 1990 flood.

The preferred option is a blend of these two approaches. The lower Conders training bank would be extended upstream; 2 more rock headed groynes will be required upstream of this; and a further two more in the Upper Conders reach.

Tree planting by a blend of willow protection planting and commercial pine (or other varieties) would be planted as back up to these works. This tree planting should occupy all the area between the channel fairway and the new realigned stopbank. Apart from stopbank protection these tree plantings will reduce the size of any flood breakout should it occur.

* On the **north bank** some form of continuous bank protection is virtually already provided by two stopbank height rock lined training banks. In between these rock banks is hillside. The only concern is therefore preventing the most upstream training bank opposite Waihopai from being outflanked at its upstream end. The June 1993 flood eroded into this area, and the river is threatening to do just that.

The logical option is therefore return banking suitably rock protected to prevent outflanking the top end of this "Wilsons" bank.

(vi) **Berm erosion -**

- Extensive areas of grassed berms, especially where there are old channels, need some plantings of trees to reduce berm velocities and scour potential. Berms need a careful blend of tree planting and open pasture. These trees should preferably be shrubby or osier multi stemmed willows. There might be the opportunity for spaced commercial tree planting, though this needs further study.

- Berm shaping works to fill in old channels and ensure that the slope generally tends back to the river is very a desirable option, particularly in the Cravens Road and Wratts Road areas.

- All berms need to be re-examined with regard to waterway capacity and berm erosion protection works. The relative merits of :

  * Bands of shrubby willows;
  * Spaced commercial tree planting;
  * Berm shaping works;

  would need to be examined for each situation on its merits.

4.2.4 Issue : Stopbank Structural Integrity

(a) Situation

(i) A complacent attitude is often held to stopbanks as an engineering structure. However, as stopbanks are raised higher it becomes clearer that their function is similar to that of a dam.

Earth dams have stringent engineering standards regarding the material that the dam is constructed of, construction methods, foundation conditions and factors of safety.

Stopbanks on the Wairau are now approaching 5m in height in some places and are obviously more "dam" like structures. In similar circumstances on the Waimakariri the stopbanks there have been reconstructed by widening to approx 50% wider than the standard Wairau dimensioned stopbanks.

Examination of stopbank structural standards is unfortunately difficult and expensive due to the extensive nature of stopbanks and variability of conditions. The stopbank structural integrity check carried out for this report was indicative rather than detailed.

Climo (1993) carried out a study of potential stopbank structural integrity at four sites considered representative of at risk conditions. The main findings are :

* The banks are constructed completely of a sandy silt, or thickly lined on the river side face with this sandy silt. This compacted material is sufficiently impermeable to inhibit seepage into the

stopbank that would weaken it. The stopbanks themselves are adequately strong.

* Layers of gravel and sand foundations typically 2m under the stopbank present a potential problem. Seepage from the main river channel through these gravel and sand layers could cause a potential problem, with a variety of failure mechanisms.

* "Piping" is a potential failure mode where water seepage through the permeable foundation leaks out on the land side of the stopbank and as it does so carries out some material eroded out of sand layers in the foundation. This leads to a 'pipe' progressively being formed under the stopbank with eventual potential collapse of the stopbank.

* The computer based analysis also indicated sliding or bank slumping could result from foundation seepage.

* The problem is greatest where

  - the silt covered berm is narrow or non existent.
  - stopbanks are high
  - there is only a thin layer of silt on the downstream side of the stopbank
  - a sand layer is present in the foundation.

The worst site for these conditions is for a 500 metre length of stopbank in the Hillocks Road area where the main channel comes close to the stopbank. In the July 1983 flood slumping of the downstream toe of the stopbank occurred here. The stopbank here is likely to be at risk in design flood conditions.

Conditions at other stopbank locations appear better. However there are other sites requiring more detailed inspection especially where the main river channel comes close to the stopbank and there is little berm, and the reaches of high stopbank on the north bank immediately upstream of Tuamarina.

(b) Methods and reasons for adoption

(i) A filter toe drain on the landward side of the stopbank appears a feasible option and would certainly be the cheapest if feasible. It is likely to be required in the Hillocks Road area both on the north and south banks, and may also be required in two other locations. More detailed investigation of alternative remedial measures is required before committing this work.

4.2.5 Issue : Flow Control Mechanisms

(a) Situation

(i) **Road Bridge Constriction**. The state highway bridge presents a problem by constricting the flow in very major floods thus raising flood levels upstream. However, it is not the apparent relatively short 300m length of the bridge that is the main problem. This was examined by Thomson, Pascoe and Wadsworth (1985) who carried out an analysis that showed that at 300m in the length of the bridge had little influence on flood levels. Other hydraulic studies of the river, found water velocities through the bridge to be similar as upstream and that the bridge length is unlikely to significantly constrict the flow (Williman (1991), Noell (1992)). To be noted is that the main channels of the lower Wairau and Wairau Diversion downstream total 270 metres, and the Wairau main channel a short distance upstream is also only 270 metres - both less than the 300 metres long bridge.

However, the low soffitt of the state highway bridge combined with pier resistance and bridge shortness is a constriction and can impede the flood. This is expected to begin to happen at very high flood levels in excess of 7.7 metres, estimated at a 4800m³/sec flood, in current conditions. The July 1983 flood is the only occasion this has been noted to occur in the life of the bridge

As the bridge is a humped back bridge the soffitt will progressively impinge on the flood waters and become more of a constriction as the water level rises with increased flood flow.

In July 1983, with an estimated 5000m³/sec passing under the bridge, the water level at the recorder relatively quickly rose by 0.6 metres to 8.5 metres (presumably by bridge soffitt restriction). Since 1983 the right stopbank has been raised to 9.2m (immediately upstream of bridge) and the left Wairau-Tuamarina stopbank raised very slightly to 8.7 metres. Hydraulic conditions downstream of the bridge have improved slightly due to Diversion development.

Thus, even with the assessed bridge constriction the flood passing through the bridge is likely to be approx 5200m³/sec or more before overtopping of the stopbank would occur. This cannot be assessed with precision at this stage and is influenced by the assessment of the bridge constriction and an assessment of required "freeboard". It is to be noted that the left Wairau-Tuamarina stopbank is in the shadow of "Barnetts" training bank and so should require less "freeboard" than the right stopbank that is 0.5 metres higher.

The effect of the constriction on raising flood water levels will diminish with distance upstream. The effect of the constriction will not be significant upstream of Cravens Road.

(ii) **Wairau-Tuamarina Stopbank** This is the stopbank on the northern (true left) side of the river immediately upstream of the bridge. Only for its last 200 metres is it adjacent to the Wairau River; upstream of that for its further 1100 metres it is adjacent to the Tuamarina river. The bank was overtopped and breached in July 1983, 1962 and 1954; and almost overtopped in October 1983 and 1975.

The construction of "Barnetts" training bank in 1984 for some two kilometres upstream now prevents direct river attack on the Wairau-Tuamarina bank, and as discussed in D4.2.2(a)(iii) should effectively lower flood levels against that bank by approximately 0.5 metres.

Whether this stopbank of 8.7m is now adequate, may depend on the assessment of the effect of the bridge constriction as discussed in (i) above. It is to be noted that the opposite Wairau right stopbank which is exposed to direct river attack is at a level of 9.2m.

(iii) **Tuamarina Pocket** Stopbank. The flat graded Tuamarina river joins the Wairau just upstream of the State Highway 1 bridge. Flood levels up the Tuamarina valley for some 5 kilometres are determined by Wairau flood levels. The fertile flats at the bottom 1km of the Tuamarina Valley are ring banked by stopbanks along the Wairau at the base, stopbanks up the Tuamarina Valley and the hills behind. The area is known as the Tuamarina pocket.

The stopbanks up the Tuamarina Valley are old steep narrow banks. The 1960 Wairau Valley Scheme expected that the Wairau Diversion would reduce Wairau flood levels at Tuamarina in excess of 2 metres. The Tuamarina pocket stopbanks would then be of more than adequate height and strength.

The reduction of Wairau flood levels has not and will not eventuate. The Tuamarina pocket stopbanks may not be to design height and this may be influenced by the bridge constriction effect. Improvement has been achieved by construction of the protective 'Barnetts' training bank as described in C4.4.2, but the bank still may not be high enough.

Of particular concern is that the stopbank is now 150mm lower than the Wairau-Tuamarina stopbank that was overtopped in the July 1983 flood and repaired to a higher bank level. The Tuamarina pocket stopbank will therefore now overtop preferentially, and the relatively small area behind with several houses would rapidly fill with water to a depth of over 3 metres.

(b) Methods and reasons for adoption

The effect of the apparent bridge constriction has to be considered together with the not quite adequate levels of the stopbanking i.e. options (i), (ii) and (iii) should be considered together.

- **Stopbank Raising Upstream**. On the right bank, even if the bridge is shown to cause significant restriction, the stopbanks are almost to height; or if they need raising this raising is unlikely to exceed 500m length of stopbank. It would be feasible to raise this stopbank.

  The left bank Wairau-Tuamarina stopbank of 1.3 km and the 2km Tuamarina pocket stopbank are more difficult. For the Wairau-Tuamarina bank the main Tuamarina river channel would need to be relocated over a length of 300m to allow room for the stopbanking raising. As houses are built immediately behind the stopbanks the option of stopbanking raising is also undesirable (as well as being costly) should the stopbank be overtopped.

  Raising the bottom 200m of stopbank beside the Wairau immediately upstream of the bridge and exposed to direct Wairau River attack is required so as to be the same level of 9.2m as the opposite bank.

  A sub option is to completely stopbank off the Tuamarina stream from the Wairau at its confluence just upstream of S.H. 1 bridge. A floodgated culvert would be installed through the stopbank, with the floodgates preventing back flow of Wairau waters.

  This appears a feasible option because of the considerable retention volume of the Para Swamp to damp out the flood peak of the Tuamarina Stream. The Para Swamp has a similar storage volume as the Taylor Dam, and the flood flows of the Tuamarina will be similar to that of the

Taylor. A floodgated culvert capable of passing approx. 100m^3/sec may be appropriate. Detailed study, including the collection of hydrological data from the Tuamarina would be required to prove this option. Furthermore, the need for it could be lessened by other options of dealing with the bridge constriction.

- **Reducing flood levels by deliberate gravel extraction**. This would have to be carried out both at the bridge site and for approx. 1 km down both the Wairau 'Diversion' channel and the 'Lower Wairau' channel. This would require the immediate removal and disposal of approximately half a million cubic metres of gravel and sediment, and a continuing annual programme thereafter.

  This sediment removal would also have to be carried out in a manner that maintained or improved the current flow split mechanism of the Division area as discussed in C4.2.3.5.

  This is a costly operation, and also needs guidelines on the manner in which it need be carried out so as to prevent an undesirable flow division. While it may be a desirable option, more detailed study of the postulated bridge constriction mechanism and effect should be carried out before committing this.

- **Increasing bridge length (and rail bridge as well)**. Studies to date have indicated that the bridge constriction effect is mainly due to lowness of the bridge soffitt and secondly to bridge pier resistance. Increasing the bridge length may not achieve the lowering of flood levels required. A detailed study would be required to assess this.

- **Raising the road bridge (and rail bridge as well)**. This may achieve the desired lessening of the constriction, but may not be a feasible option, and would be very expensive.

- **New road bridge (and rail bridge as well)**. Obviously very expensive.

Summary

The need to raise stopbanks immediately upstream of S.H. 1 bridge principally depends on the assessment of the degree of effect the road and rail bridges have on constricting the flow in very major floods. The bridge interaction with the flow is very complex hydraulically, and even then it may be that the constriction effects are fairly localised and have a limited effect on backing up river levels upstream.

On the information available the current capacity is approx 5200m³/sec, still less than the design flood size of 5,500m³/sec.

A detailed study of the bridge hydraulics requiring computer mathematical modeling and a physical model of the bridge to model bridge soffift effects is required. This should include examining a 5800m³/sec flood, which is a standard that may be adopted in the future. Associated with this study are also detailed studies of :

- the effect of extensive gravel removal downstream on the flow split mechanism of the Wairau Diversion and Lower Wairau.

- A floodgated culvert on the Tuamarina Stream outlet as these effect options of dealing with the consequences of the bridge constriction.

These studies will have a priority in the plan, so that the physical remedial works can be carried out within the ten year time frame of the plan. The studies should desirably be a joint study with Transit NZ (the roading authority) and New Zealand Rail.

The low Tuamarina pocket stopbank at any rate, should be raised by at least 400mm and be widened and strengthened at the same time, but this work should be subsequent to the detailed bridge study as higher raising may be required.

The bottom 200m of the Wairau-Tuamarina bank should also be raised 0.5m.

D5 Waihopai (Wairau Confluence to 500 metres upstream of S H 63 Bridge)

Reference Map 5

Channel characteristics

Type	:	Wide Braided gravel river
Length	:	2 km
Fairway Width	:	150 metres
Slope	:	0.6% (1 in 160)
Design Flood	:	1200m³/sec

D5.1 Policy for Waihopai River (Wairau Confluence to SH 6 bridge) Right bank only.

REFERENCE	POLICY	APPROXIMATE PRIORITY CATEGORY
	DESCRIPTION OF PROGRAMMED METHODS	
D8.5.2	A cleared fairway of 150 m width	(r)
D8.5.2	A 0.6m high stopbank on right bank.	(c)
D8.5.3	Tree planting and piled retards.	(c)
	Flood damage repair	(r)
	Maintenance	(r)

D5.2 Reasons for Methods and Policies

5.2.1 Issue : Sedimentation

(a) Situation

Cross sectional survey has been taken in 1957, 1969 and 1991. Between 1957 and 1991 the bed generally degraded slightly by 0.15m. However at the bridge channel degradation of 0.8m has occurred. Upstream of the bridge the deposition has again been approx 0.15m for the 1.5km that cross sections have been taken.

The lowering of bed levels in the bridge vicinity has affected the intake for an abstraction of up to 2.8m³/sec to Gibsons Creek, a Council operation as part of the Wairau Valley Scheme. Greater costs are now required to keep the intake operating.

The reduction in bed levels at this bridge site may be due to the replacement bridge construction in 1972, where the new bridge was put on an alignment 50 metres downstream.

The general slight degradation may be related to Benhopai dam construction 25km upstream some 50 years ago, and the consequence starving of the lower Waihopai of coarse gravel sediment.

It is to be noted that the Waihopai carries a considerable amount of the fine sandy silt as suspended sediment. This does not deposit on the steep Waihopai fan, but much lower down the Wairau.

(b) Methods and reasons for adoption

Apart from the abstraction intake the slight channel lowering is a small advantage. Nothing can be done to change the slight erosion pattern, which may at any rate not be a long term trend now that Benhopai dam is full.

5.2.2 Issue : Waterway Capacity

(a) Situation

The main concern is that the Waihopai should not overtop the right bank and its terrace, and so outflank the Wairau stopbanking system. This potential threat is limited to the Waihopai/Wairau confluence up to 500 metres above SH 63 bridge.

A major stone and netting groyne was constructed in 1911 to prevent the Waihopai from breaking out around the base of its terrace at the junction with the Wairau floodplain flats. A further groyne was built upstream to keep the flood waters out from the right bank terrace in the same period.

Under the Wairau Valley Scheme an open ended training bank was built to supplement these earlier groynes.

Design flood level is just above the right bank terrace level for the bottom 1km. The groynes and training banks keep the main flow away from the terrace and so reduce the flood levels along the terrace.

(b) Solution Options

- To improve channel efficiency by vegetation removal. A cleared 150m wide fairway is desirable, for the 2.5km from the Waihopai/Wairau confluence up to 500 metres upstream of SH 63 bridge.
- To build a 0.6m high stopbank on top of the right bank terrace for the downstream 1km.

Both these options are desirable.

5.2.3 Issue : Stopbank Erosion Protection

(a) Situation

The 'stopbank' is the natural terrace, on the right bank. The groynes and training bank over the bottom 1km keep the river away from the terrace. For the 1km above this to the bridge, trees form the only protection, but as the terrace is above required flood height this of less concern.

On the left bank some 60 hectares of valley flats are partly protected against erosion by a 500 metre long training bank just downstream of the bridge, and also by treeplanting.

While this left bank area is not part of the main Wairau Floodplain, it is affected by the bank protection work on the right bank that may direct water across on to the left bank. This bank is also affected by works to maintain the Gibsons Creek abstraction intake just upstream of the bridge (See D8.5.5. below). The plan therefore needs to make provision for bank erosion protection measures on both the left and right bank.

(b) Methods and reasons for adoption

- The maintenance of the existing groynes and rock training banks on both sides of the river from the confluence to 500 metres above SH 63 bridge.
- In other places in the reach to rely on willow tree planting supported by piled retards as necessary, as bank edge protection.

5.2.4 Issue : Flow Control Mechanisms

(a) Situation

The Council maintains an abstraction of up to 2.8m³/sec of flow from the Waihopai river at SH 63 bridge into Gibsons Creek. It is planned to continue this abstraction as discussed in D9.6

The abstraction intake from the Waihopai is situated at the SH 63 bridge, on the basis that the river is confined at this point and a braid of water is more reliably against the river bank. A gravel bank is currently used to divert the water into the intake channel and thence to control gates 600 m downstream. The gravel bank at times extends up to 200 metres above the bridge and diversions of the river channel braids are also needed to lead an appropriate flow to the gravel banks. In all these works can extend 400 metres above the bridge.

(b) Methods and reasons for adoption

- Continue using the gravel bank and braid diversions. At the time of construction in 1960, the intake channel was set lower than the river bed. Since then however the river bed has degraded by 0.8 m at the intake. This may be due to the new bridge construction in 1972 on a different alignment, for elsewhere upstream and downstream only 0.15 m of degradation has occurred. The gravel bank used to divert the water into the intake channel therefore has to lift the water by often over 0.5 m. This gravel bank is prone to wash out in floods or freshes several times a year. River channel works, sometimes quite extensive, are then required to re-establish a braid against the intake, at a cost of typically $15,000 per year. **This is the preferred option.**
- Other options include the construction of a rock weir across the river to lift the water, or a new intake at a different location. Both these options are likely to cost in excess of $100,000. The options would get over the question of requiring lifting the water level, but some significant channel diversions and associated costs would still be required to bring a braid against the intake site from time to time.

D6 Lower Opawa/Taylor

Reference Map 6
Channel characteristics (typical)

Channel blocks were put across the Opawa Loop in 1967 to separate the Upper Opawa from the Lower Opawa. The lower Opawa/Taylor is now a single river up through Blenheim, until the Doctors Creek tributary on the west side of Blenheim.]

(Up to Doctors Creek confluence).

Type	:	Deep narrow silt bed river
Channel Width	:	30 m
Floodway Width	:	150m
Slope	:	Tidal, flood slope 0.025% (1 in 4000)
Design Flood	:	170m³/sec Design Freeboard 0.4m.

(Above Doctors Creek confluence).

Type	:	Gravel bed river
Channel Width	:	30 m
Floodway Width	:	200m
Slope	:	0.6% (1 in 160)
Design Flood	:	115m³/sec Design Freeboard 0.5m.

D6.1 Policy for Lower Opawa/Taylor

REFERENCE	DESCRIPTION OF PROGRAMMED METHODS	APPROXIMATE PRIORITY CATEGORY
D6.2.2	Removal of overhanging willows and other riparian trees from	
	- upstream of Riverlands corner	(a)
	- down to Swamp Road.	(b)
D6.2.2	Berm shaping works from	
	- upstream of Riverlands corner	(a)
	- down to Swamp Road.	(b)
D6.6.2	Stopbank raising from Riverlands corner to Malthouse Road.	(b)

REFERENCE	DESCRIPTION OF PROGRAMMED METHODS	APPROXIMATE PRIORITY CATEGORY
D6.2.4 (a)+(b)(i)	Narrow stopbank reconstruction	(c)
D6.2.4 (a)+(b)(ii)	Stopbank relocation on Taylor opposite Doctors Creek	(c)
D6.2.4 (a)+(b)(iii)	Stopbank improvements to Taylor in Blenheim commercial area	(b)
D6.2.4 (a)+(b)(iv)	Replacement of inadequate culverts	(r)
D6.2.2 (a)+(b)(iv)	Land purchase to carry out berm shaping and stopbank improvement works.	(b) + (c)
	Flood damage repair	(r)
	Maintenance	(r)

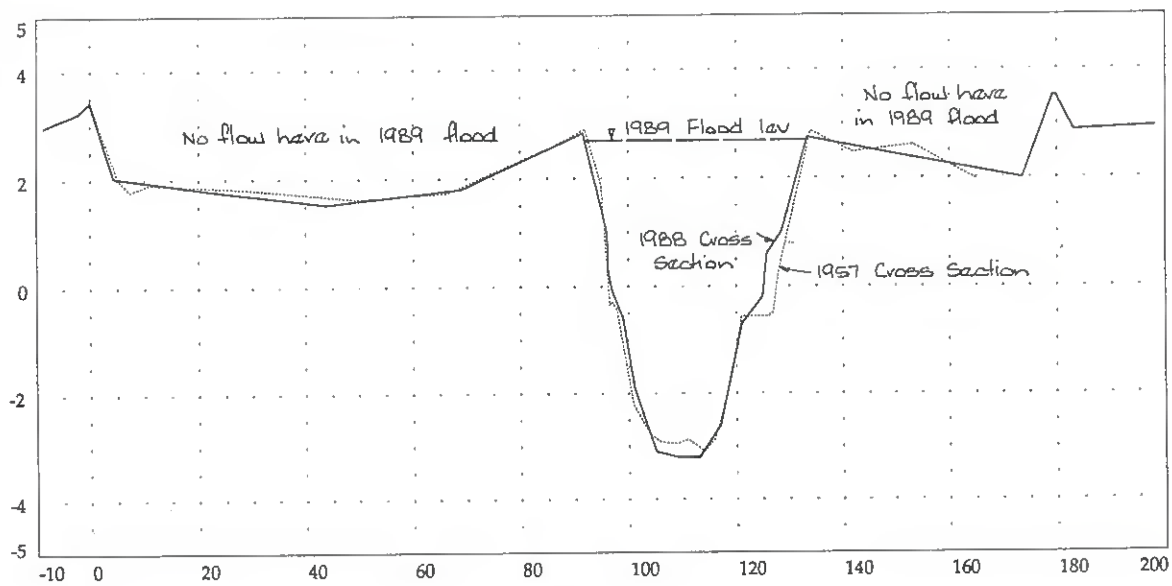


FIGURE D10 LOWER OPAWA RIVER

Cross Section 24 near Malthouse Road
In Sept 1989 high flood levels occurred in main channel but no flow on berms. Also note similarity of 1988 and 1957 cross section profiles.

D6.2 Reasons for Policies and Methods

6.2.1 Issue : Sedimentation

(a) Situation

(i) Generally cross section survey of the river channel has been carried out in 1957, 1966 and 1988. Some selected cross sections have also been surveyed in 1972, the Taylor through Blenheim also resurveyed in 1979, but the Taylor upstream of Doctors Creek confluence only surveyed in 1957 and 1990.

(ii) Downstream of Riverlands corner the lower Opawa channel has been extremely stable, with no change in width, position or channel bed levels. This reach is not aggrading despite the change in flow regime, or any effect of earthquakes, or cessation of the coastal trading vessel the "Echo". These had been suggested as possibly causing future deposition.

(iii) From Riverlands corner up to Doctors Creek confluence some deposition of the channel has occurred. This deposition is of silt, sand and fine gravels and over 30 years is at a maximum of 1 metre at the downstream end of town at the confluence of the lower Opawa and Taylor. Downstream the deposition steadily reduces for the 2.5km to Riverlands corner. In the Taylor upstream to the Doctors Creek confluence this deposited material has been excavated every approx 7 years. A small sediment trap at the Taylor/Doctors Creek confluence is also cleared out regularly.

This sediment deposition is confined to the central 10 metres of the channel. This sediment deposition has negligible effect on the flood levels. It does have an effect on low flow and thus tributary drainage levels and the dredging of the channel is to improve tributary drainage.

(iv) Upstream of Doctors Creek confluence the Taylor is a steep gravel bed river with boulders up to 300mm diameter. Considerable gravel extraction has taken place which has lowered this 3km reach of channel bed by typically 2.5 metres, representing some 400,000m^3 of material removed.

This gravel extraction has considerably increased the waterway capacity of this reach of the river so it can now easily pass the design flood.

The gravel extraction has had a considerable side effect. Finer materials is exposed for the river to erode and deposit in the Taylor/lower Opawa downstream. It is to be noted that there are now few sources of sediment for the lower Opawa/Taylor.

The Taylor dam inhibits the movement of gravel through it. The lesser flood flows downstream of the dam have also reduced the erosive capacity of the river. Doctors Creek does not carry sediment down.

A main sediment source is the finer material that is exposed when gravel is extracted from the river, in the reach above Burleigh Bridge.

(b) Methods and reasons for adoption

(i) Deposition Riverlands corner to Doctors Creek confluence.

- The sediment source can be reduced by stopping further gravel extraction from the Taylor river channel. Any further extraction should only be from berm areas well above normal water level.
- Large 'oversize' boulders that have been rejected from gravel extraction and pushed up against the banks. Some of these could be spread back over the river channel surface to inhibit further channel surface erosion.
- The sediment trap just upstream of Doctors Creek confluence should continue to be operated with regular cleaning out of built up material.
- Dredging the lower Opawa/Taylor for most of this reach, in which 0.5 metres is dredged out at any one time and spread in hollows on the berms is a practical option. It is however inferior to the previous 3 options, and would be carried out to remove only what the previous option s have failed to prevent.

6.2.2 Issue : Waterway Capacity

(a) Situation

(i) Prior to the construction of the Taylor dam the 1 in 100 year flood for the Lower Opawa/Taylor would have been approx. 330m³/sec. The Taylor dam, constructed in 1965 and the outlet of which was adjusted in 1980 has (together with the 1967 Opawa Loop channel blocks) reduced this design flood to 170m³/sec. This is detailed in the Appendix I.

Because of this considerable improvement the need for further improvements in waterway capacity was uncertain. The hydraulic analysis outlined in Appendix II however, indicates further improvement is required.

(ii) Most of the stopbanks in the lower Opawa are steep, narrow horse scoop constructed banks over 100 years ago. The banks date from when Wairau water flowed down the Opawa distributary. Where there are large meander loops the stopbanks cut across the inside of the bends on a short cut path. This was obviously a cost saving in the days before mechanical earth moving equipment. The Wairau Valley Scheme did not upgrade these stopbanks.

The Taylor was improved by straightening and clearing works and also by stopbank upgrading in the 1950s. Downstream of Hutcheson Street the walls of some of the buildings are the "stopbanks".

Over the last 8 years the right stopbank of the lower Opawa for the 2km downstream of Blenheim has been upgraded by raising and widening, following the 1980 flood as per Thomson (1980). Considerable berm improvements have also been carried out by berm shaping works that have removed berm material and shaped the berms to be considerably more hydraulically efficient. As part of the process the overhanging willow trees that have steadily been growing and impeding the flood were also removed. These works have improved the channel efficiency for much of the 2.5km distance from the lower Opawa/Taylor junction to Riverlands corner.

(iii) For the most downstream 5km from the mouth to Eckfords Road the flood levels are determined primarily by levels in the Wairau lagoon. For the next 5km up to Malthouse Road is a combination of Wairau levels and channel hydraulics. Above Malthouse Road the channel hydraulics are the major factor. The tide does not effect flood levels in Blenheim. However, the lower Opawa channel is so flat graded that flood levels and channel efficiency in the lower Opawa effect flood levels of the Taylor through Blenheim.

(iv) The floodway is under capacity for the 7km from Malthouse Road on the lower Opawa to Hutcheson Street bridge on the Taylor. (With the exception of the 2km of upgraded stopbank of the lower Opawa downstream of Blenheim). Central Blenheim is under threat from Taylor river flooding. The current standard is approx. 130m³/sec flood, estimated to be a 1 in 20 year return period event, i.e. a 40% chance of occurring in the next 10 years.

(v) A 1.5km section of the right bank from Malthouse Road to Riverlands corner is particularly low.

(vi) For short sections of the left bank of the Taylor from the Opawa Confluence to Hutcheson Street bridge there are inconsistencies in the height of the stopbanks and mass concrete floodwalls.

(vii) Upstream of Hutcheson bridge the Taylor is to capacity, and upstream of Doctor's Creek confluence the capacity is considerably greater than required, due to the gravel extraction that has been carried out.

(b) Methods and reasons for adoption

(iii) Downstream of Eckfords Road.

- The flood levels here are determined principally by levels in the Wairau estuary. The maintenance of a direct mouth at the Wairau bar will be the most effective method of keeping the flood levels here to below the July 1983 flood levels. No general stopbank raising or channel improvement works are required.

(iv) Floodway capacity Malthouse Road to Hutcheson Street

- A "do nothing" option is contrary to the plans objective and exposes Blenheim residents to an unacceptable risk.

- **Doctors Creek detention dams to reduce Doctors Creek tributary inflow.**

  Davidson (1959) in the Wairau Valley Scheme proposed that detention dams should be built in four of the tributaries of Doctors Creek. This would reduce Doctors Creek flood flows by about half. The major benefit was expected to be on agricultural land that Doctors Creek flooded. Reduction of the flood size through Blenheim was considered to be a secondary benefit.

Following observation of the 1966 and 1971 floods it was found that Doctors Creek sometimes naturally peaked before the Taylor. Detention dams in Doctors Creek may then only delay Doctors peak floods so as to co-incide with the Taylor flood from its dam. At this time it also became more apparent from the 1966 and 1971 floods that the lower Opawa/Taylor was not to adequate capacity despite the Taylor dam. Doctors Creek flood flow reduction would therefore have a significant benefit to reducing the risk to flooding of Blenheim.

Further detailed studies have not been carried out on Doctors Creek detention dam proposals. At times the dams would reduce the flood peaks; but at other times, as Thomson argued, that may be of little or no benefit.

The dams were also considered to be more expensive than previously estimated. Thomson (1972) recommended against proceeding with the detention dam proposal and instead recommended a Doctors Creek diversion proposal be fully investigated for the purpose of reducing flows in the Taylor through Blenheim.

It is to be noted that there is considerable natural detention in the Batty's Road - Bells Road area. This is different from the detention dams envisaged by Davidson. From the viewpoint of reducing flood flows in the lower Opawa/Taylor, increased storage in this area may be more effective. This could be an option deserving more examination in the future.

- **Doctors Creek diversion to reduce Doctors Creek tributary inflow.**

Quite detailed plans and drawings were prepared for a 4 km diversion of the majority of Doctors Creek to be taken to the Fairhall diversion. Cunliffe (1975) quoted an estimate of $306,000. In todays present value dollars this would be $2.5 million.

Allowing for increased land purchase and compensation costs of $470,000 (Trueman (1993)), engineering design costs and contingency items, a current estimate is $3 million.

This diversion proposal has not got a resource consent, but the land over which it would go has been designated in the district scheme. Significant objection and legal costs may also be incurred with this proposal.

In his report Cunliffe showed that the Doctors Creek diversion proposal was economic but that the main economic benefit was due to reduction of flood risk to Blenheim, and that the agricultural benefit was minor. Landcorp (1993) have confirmed that the capitalised agricultural benefit of a Doctors Creek diversion in the Doctors Creek catchment is only $180,000. Thus the benefit to Blenheim would be the dominating reason for a Doctors Creek diversion.

- **Channel efficiency improvement.**

  The Taylor river below Hutcheson Street bridge is a fairly straight channel with short grassed berms sloping down into the channel and few trees. Hydraulically this is an efficient channel.

  The channel improvements from lower Opawa and Taylor junction for 2km downstream have also resulted in a quite efficient channel. From examination and analysis of the 1989 flood levels the Mannings "n" roughness for this reach has been reduced from 0.07 to 0.04, an improvement of some 60% (Reference Appendix II).

  The removal of riparian trees for the following 5 kilometres down to Swamp Road will have a significant effect on improving channel efficiency. This will reduce flood levels not only in this reach of the lower Opawa but for the Taylor through Blenheim up to Hutcheson Street. The berms should be kept in moderately short grass conditions for even crops such as sweet corn would seriously impede the flow - as in 1980.

- A similar improvement to channel efficiency can be obtained by berm shaping works. Figure D10 shows cross section 24 of the lower Opawa near Malthouse Road. It can be seen that a high channel bank, nearly to stopbank height prevents access of flow from the channel on to the flood berm. This 20 metre wide gently sloping bank has been naturally formed in the past by silty Wairau water (pre Opawa breach days) spilling out from the channel and depositing on the berm. Farming operation since may have increased its height. Such natural channel banks exist for the full length of the lower Opawa.

Removal of this channel bank by berm shaping excavation works will increase the waterway capacity in places by 50% and have a substantial effect on improving the efficiency of the channel.

This channel bank removal need not be for the full length of the bank, but simply at the top and bottom ends on the inside of a bend. Five such bends occur between town to Swamp Road.

The material excavated from the "channel" bank would be used to upgrade the stopbank by widening and in places raising - as will be discussed in D8.5.4.

The more expensive, in engineering costs, option is removal of the 'channel' bank for its full length. This may enable the stopbank to be relocated further in towards the river, and release land from the floodway. Depending on the value of the land and the attitude of the landowner, this may be a preferred option for some sites. This is a design detail on a case by case basis. The berm shaping works done to date on the 2km downstream of Blenheim have adopted this approach, though a further factor was to obtain fill for stopbanking work elsewhere, as well as delicate negotiations with land owners.

The combined effect of the berm shaping and tree removal will substantially improve channel efficiency to such an extent that no stopbank raising would then be required for the Taylor through Blenheim.

(v) The 1.5km reach from Malthouse to Riverlands Corner.

Even with berm and channel efficiency works as outlined this stopbank is low and the stopbank would be required to be specifically raised by 0.5m. This would readily be carried out as part of the berm shaping works using material excavated from the berm shaping.

The cost estimate for carrying out these tree removal and berm shaping work and stopbank raising to improve channel effluent in the Swamp Road up to Hutcheson Street reach is $800,000 including land purchase.

- Stopbank raising is also an option in itself, but is difficult to consider separately from berm shaping works as the best source of material for the stopbank raising is from the berms. Stopbank raising on the Taylor through Blenheim up to Hutcheson Street is also very difficult due to the lack of space.

  The town bridges, especially the railway bridge are under height. They cannot easily be raised. Sand bagging in emergencies is an option, but an unsatisfactory option.

  A straight stopbank raising solution, independent of berm improvements inside the floodway, is unsatisfactory.

(v) Taylor Opawa Confluence - Hutcheson Street Bridge

The minor inconsistencies in wall and bank heights in this reach is best addressed by minor extensions to existing walls and the construction of nib walls along footpath edges

- Summary

  Improving the channel efficiency between Swamp Road and Blenheim by riparian tree removal, berm shaping works and some stopbank raising is the most economic solution to improving the waterway capacity of the lower Opawa/Taylor to design standard. It is much cheaper than the previously proposed Doctors Creek diversion. Controls would be needed to ensure the floodway land was kept predominantly in short or moderate length grass.

6.2.3 Issue : Stopbank Erosion Protection

(a) Situation

(i) Lower Opawa up to Taylor River confluence.

The gentle slope of the river and low velocities require only minimal bank protection works limited to the outside of the bends. Here willow trees, already established are quite satisfactory. In areas where, proximity of the stopbank and buildings behind it reduce available space for tree planting, rock rubble work has been used.

(ii) The Taylor River, especially upstream of Doctors Creek confluence, is steeper and more erosive. However, flood flows have been reduced by the dam.

A variety of bank protection methods has evolved, stone filled crates, rock riprap, willow trees and 300mm "oversize" natural river boulders not will in the gravel extraction process.

The use of rock riprap in the lower reaches of the Taylor through town is primarily to maintain an aesthetic berm for recreational use rather than protecting the more distant stopbanks.

(iii) In the bottom 7km of the lower Opawa estuary area wave lap erosion is occurring in places.

(b) Methods and reasons for adoption

(i) Lower Opawa

Maintaining willow trees on the outside of bends is the practical economic bank protection method, with rock rubble work limited to areas of lack of space.

(ii) Taylor

Maintaining the current blend of rock riprap, willow trees and large boulders is appropriate.

(iii) Lower Opawa estuary area.

Rock rubble may be required from time to time, but the option of moving back the low stopbanks, where there is adequate room, need also been examined on a case by case basis if and when the problem arises.

6.2.4 Issue : Stopbank Structural Integrity

(a) Situation

(i) The Lower Opawa stopbanks are typically 1.2 metres with 1 metre top width and steep sides. Inconsistent original construction, animal damage and vehicle crossing damage has locally reduced the height of the stopbanks in many places. This is particularly so where fencing is along the top of the stopbank.

As the banks are so narrow this damage is significant and could lead in an overtopping situation to complete bank failure.

(ii) The Taylor right stopbank for 400 metres in the reach immediately downstream and opposite Doctors Creek Confluence has poor foundation conditions. Seepage/piping occurs in major floods and collapse of the whole stopbank is possible.

(iii) For the Taylor in the reach from Opawa Confluence up to Hutcheson Street bridge mass concrete walls and buildings comprise the "stopbanks" in some locations. Several of these are in poor condition or with poor foundation conditions and/or with steep river side earth batter beneath them. Leakage has occurred in major floods with the potential for failure.

(iv) There are many floodgated drainage culverts through the stopbanks, which are a potential source of stopbank failure.

(b) Methods and reasons for adoption

(i) **Lower Opawa poor condition narrow stopbanks.**

From Blenheim down to Malthouse Road stopbank improvement works would be readily done in conjunction with berm shaping works. Downstream of Swamp Road the berm shaping is not required so the cost of stopbank upgrading will in effect be higher. Stopbank reconstruction and widening would be limited to these lengths of stopbank in particularly poor condition. For the better lengths of bank the "do nothing" option would be acceptable.

(ii) **Taylor right bank opposite Doctors Creek Confluence**

The relocation and reconstruction of 400 metres of new stopbank is the only sensible option. This will also require land purchase of private land for the stopbank.

(iii) **Poor condition walls and buildings**

Replacement and repair of inadequate walls and their foundations and/or structural stabilisation of river bank edge by gabions or similar appears the feasible solution. Further detailed engineering design is required to confirm appropriate option.

(iv) **Culverts**

As stopbanks are improved any culverts would be checked with possible lengthening or replacement.

D7 Upper Opawa and Rose's Overflow

Reference Map 7

Channel characteristics (typical)

(Channel blocks were put across the Opawa Loop in 1967 to separate the upper from the lower Opawa. The upper Opawa and Rose's Overflow is really a single, albeit artificial river channel).

Type	:	Artificial watercourse on Wairau floodplain
Length	:	16 km
Channel Width	:	10 m
Floodway Width	:	200m
Slope	:	0.06% (1:600), varying from 0.1% (1:1000) at Rose's Overflow to 0.25% (1:400) at Omaka Confluence
Design Flood	:	600m³/sec up to Fairhall Confluence, 400m³/sec above Confluence
Design Freeboard	:	0.4m on right bank up to Fairhall Diversion 0.3m for left bank above Fairhall Diversion

D7.1 Policy for Upper Opawa and Rose's Overflow

REFERENCE	POLICY	APPROXIMATE PRIORITY CATEGORY
	DESCRIPTION OF PROGRAMMED METHOD	
D7.2.2 (a)+(b)(ii)	Hammerichs Road area under capacity to be improved by new stopbanks and channel efficiency improvements.	(a)
D7.2.2 (a)+(b)(iii)	Removal of impeding trees on berms, especially Waipuna Street area	(b)
D7.2.4	Various isolated sections of poor condition stopbank to be upgraded	(b)
	Flood damage repair	(r)
	Maintenance	(r)

D7.2 Reasons for Policies and Methods

7.2.1 Issue : Sedimentation

(a) Situation

(i) Rose's overflow is clearly an artificial watercourse being constructed as a straight channel. The upper Opawa is also relatively artificial in that the flow regime of the river is not the flow that formed the watercourse initially. The Omaka and Fairhall tributaries to the upper Opawa simply use an old braid of the former Wairau "Opawa" distributary, to which is added a diversion from the Waihopai.

The floods of the upper Opawa are now much less than the floods that formed the channel in the first place. Current flood flows are too small to transport the alluvium of the channel on the channel slope.

In Rose's Overflow also the floods are too small and the slope too flat for erosion and deposition to occur.

Sediment build up is not a problem in the upper Opawa/Rose's Overflow.

(ii) The river has been a source of gravel for commercial extraction in the past and some gravel extraction is still continuing today.

Over the last 15 years the floodway has been narrowed to the minimum acceptable to carry the floodwaters. Gravel extraction should no longer be conducted in the cavalier manner of the past.

(b) Methods and reasons for adoption

(ii) Gravel extraction. This should be carried out so as not to conflict with groundwater recharge, maintaining low flows for fisheries and aesthetics and not to be likely to cause bank erosion. In future gravel extraction should be limited to areas significantly above normal water levels so as not to conflict with those other river users.

7.2.2 Issue : Waterway Capacity

(a) Situation

(i) Historically the upper Opawa carried flood flows of over 1000m^3/sec from the Wairau and was typically several hundred metres wide. The stopbanks that were constructed were not to a uniform standard, but to exert some control on the river course. Shallow flooding of this stony pastoral land was acceptable, and the Wairau Valley Scheme made no provision to significantly improve this.

With viticultural development the land has become much more valuable and over the last 20 years new stopbanks have been built and some of the old ones reconstructed so as to narrow the floodway to only carry the design flood of the Omaka and Fairhall tributaries as outlined in Appendix I. Some of this stopbanking was carried out as per calculation of Pascoe and Wadsworth (1980), and more recently work programme as per review by Williman and Gardiner (1989). This stopbanking work was jointly funded between Council and benefiting landowner. Because of delays in obtaining landowner contributions the programme has not been completed.

(ii) There is a section of 1km on the left bank above Hammerichs Road that is not to capacity.

(iii) The waterway is unusual in that a narrow main channel carries less than 20% of the design flood and the majority is carried on the wide floodway berms. This is a legacy of the artificial nature of the watercourse in that the flood flows are much less now than the flood flows that laid down the original channel. Current flood flows are unable to erode out a bigger cleared channel.

It is therefore particularly important that the floodway berms are kept in as a hydraulically efficient waterway. For optimum conditions the floodway would be in grass with a minimum of trees, bushes or scrub.

The hydraulic calculations of waterway capacity to carry the design flows assume reasonably good hydraulic conditions on the berms. Berm conditions are good for much of the floodway. An exception is a kilometre reach predominantly of willow growth in the Waipuna Street area. There are also various isolated stands of impeding trees between Waipuna Street and Hammerichs Road.

(b) Methods and reasons for adoption

(ii) Hammerichs Road area under capacity.

- To construct a stopbank on top of the natural stopbank terrace line. This was intended to be constructed as part of the 1989 programme. The landowner has indicated he would prefer a different alignment and prefers the option of :-

- Construction of a new stopbank on an alignment that reduces the floodway width to the minimum acceptable for adequate waterway capacity and simultaneously improve the channel efficiency in this reach by tree removal and berm shaping works. This option gains an extra 3 hectares out of the floodway. This is the preferred option.

(iii) Waterway Efficiency

The berm areas should be cleared and kept reasonably clear of impeding trees, bushes, scrub and other impeding vegetation.

7.2.3 Issue : Bank Erosion Protection

As explained previously, this is a minor issue. Willow trees on the outside of bends where the main channel comes close to the stopbank will provide adequate bank erosion protection.

7.2.4 Issue : Stopbank Structural Integrity

(a) Situation

There are some isolated sections of stopbank between State Highway 1 and Hammerichs Road that are original narrow steep sided stopbanks, of erratic height and that have suffered stock damage, rabbit damage and access crossing damage. There are vulnerable to direct failure or following isolated overtopping of low or weak sections.

(b) Methods and reasons for adoption

In places these stopbanks need widening and reconstruction. In some isolated areas complete reconstruction on a slightly different alignment preferred by the landowner is an option. That would be acceptable if the landowner is prepared to pay the extra cost involved.

7.2.5 Issue : Flow Control Mechanisms

The upper Opawa plays a role to receive diverted Waihopai water via Gibsons Creek, some of which is recharged to the aquifer and the remainder is split between Rose's Overflow and the Opawa Loop. These flow splits, and mechanisms for controlling them will be outlined in the Wairau/Awatere Resource Management Plan to be published later.

D8 Omaka River (Upper Opawa Confluence to Hawkesbury Road Bridge and Fairhall River (to New Renwick Road)

Reference Map

Channel characteristics (typical)

Type	:	Braided gravel river
Length	:	4.8 km braided gravel river
Slope	:	.8% (1 in 130)
Fairway Width	:	50 m
Floodway Width	:	150m
Design Flood	:	400m³/sec Design Freeboard 0,4m.

D8.1 Policy for Omaka River (Upper Opawa Confluence to Hawkesbury Road bridge) and Fairhall

REFERENCE	POLICY	APPROXIMATE PRIORITY CATEGORY
	DESCRIPTION OF PROGRAMME METHODS	
D8.2.2	Complete the stopbanking over downstream 800m of river	(b)
D8.2.3	Tree Planting with piled retards for bank protection.	(b)
	Flood damage repair	(r)
	Maintenance	(r)

D8.2 Reasons for Policies and Methods

8.2.1 Issue : Sedimentation

(a) Situation

(i) The Omaka is formerly a wide gravel bed river that has historically built up a significant fan of coarse gravel. The relative infrequency of bed load moving floods keeps gravel replenishment quite low.

A considerable amount of gravel extraction since 1970 has lowered the river channel over the bottom 2.3km of the river, and has been particularly noticeable in the reach ± 1km of SH 6 bridge where the main channel has been lowered by typically 0.8 metres between 1957 and 1990. These are the two times when cross sectional survey of the river has been carried out.

This lowering of the river channel has increased the waterway capacity considerably. The lowering of the river bed also resulted in considerable undermining and failure of rock lined banks during the 1989 flood.

More recently some gravel extraction has been used for stopbank construction in the Hawkesbury Road bridge area and downstream.

The enlargement of the waterway by gravel extraction has been of benefit, but it has reached, if not gone past, the point of detriment due to undermining of banks and of undermining bridges.

(ii) The Fairhall river and its tributary Mill Stream carry very little gravel on to the floodplain and do not present the same problems.

(b) Methods and reasons for adoption

(i) The most desirable solution is to stop gravel extraction from the Omaka at least till such time river resurveys indicate that gravel is building up again. Otherwise further expensive bank protection works may be needed to hold collapsing banks.

8.2.2 Issue : Waterway Capacity

(a) Situation

(i) The Omaka is now stopbanked, or has stopbanks in association with natural terraces for practically its full length. Most of this stopbanking has been recently carried out to design standard.

Stopbanking has only been partially carried out for the bottom 800 metres down to the upper Opawa Confluence. This section is not to full design flood standard.

The cleared fairway of typically 50 metre width will be capable of carrying most of the design flood.

(ii) The Fairhall has a nearly 2 kilometre diversion from its former, pre 1930 channel. The 150 metre wide grassed floodway was designed to cope with $425m^3/sec$, amply big enough to cope with the now assessed design flood of $210m^3/sec$, even though the floodway is very flat graded.

(iii) Between the top of its diversion and New Renwick Road the Fairhall divides into its tributary Mill Stream and the mainstream Fairhall. Neither of these are stopbanked, but both are quite entrenched rivers. Both channels coped with the September 1989 flood event, which was an approx 1 in 10 year return period event hence. In the current partly vegetated state the channels are probably not up to full design standard.

(b) Methods and reasons for adoption

(i) The practical solutions for getting and maintaining the channel to design capacity are clear.

- To maintain the active fairway in an efficient condition by keeping it clear of vegetation.
- To complete the stopbanking over the bottom 800 metres of the river.

(ii) Tree clearing of Fairhall and Mill Stream is the practical solution to improve the capacity of those streams.

8.2.3 Issue : Bank Erosion Protection

(a) Situation

(i) The Omaka is a steep river with significant flood flows and velocities which are capable of easily eroding stopbanks.

Bank protection erosion protection work is required.

Willow trees, at times anchored, are adequate bank protection works for this river. Because of difficulties in getting willow trees to survive, extensive use of rock work has also been used for bank protection works. Improved techniques for tree planting have recently been more successful.

Downstream of Old Renwick Road the river slope and velocities are less and bank protection works may not be necessary.

(ii) The Fairhall does not have significant bank erosion problems.

(b) Methods and reasons for adoption

(i) **Bank Protection Works**

Bank protection in the form of continuous fairway edge willow tree plantings would be the cheapest form of bank protection supported on the outside of bends by rail iron retards. Maintenance of the trees will be required.

Where tree growth is not adequate, and/or localised areas of severe bank attack rock work will be required.

D9 Riverlands Floodway and Wither Hills Stream

Reference Map
Channel characteristics

Riverlands Floodway

Type	:	Straight artificial channel for drainage and floodwater from Wither Hills Stream
Slope	:	Tidal 0.025% (1 in 4000)
Length	:	7 km plus 1.7km of channel within Vernon Lagoons
Design Flood	:	$14m^3$/sec Design Freeboard 0.2m.

The Wither Hills Streams include Mapps, Jacksons, Fifteen Valley, Sutherlands, Wither and Rifle Range. These latter 3 flow through and also receive stormwater from 'Blenheim' urban areas. (Rifle Range is actually diverted to the Taylor, but it is more appropriate to consider here).

D9.1 Policy for Riverlands and Wither Hills Streams

REFERENCE	POLICY	APPROXIMATE PRIORITY CATEGORY
	DESCRIPTION OF PROGRAMMED METHODS	
D9.2.1	Channel excavation	(b)
D9.2.2 (a)+(b)(iv)	Completion of Wither Streams concrete channel and other improvements	(a) + (b)
D9.2.2 (a)+(b)(i)	Completion of Riverlands channel enlargement and other improvements	(a) + (b)
	Flood damage repair	(r)
	Maintenance	(r)

D9.2 Reasons for Policy and Methods

9.2.1 Issue : Sedimentation

(a) Situation

Sediment eroded from the Wither Hills has in the past regularly filled the channels of the flat graded channels of the Riverlands floodway system through and to the east of Blenheim. The considerable soil conservation works done on the Wither Hills have been of tremendous benefit in virtually stopping this erosion.

Silt traps on Mapps, Sutherlands and Fifteen Valley Stream further reduce sediment into the channel system. Even so, siltation does occur to some degree in the flat graded Riverlands channel, including the 1.7km of channel through the estuarine Vernon Lagoons.

(b) Methods and reasons for adoption

(i) Wither Hills Soil Conservation Works. The valuable and important soil conservation works on the Wither Hills are proposed to be maintained and improved as set out in separate document "Wither Hills Property Draft Management Plan", prepared for the Marlborough District Council by Landcorp (1993).

(ii) Silt Traps. Regular cleaning out of the silt traps is necessary.

(iii) Channel Siltation. Excavation of the channel, including the 1.7km of outlet channel within the Vernon Lagoons, is necessary every approximately 7 years to prevent serious impairment of the waterway capacity, and/or low flow drainage effectiveness.

9.2.2 Issue : Waterway Capacity

(a) Situation

(i) Stopbanking exists on both sides of the Riverlands floodway for a distance of 3.5km below Blenheim to where higher ground levels are intercepted, and for 1.5km on Mapps tributary floodway.

Enlargement of these floodway channels with stopbank raising is currently underway as per report of Fitzgerald and Carr (1987) but is not yet finished. The floodway is being enlarged by provision of a berm, and the stopbanks are being raised typically by 0.5m. There is a defined programme of work to complete this work.

(ii) A separate outlet, Sandhills outlet, capable of carrying 25% of flood flows goes directly to the lower Opawa river just downstream of Riverlands corner. This does not operate at times of co-incidental high lower Opawa flows.

(iii) Sutherlands stream has been recently upgraded in 1990 for 0.8km through Blenheim to enable urban development in the area. The capacity of the twisty main channel is not clear but a wide grassed berm area flanking the channel ensures plenty of waterway capacity.

(iv) Wither Stream flows through the most urban developed area. Flood design standards are now needed to be higher than when the Stream channel was initially enlarged by channel excavation in the 1960's when the land was mainly undeveloped. Ironically the intrusion of the urban development reduced the waterway capacity of the channel and inhibited its economic maintenance.

Following a report from Davidson Ayson (1991) the Council decided to improve the waterway capacity by construction of a detention dam at Harling Park, and reconstructing the Wither Hills as an open concrete channel. Separate resource consents were obtained for their activities and some of the work has already been completed.

(v) Rifle Range Creek was upgraded following the 1980 flood on the area. The waterway capacity is estimated as being just to capacity for the design flood, but requires the channel to be kept in good clean condition.

(b) Methods and reasons for adoption

(i) Riverlands and Mapps Floodway improvement programme. The logical option is to complete the partially completed works programme.

(ii) Sandhills Outlet. Provides useful drainage and to a lesser degree flood relief and is sensible to maintain.

(iii) Sutherlands Stream. Maintenance of the channel and berm in a clear state is the logical option to ensure waterway capacity.

(iv) Wither Streams. The logical option is to complete the concrete channel construction programme.

(v) Rifle Range Creek. Maintenance of the stream channel in a good clear condition is the practical option to ensure waterway capacity.

D10 Floodplain Rivers not examined in Detail this Plan

D10.1 Description of Issue

Several Wairau floodplain rivers are particularly complex in that they currently pond over extensive areas outside their natural channels, or further works are interrelated with urban stormwater questions and/or involve diversion. These require more extensive investigation and public discussion, which will be dealt with in the later Wairau/Awatere Resource Management Plan.

D10.2 Policy

The interim policy will be to carry out maintenance and flood damage repair work on their river floodways, while further investigation for the Wairau/Awatere Resource Management Plan proceed. Policies and methods to upgrade these floodways is nevertheless likely to be required within the 10 year time span of this plan.

D10.3 Reasons for Interim Policy

10.3.1 Pukaka River

The Pukaka River has a deliberate low spillway reach in its stopbanks. In flood times up to 30 hectares or more land can be flooded. This floodable land is not zoned as such in the current District Scheme. The degree of frequency of flooding is determined jointly by floods in the Pukaka and floods in the Wairau Diversion. There are options to improve the situation. However, the problem is very complex hydrologically and hydraulically. The Pukaka stopbanks are already undesirably high from a viewpoint of blocking a Wairau secondary flood overflow path, so options to increase Pukaka stopbank levels may not be desirable. The Pukaka outlet gates into the Wairau Diversion were also designed for flood sizes only half what is now recommended.

Considerably more investigation, including consideration of secondary flood paths, is required before recommendation on options can be made. Substantial expenditure could be involved, and a preferable option could be accurate zoning of the flood ponding hazard area.

In the meantime normal maintenance and regular flood damage repair is required for the Pukaka.

10.3.2 Doctors Creek

The previously proposed Doctors Creek diversion (Thomson (1972)) has been demonstrated to be a non preferred option from the viewpoint of reducing flood risk of the Taylor River through Blenheim as described in D8.6

McNabb (1993) has also shown that farming practices have adapted to the extensive ponding in the Batty's Road/Bells Road area on the occasions of Doctors Creek flooding, and that relatively little expenditure is justified for agricultural benefit.

Currently the land on which ponding takes place is not zoned as floodway. The expected area of land over which ponding would occur in a one in 100 year flood event has yet to be assessed. It is approximately 300 hectares.

A range of options are available regarding banking work to reduce the ponding area, or possibly (but unlikely) the previously proposed Doctors Creek diversion. The benefit of such work would only be if the land was required for housing or lifestyle development of Blenheim. More detailed investigation is required of this. In the meantime normal river maintenance work is required. Nor should the designation of the land as floodway for a Doctors Creek diversion yet be uplifted.

10.3.3 Opawa Loop

The Opawa Loop is a 2.5 km reach of river that formerly joined the Upper Opawa and Lower Opawa rivers, and carried large flood flows. The flat graded reach was not significantly stopbanked and considerable flooding occurred of adjacent urban land in the May 1966 flood event. The loop was subsequently blocked at both the upstream and downstream end in 1967. Gated 1.8m culverts at both ends allow for low flows to be diverted through it.

The Opawa Loop now has a much lesser flood role in dealing with stormwater from urban Blenheim.

However, being an urban river, the aesthetics and other environmental aspects of this channel are very important. There is also significant potential recreational use.

The river has significant problems of summer weed, and poor water quality. A resource consent has recently been obtained for use of grass carp to control the weed in this reach.

Potential future management of this channel must consider its role in dealing with stormwater, what potential there may be for increasing flows in the channel, weed, water quality and potential recreational use and aesthetics within the town environment. More detailed investigation is required on this. In the meantime normal river maintenance is required.

10.3.4 School and Terrace Creek, Renwick

These two creeks are sourced from both rural and urban runoff. Works have been carried out in the past under the Wairau Valley Scheme on both these streams, but the degree of flooding is still not to an acceptable standard. Further planning for works in these rivers is inter-related with stormwater planning for Renwick, currently separately being examined.

10.3.5 Gibsons Creek

Gibsons Creek has a natural catchment, especially the 6km^2 'Delta' area, and also has a nearly continuous abstraction of some 3m^3/sec from the Waihopai. This abstraction was put in as part of the Wairau Valley Scheme to recharge the groundwater aquifer, and other riparian values that had been affected by river control works earlier this century blocking off overflows from the Waihopai and Wairau Rivers.

There was considerable public interest in getting Gibson's Creek rewatered by an abstraction from the Waihopai. It was accepted in 1960 that this work was a responsibility of the river control authority - then the Marlborough Catchment Board - to install and maintain such an abstraction as a compensatory work.

This plan makes provision for abstraction from theWaihopai (including the necessary intake works maintenance as outlined in D8.5) to continue. The plan does not include specifying how much water should be abstracted from the Waihopai, whether this amount should be restricted in times of drought, and the management of the water along the length of the Gibson Creek and Upper Opawa channels.

The degree to which groundwater recharge is now benefiting from the abstraction is unclear. There is no doubt however that the abstraction is of considerable benefit for environmental uses not only of Gibsons Creek, but also for the Upper Opawa, Opawa Loop and Rose's Overflow.

Future management decisions on Gibsons Creek need more extensive investigation and discussion. In the meantime normal maintenance work is required.