REPORT

WAIMEA WATER AUGMENTATION COMMITTEE

Waimea Water Augmentation Phase 2 - Lee Valley Dam Feasibility Investigations - Summary Report

Report prepared for:-

WAIMEA WATER AUGMENTATION COMMITTEE

Report prepared by:

TONKIN & TAYLOR LTD

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Executive Summary

In 2007 Tonkin & Taylor Ltd (T&T) and its sub-consultants completed a Phase 1 pre-feasibility evaluation of a number of options to provide water storage for long-term irrigation and community supplies in the Waimea Basin, Tasman District. The evaluation was undertaken on behalf of the Waimea Water Augmentation Committee (WWAC). The overall principle of the study was to identify and develop a water augmentation scheme to capture excess water for storage and release that water back into the Waimea River system during periods of high water demand and/or low natural water flows to augment those supplies, either directly or via recharging of the groundwater system.

The outcome of that Phase 1 study was to focus feasibility investigations on a water storage dam and reservoir site located in the upper Lee River catchment, a tributary of the Waimea River.

In late 2007 WWAC commissioned Phase 2 of the study, to take the Lee investigation programme to a feasibility level.

This report summarises the final reporting of the investigations completed as part of the Phase 2 feasibility study. The study is based on a potential dam on the Lee River in Tasman District, at a site approximately 300 metres upstream of the confluence of the Lee River and Anslow Creek. The required storage capacity of the reservoir to meet the identified water demands has been determined to be approximately 13 million cubic metres. This equates to a normal top water level of RL 196.4m (rounded up to RL 197m). The reservoir would extend approximately 4km upstream from the dam, and cover an area of approximately 65 hectares (based on normal top water level). The total area potentially directly involved (including construction areas and a flood buffer zone), is approximately 86 hectares.

This report summarises all work undertaken during the Phase 2 feasibility study. It is accompanied by 11 detailed technical investigation reports. The key points are summarised as follows:

Water Resource Investigations:

- The size of the reservoir has been determined to be approximately 13 million cubic metres based on the following inputs to an assessment of total water demand:
  - The scheme assumes provision is made for irrigation of approximately 5850 hectares of land on the Waimea Plains and environs.
  - Provision is made for urban and industrial water supply for Tasman District for a 100 year planning horizon.
  - Provision is made for a possible future regional water supply.
  - The scheme assumes that a minimum flow of 1100 litres/second is retained in the Waimea River at Appleby Bridge (after all water supply abstractions have been taken into account).
- The storage provided by the scheme can provide an approximate 66 year return period drought security.

- On a long-term average, based on supplying the full future water demand, the reservoir would be full for about 83% of the time, and within 5m of full for about 97% of the time.
- As a result, for much of the time the river flow downstream of the dam will be almost the same as the river flow coming into the reservoir; ie there will be little noticeable change in the Lee River flow after the dam is built. However, summer low flows will be boosted by the flow releases from the dam. At times, and more likely in summer, small floods in the river will be captured in the reservoir, resulting in lower flows than would otherwise occur, downstream of the dam.
- As a minimum, there will always be a flow of at least 510 l/sec released from the dam.

Dam Design

- A geotechnical investigation programme has been undertaken that has identified a potentially suitable site for a concrete-faced rockfill dam approximately 300 metres upstream of the confluence of Anslow Creek and the Lee River.
- A preliminary design has been prepared for the dam.
- The crest of the dam will be a maximum height of 52m above riverbed level.
- The design and standards have been selected in accordance with the requirements of the dam industry and legislation for a high potential impact category dam.
- The design and investigations have been reviewed by an independent peer reviewer.
- The capital cost of the dam structure has been estimated at $38.1 million (GST excl). Some options exist to reduce this cost. This will be examined further at the detailed design stage.
- There is potential to utilise the head provided by the dammed water to generate hydro-electric power. The optimum scheme would generate approximately 1MW.

Land Tenure and Access Replacement

- A large portion of the land on which the dam and reservoir would be located is privately owned; the balance comprises Crown forest licence, Public Conservation land (Mt Richmond Forest Park), and Road Reserve.
- The existing road network that gives access to and within the forestry areas will need to be re-routed in places. Alternative routes have been investigated, and preliminary routes identified.

Environmental Issues

- The 'footprint' of the dam and reservoir would extend over land that has had its original vegetation cover greatly modified. Part of it is currently in exotic forest although there are also areas of indigenous vegetation remaining, including within Mt Richmond Forest Park.

- The area supports a range of indigenous vegetation species and communities, some of which are of botanical significance.
- All vegetation species of significance identified in the survey are represented elsewhere in the local area; that is, there are no plant species that are threatened with extinction by the development of the Lee dam and reservoir.
- The potential or actual effects on indigenous wildlife are regarded as being minor.
- Water quality investigations indicate that water quality in the reservoir is likely to be very high. It is recommended that two water offtake structures are installed, at different levels, to ensure that the water is well mixed for release to the river.
- The scheme has been designed so that a minimum flow of 1100 l/sec can be retained in the Waimea River at Appleby Bridge, after all other water demands have been met. The natural 7-day mean annual low flow (510 l/sec) has been selected as the appropriate minimum flow to be retained in the Lee River immediately below the dam. These flows will provide conservative protection for the habitat of trout and indigenous fish species.
- The main effect of the scheme on the river system will be to increase flow in the Lee, Wairoa and Waimea rivers during the summer irrigation (and low flow) period; as a result, habitat availability for most fish species is predicted to increase. For the other seasons (April-November inclusive), it is predicted that there will be no more than a 3% change in habitat availability at the monthly median flows as a result of the scheme, for any of the fish species modelled.
- Given the height of the proposed dam (approximately 52 m to the dam crest) and the relatively low status of the trout fishery in the Lee River, it is considered that mitigation of fish passage issues associated with the dam is only necessary and practical for the strongest of migrants such as young eels and young koaro.
- A nature-like fish passage channel has been incorporated in the proposed dam design so that eels and koaro can migrate past the dam.
- Provision is made for flushing flows from the reservoir to manage any nuisance aquatic plant growth in the river below the dam.
- It is unlikely that didymo will proliferate in the reservoir.
- Most fish species (trout, eels, torrentfish, koaro, and upland bully) are predicted to benefit from the augmentation scheme as a result of increased flows in the lower Waimea River during dry periods.

Recreation

- The main existing recreational activity in the Lee River is swimming. This will not be adversely affected by the scheme.
- The net adverse recreation effect of the proposal on the existing recreation setting, without mitigation, will be to limit public access along the bed of the

upper Lee River, although access is currently difficult, limited to foot, and used very infrequently.

- There will be an improvement in trout habitat in the Waimea River, and an increase in adult trout numbers, as well as minor positive effects on opportunities for jet boating and kayaking.
- Short-term effects relate to a minor reduction in water clarity and potential increase in periphyton growth in the Lee River downstream of the dam for the first three to four years of operation. These effects will have minor adverse effects on swimming. The opportunity to release flushing flows will minimise the effects of periphyton.
- The net effect of the proposal on recreation without mitigation is likely to be slight, but potentially positive.

Tangata Whenua Perspective

- A survey of taonga identified ngahere (native trees) and kohatu (stone/minerals) as being worthy of harvest from within the scheme footprint prior to the scheme being constructed.
- A harvest plan has been prepared.
- A list of opportunities has been identified for restoration of biodiversity and management of the proposed dam and reservoir area.
- Fourteen sites have been identified for potential restoration.
- Six indicator sites have been identified for monitoring cultural and environmental health.

Environmental Mitigation

- An environmental opportunities scoping plan has been developed for the project.
- The plan identifies the potential environmental, recreational and cultural effects, and describes mitigation measures (that are built into the scheme design) and those effects that will require some offset compensation.
- Measures that are built into the scheme include:
  - Maintaining minimum flows in the river downstream of the dam to protect instream habitat
  - Incorporating a fish pass channel in the dam design
  - Using variable height offtake structures to manage water quality
  - Provision for flushing flows
- A list of priorities has been identified to offset the removal of significant indigenous vegetation and communities.

Enhancing Distribution of Water

- The scheme will deliver water to a large proportion of the Waimea Plains via the river system and recharge of the groundwater system. This area is described as the 'zone of effect'.

- Water users beyond the zone of effect would require additional water reticulation systems if they wish to join the scheme. The indicative cost of water distribution systems to those users has been assessed.

Water Allocation and RMA Issues

- A range of options has been identified to allocate the water to users.
- WWAC prefers that resource consents for taking and using water from the scheme are held by the scheme owner rather than individual users.
- There will be a range of resource consents needed to enable the construction and operation of the scheme.
- Some changes will be required to Tasman District Council's Regional Resource Management Plan to accommodate the scheme.

Ownership Structure

- WWAC's preference is that the scheme is owned and operated by the water users, where the scheme assets are owned and operated by a limited liability, community-based entity.
- The scheme should be operated on a cost recovery basis.
- Ultimate control over access to the water should be vested in all water users, including the consumptive and environmental users.
- An allocation of the capital and operating costs should be made for environmental flows, broadly reflecting the incremental cost of building a larger storage reservoir than that needed to meet consumptive demand.
- All remaining capital and operating costs should be shared between consumptive users on the basis of water demand. Costs allocated to the urban and industrial demand within Tasman District would be met by the TDC, and future regional demand would be met by another party.

Financial modelling

- The cost of the scheme to users is highly dependent on the number of participants who join the scheme, and is linked to the assumed size of the scheme to meet the demands of the users.
- The cost of the scheme to users has been determined on the basis of an annual charge per hectare. This comprises an annual fixed charge over an assumed 25 year repayment period, plus an ongoing annual operating charge.
- The option may exist to pay a one-off, upfront payment, rather than the annual fixed charge. The annual operating charge would still apply.
- The base scenario assumes a total capital cost of $41.6 million (including dam, land purchase and access, environmental mitigation, and the resource consent process), with 30% of the cost funded by the community at large.
- Based on the above, and depending on the number of scheme participants, the indicative cost for water users ranges from $420-$580 per hectare per

year. This comprises $370 - $510 per hectare annual fixed charge (over 25 years) plus the ongoing $50 - $70 per hectare annual operating charge.

- The one-off upfront payment option would be $3750 - $5130 plus the ongoing $50 - $70 per hectare annual operating charge.
- There would also be a total annual community charge of between $1.9 million and $2.1 million over the 25 year repayment period. The annual operating charge would be ongoing.
- An assessment has been done of the effect on irrigators and the community if the water augmentation scheme did not proceed:
    - In the worst-case scenario of addressing the current over-allocation issue (ie if the scheme did not proceed, and if a minimum flow of 1100 l/s had to be retained in the Waimea River at Appleby Bridge) water allocations may be reduced to a level which leaves sufficient water to irrigate just 705 hectares of the 3800 hectares that are currently irrigated.
    - There would therefore be a forced shift to dryland farming, with the potential for an aggregate capital value loss of approximately $165 million.
    - There would also be significant effects on both industrial users and urban/community water users (via restrictions on TDC's reticulated water supply).

1 Introduction

1.1 Background

In 2007 Tonkin & Taylor Ltd (T&T) and its sub-consultants completed a Phase 1 pre-feasibility evaluation of a number of options to provide water storage for long-term irrigation and community supplies in the Waimea Basin, Tasman District. The evaluation was undertaken on behalf of the Waimea Water Augmentation Committee (WWAC). The overall principle of the study was to identify and develop a water augmentation scheme to capture excess water for storage and release that water back into the Waimea River system during periods of high water demand and/or low natural water flows to augment those supplies, either directly or via recharging of the groundwater system.

The outcome of that Phase 1 study was to focus feasibility investigations on a water storage dam and reservoir site located in the upper Lee River catchment, a tributary of the Waimea River.

In late 2007 WWAC commissioned Phase 2 of the study, to take the Lee investigation programme to a feasibility level.

1.2 Scope

This report summarises the final reporting of the investigations completed as part of the Phase 2 feasibility study. The study is based on a potential dam on the Lee River in Tasman District, at a site approximately 300 metres upstream of the confluence of Anslow Creek and the Lee River (at Chainage (Ch) 12,430m[1]). The required storage capacity of the reservoir has been determined to be approximately 13 million m^3, with a normal top water level to approximately RL 197m. The reservoir would extend approximately 4km upstream from the dam, and cover an area of approximately 65 hectares (based on normal top water level). [2]

Figure 1.1 shows the location of the proposed dam, and the indicative reservoir extent.

The work has been undertaken by a team of specialist consultants, led by T&T. The specific specialist areas and consultants, as well as input by TDC are as follows:

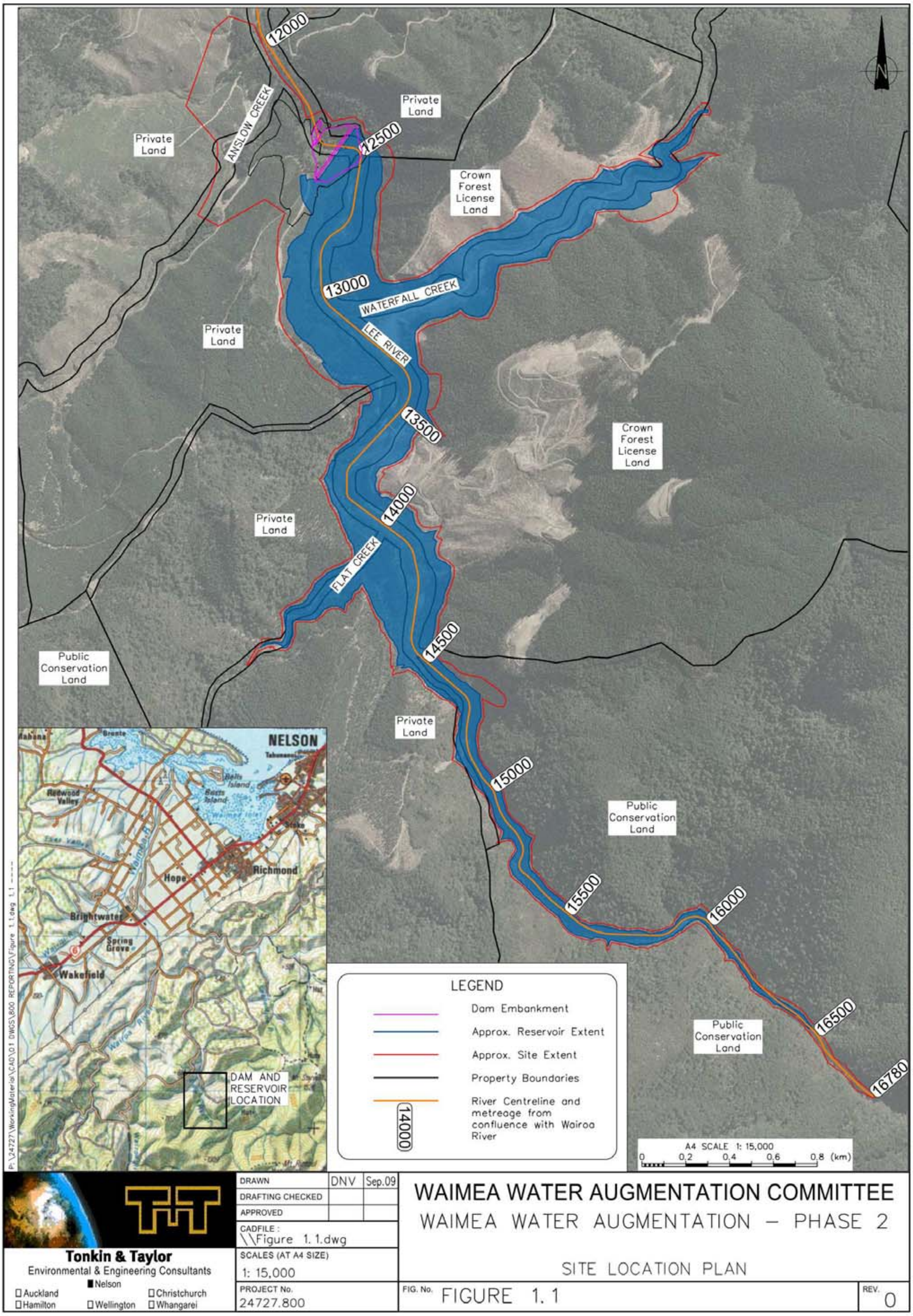
- Lead Consultant and project management – Tonkin & Taylor
- Determination of irrigation demand - Agfirst Consultants (Nelson)
- Assessment of community/industry water demand - Tasman District Council
- Modelling of groundwater system and groundwater/surface water interaction – GNS Science
- Catchment hydrology – Tonkin & Taylor
- Modelling of surface water system (incorporating water demand and groundwater requirements as above) to determine reservoir storage requirements – Tonkin & Taylor

[1] A river referencing system has been set up for the project for the Lee River, based on the distance in metres upstream from the confluence of the Lee River with the Wairoa River.
[2] Use of the terms "right" and "left" in this report when referring to riverbank or abutment should be interpreted when looking downstream.

- Dam site identification and optimisation – Tonkin & Taylor
- Geotechnical investigations – Tonkin & Taylor
- Dam design – Tonkin & Taylor
- Operating regime – Tonkin & Taylor
- Dambreak hazard assessment – Tonkin & Taylor
- Costing of capital works – Tonkin & Taylor, with review input from Earthworks and Civil Marlborough Limited, and The Breen Construction Company Ltd
- Assessment of land tenure – information provided by Tasman District Council
- Assessment of replacement access requirements – Tonkin & Taylor and WWAC, in consultation with land owners and occupiers
- Assessment of vegetation values – Uruwhenua Botanicals (Dr Philip Simpson) and Tonkin & Taylor
- Assessment of indigenous wildlife values – Tonkin & Taylor
- Aquatic ecology (instream requirements, water quality and fish passage) – Cawthron Institute
- Tangata whenua perspectives – Tiakina Te Taiao
- Assessment of recreational values – Rob Greenaway & Associates
- Assessment of environmental mitigation requirements and options – Tonkin & Taylor
- Assessment of water allocation methods and RMA implications– Landcare Research and Tonkin & Taylor
- Assessment of water distribution enhancement requirements – Landcare Research and Agfirst Consultants
- Identification of scheme ownership structure options - Northington Partners
- Financial modelling - Northington Partners, with input from Agfirst Consultants and Landcare Research

Critical aspects of the investigations have been independently peer reviewed as follows:

- Water resource investigations covering water demand, groundwater and surface water hydrology, and storage assessment – Dr Vince Bidwell (Lincoln Ventures, Lincoln University)
- Geotechnical investigations, dam design, dambreak hazard assessment, and flood hydrology – Dr Trevor Matusckha (Engineering Geology Ltd).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16780
ANSLOW CREEK
WATERFALL CREEK
LEE RIVER
FLAT CREEK
Private Land
Crown Forest License Land
Public Conservation Land
NELSON
Richmond
Hope
Brightwater
Spring Grove
Wakefield
DAM AND RESERVOIR LOCATION
LEGEND
Dam Embankment
Approx. Reservoir Extent
Approx. Site Extent
Property Boundaries
River Centreline and metreage from confluence with Wairoa River
14000
A4 SCALE 1: 15,000
0 0.2 0.4 0.6 0.8 (km)
Tonkin & Taylor
Environmental & Engineering Consultants
Auckland Hamilton Nelson Wellington Christchurch Whangarei
DRAWN DNV Sep.09
DRAFTING CHECKED
APPROVED
CADFILE : \\Figure 1. 1.dwg
SCALES (AT A4 SIZE) 1: 15,000
PROJECT No. 24727.800
WAIMEA WATER AUGMENTATION COMMITTEE
WAIMEA WATER AUGMENTATION – PHASE 2
SITE LOCATION PLAN
FIG. No. FIGURE 1. 1
REV. 0

This report summarises all work undertaken during the Phase 2 feasibility study. It is accompanied by 11 detailed technical reports, as follows:

- Water Resource Investigations (covering water demand, groundwater/surface interaction modelling, catchment hydrology, flood hydrology, and dam storage modelling)
- Geotechnical Investigation Report (covering site investigations, site geology and geotechnical conditions, and construction materials availability and suitability)
- Engineering Feasibility Report (covering preliminary dam design, options, hydropower assessment, construction methodology, estimate of capital costs and dambreak hazard assessment)
- Terrestrial Ecology Effects Assessment (covering vegetation and indigenous fauna)
- Aquatic Ecology: Mitigation and Management Options (covering instream habitat requirements, water quality, and fish passage)
- A Management Plan for Lee Valley – A Tangata Whenua Perspective
- Assessment of Effects on Recreation (covering existing and potential recreational values)
- Enhancement Opportunities Scoping Plan (covering environmental effects, mitigation, and offset compensation options)
- Water Allocation Options and Resource Consent Requirements (covering options for initial and ongoing allocation of water from the scheme, and resource management implications)
- Enhancing Water Distribution (covering an initial assessment of water distribution infrastructure that would be needed to allow the augmented water supply to be made available to potential users who are beyond the direct supply area)
- Financial and Economic Assessment of Water Augmentation (assessing the likely cost of the scheme to users, presenting a cost/benefit assessment, and including the 'lost opportunity' costs if the scheme does not proceed).

The outcomes of each of the above reports are summarised in this report. The reader is referred to the accompanying technical reports for details.

1.3 Purpose of Scheme

The principal purpose of the proposed scheme is to provide water storage to augment river flows and groundwater recharge for irrigation, community water supply and instream requirements (ecological, cultural, and recreational). The ability to use the head produced by the dam to generate hydro-electricity has also been evaluated as a secondary purpose.

2 Water Resource Investigations

2.1 Scope

This section summarises the investigations and results that are presented in detail in the accompanying **Water Resource Investigations Report**.

The water resource investigations addressed the following aspects:

- confirmation of the potential future water demand for irrigation use, as well as long-term community and industrial demands, plus in-stream flow requirements
- groundwater - surface water interaction modelling of the Wairoa River and Waimea aquifers and development of a flow augmentation regime for meeting future demand and a residual flow in the Waimea River of 1100 l/s at Appleby Bridge
- confirmation of flow characteristics and water availability of the Lee River (catchment hydrology)
- dam storage modelling to confirm the required storage capacity at the selected dam site on the Lee River to service the identified water needs
- flood hydrology and development of design flood hydrographs for feasibility design of the dam spillway, and for construction diversion
- description of a preliminary operating regime at the proposed dam including the flow changes anticipated below the dam site and at the Wairoa Gorge
- description of an operating regime based on a possible hydro-electric power add-on.

The work reported here incorporates input from the following parties:

- Tasman District Council (hydrometric data; urban and industrial water demand)
- Tonkin & Taylor (overall integration; hydrological modelling and storage demand assessment; flood hydrology operating regimes)
- GNS Science (groundwater modelling)
- Agfirst Consultants (consumptive water demand)
- Landcare Research (irrigation demand scheduling)
- Lincoln Ventures (external peer review)
- Engineering Geology Ltd (external peer review).

2.2 Water Demand

2.2.1 Introduction

The first step in assessing the required capacity of the reservoir and therefore the overall size of the scheme was to identify and quantify the categories and quantities of water required for the various uses. The uses can be generally described as either 'consumptive' (ie those uses where water is taken out of the system such as for irrigation or community supply) or non-consumptive (ie where water remains in the system and is available for 'uses' such as instream ecology and fisheries values, recreation, cultural or aesthetic purposes).

Once the required uses, users and volumes had been identified, the information was put into hydrological models to determine:

1. The relationship between the Wairoa/Waimea river system and groundwater aquifers on the Waimea Plains based on running the model using data obtained from previous known low flow or drought years;
2. The pattern of flow releases from a dam sited on the Lee River required to meet all the uses (both consumptive and non-consumptive) and thus the storage capacity required at the dam to accommodate any specified drought event;
3. What effect the reservoir would have on water availability and the flow regime downstream (assuming that the reservoir had been in place).

These aspects are described in the following sections.

2.2.2 Assumptions

A technical workshop on water demand was held in October 2007 to update and agree the demand assumptions on which to base the live storage requirement for the proposed dam and the input to groundwater modelling.

A summary of the decisions made at the workshop by the WWAC Technical Group, is as follows:

- Extent of irrigable area
    - provide for irrigation of 250 ha (or about 25%) of Rabbit Island
    - allow for irrigation of 300 ha in the lower Wai-iti Valley
    - irrigation application rate to be based on 80% of irrigable area
    - in total provide for irrigation of 5856 ha
- Crop mix in the irrigation service area
    - Irrigation rate to be based on pasture throughout (conservative), with a peak application rate of 30 mm/week
- Design drought and the drought security standard
    - Provisionally target 60 year return period drought standard (as adopted during Phase 1)
    - Rationing not likely to be an issue given the high drought security standard adopted
    - This assumption to be reviewed once the drought return period versus storage volume relationship was defined
- Instream residual flow
    - Be able to achieve a minimum flow in the Waimea River of 1100 l/s at Appleby Bridge (after all consumptive uses provided). This is a retention of the assumptions adopted during Phase 1 investigations
- Tasman District urban/industrial demand

- Include provision for water demand for 100 years planning horizon
- Peak daily demand and annual demand pattern was subsequently confirmed by TDC
- Future wider regional demand
- Make allowance for 22,000 m^3/day (assumed to be a surface flow take at Wairoa Gorge) noting that this level of demand is not projected to be reached until 2060

- Climate change effects
    - Mean precipitation may decrease and extremes may worsen
    - No specific measures taken other than adopting a high drought security standard (with the expectation that the standard may lower with future climate change)
- Hydro-electric power generation
    - Explore conjunctive use of dam for power generation (expected to be modest)
    - Warrants some optimisation but it was agreed not to increase the dam size significantly to specifically enhance hydro-generation
- Distribution to service areas beyond aquifer zone of supply
    - To determine approximate need for and cost of distribution (of irrigation water) to areas beyond the zone of effect of the aquifers

2.2.3 Consumptive Water Demand

The three main components of 'consumptive' water demand are:

1. Irrigation demand;
2. Urban and industrial demand for Tasman District;
3. Future regional demand.

2.2.3.1 Irrigation Demand

Irrigation usage depends heavily on the actual rainfall pattern over the irrigation season, and to a lesser extent on other climatic variables (wind, temperature, etc.). The total volume of water required will be greater when in a drought situation. It is reasonable to assume that high irrigation usage will often coincide with lower than average river flows over an irrigation season, as both variables are driven to a large extent by rainfall patterns – low rainfall generally corresponds with low river flows and high irrigation usage. In assessing the size of reservoir required, low inflows to the reservoir and high irrigation usage are compounding factors, and so must be captured appropriately in the reservoir simulation. If this were not done, the result would be unconservative.

Modelling was undertaken to determine the irrigation usage that would have been required corresponding with the entire period of available flow data in the Wairoa River (1958 to 2008).

The irrigation demands were assessed based on soil type (specifically soil moisture holding capacity), daily rainfall and other climate parameters, crop type (viz. all pasture, as noted earlier), maximum weekly application rate (viz. 30 mm/week), and a measure of irrigator behaviour (viz. “aggressive” versus “modest” (efficient) irrigator).

Figure 2.1 shows the year to year variation in the predicted irrigation demand based on historical climate data. High demand years, greater than 25 million m³ per annum, are indicated by red bars; i.e. 1973, 1983 and 2001 (year ending 30 June). By contrast, in low usage years such as 1996 and 2002, the irrigation demand would have been as low as 11 million m³ (less than half the requirement in a drought year).

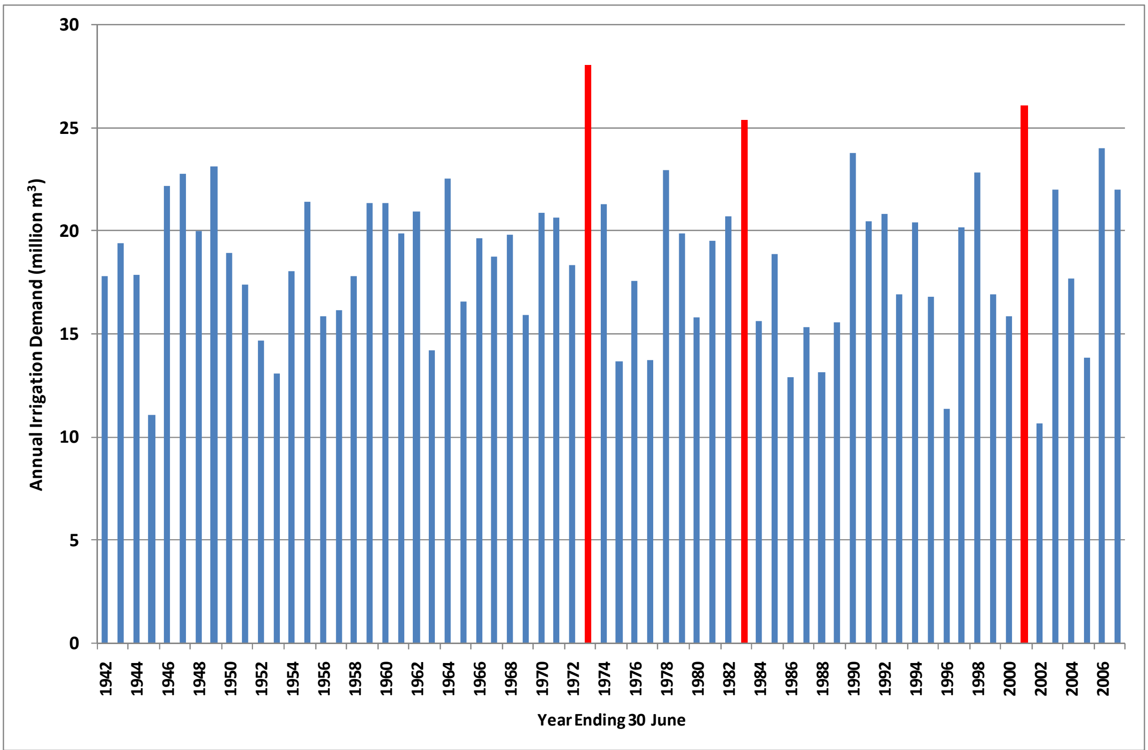


Figure 2.1: Annual Irrigation Demand Volumes from 1942 to 2007 (year ending 30 June)

2.2.3.2 Urban and Industrial Demand

TDC has predicted that based on a 100 year planning horizon, the urban and industrial demand for the District will be a nominal peak daily demand of 60,000 m³/day. This demand is to be met from the aquifers of the Waimea Plains. Demand is predicted to be strongly seasonal with the peak demand occurring in January and the lowest demand in June. The averaged demand over a full year is approximately 24,000 m³/day.

2.2.3.3 Future Regional Demand

Provision has also been made in the modelling for a potential ‘future regional demand’ of 22,000m³/day. For modelling purposes, this volume has been assumed to be a surface water take, upstream of the Waimea Plains aquifers.

2.2.4 Instream Requirements (Non-consumptive Demand)

During the Phase 1 investigations, Cawthron undertook an assessment of the minimum flows required to provide instream habitat in the lower Wairoa/Waimea River and immediately below the potential dam site. Different minimum flows were identified to span a range from an "environmental benchmark" minimum flow that would be conservative in terms of environmental protection, to a minimum flow that would be weighted towards out-of-stream values.

Cawthron's findings from Phase 1 were:

1. Instream residual flow requirements at Appleby:
   - 1300 l/s (environmental benchmark)
   - 800 l/s (minimum flow retaining 80% of the adult brown trout habitat)
   - 500 l/s (minimum flow retaining 70% of the adult brown trout habitat).
2. Instream residual flow requirements immediately below the potential dam site:
   - existing MALF (environmental benchmark)
   - 1 in 5 year low flow
   - 1 in 10 year low flow

WWAC took a decision to provide for an instream minimum flow in the Waimea River of 1100 l/s at Appleby Bridge; ie this is the flow that is to be retained in the river after all abstractions for consumptive uses have been made. As noted in Section 2.2.2, WWAC endorsed this decision for the Phase 2 investigations.

As part of Phase 2, Cawthron undertook additional investigations and habitat modelling for the Lee River in order to assess an appropriate minimum flow below the proposed dam, and to provide an indication of the flushing flows required to flush sediment and algae from this reach of the river. Details of Cawthron's study are provided in the accompanying technical report "**Aquatic Ecology: Mitigation and Management Options Associated with Water Storage in the Proposed Lee Reservoir"** and summarised in Section 6.2.4.

As a result of these investigations, the environmental benchmark of the natural 7- day MALF (ie. 510 l/s) has been confirmed as an appropriate minimum flow in the Lee River immediately below the dam. In addition, Cawthron has recommended that a 5 m^3/s flushing flow capability be provided at the dam as part of an adaptive management approach to potential algal proliferation.

2.3 Groundwater – Surface Water Interaction Modelling

In order to estimate the required storage capacity for the reservoir on the Lee River to meet the future water demands as described in Section 2.2, a reservoir storage simulation model was developed, using historical data for flows in the Wairoa River over the period from 1958 to 2008.

Groundwater modelling was carried out to determine the augmented flows required in the Wairoa River at Wairoa Gorge (Irvines) to ensure that a residual flow of at least 1100 l/s could be maintained in the Waimea River at Appleby Bridge while meeting unrestricted abstractive demands from the Wairoa River and Waimea aquifers. The modelling was undertaken for selected drought years (1982/1983 and 2000/2001) and an average year (2004/2005). The groundwater model was developed to simulate recharge to and abstractions from the confined and unconfined aquifer systems which underlie the Lower Wairoa/Waimea River plains. Using this model, the sequence of required augmented flows at Wairoa Gorge was determined for a number of scenarios from repeated (trial-and-error) runs of the model.

Groundwater modelling showed that, to meet the future water demand and maintain a minimum flow of 1100 l/s at Appleby Bridge, the average augmented river flow required at the Wairoa Gorge over the driest part of the 2000/2001 drought (1 February through 31 March 2001) would be 2,822 l/s (upstream of the Waimea East Irrigation Scheme take). Similarly, modelling of the scenario for the 1982/1983 drought (with the driest part of it also being the 1 February through 31 March time frame) showed that an average augmented flow at the Wairoa Gorge of 2,744 l/s would have been required to meet the target minimum flow of 1,100 l/s at Appleby Bridge. With abstractions at the future demand level, and without any augmentation, natural river flow is predicted to be able to maintain a river flow above 1,100 l/s at Appleby Bridge at all times except for 3 days in the 2004/2005 irrigation season.

Results of groundwater modelling were used to develop simplified empirical relationships between the flow augmentation required and the natural flow at Wairoa Gorge for varying levels of groundwater demand. Forward simulations were then undertaken to assess whether the augmented river flow regime at the Wairoa Gorge based on these empirical relationships could maintain a minimum 1,100 l/s flow at Appleby Bridge for the 1982/1983 and 2000/2001 drought years.

Forward simulation results indicated that the proposed augmented river flows would maintain river flow above 1,100 l/s at Appleby Bridge on most days, but not all days, in the critical periods of late March 1983 and April 2001. Subsequently, some further adjustments to the proposed flow augmentation regime were made to reduce these occurrences and compensate for the shortfalls.

It is noted that when the dam is commissioned and the flow augmentation scheme implemented, it will be possible (and also preferable) to make use of real-time flow monitoring data at Appleby Bridge to refine flow releases from the reservoir so that flow above 1,100 l/s at Nursery-Appleby Bridge is achieved at all times.

2.4 Surface Water Hydrology

2.4.1 Introduction

Hydrological aspects considered include:

- Catchment water balance and assessment of the mean flow of the Lee River at the dam site;
- Assessment of the frequency of low flows in the Lee River;
- Analysis of flood frequency and design flood estimation for the proposed dam.

Assessments of catchment hydrology from Phase 1 have been updated. At the commencement of Phase 2, TDC installed an automatic flow recording station on the Lee River upstream of the dam site (upstream of the Waterfall Creek confluence) and commenced monitoring of flows in April 2007. The nearest and most representative flow recorder with continuous long-term flow records is on the Wairoa River at Irvines (or Gorge) which commands a catchment area of 463 km^2 which includes the Lee River catchment.

A comparison of the contemporaneous flows from the Lee River at Waterfall Creek and the Wairoa River at the long-term flow recorder at Irvines shows that flows in the upper

Lee behave in the same way as flows in the Wairoa River, and that both flow regimes are in complete synchronisation. Therefore, a synthetic record of flows in the Lee River (back to November 1957) has been able to be generated by scaling the Wairoa River historical flows.

2.4.2 Assessment of Mean and Low Flows

The long-term mean flow of the Lee River at the proposed dam site (upstream of Anslow Creek) is estimated to be 3.60 m^3/s. At the flow recording site on the Lee (above Waterfall Creek), the estimated long-term mean flow is 3.20 m^3/s.

The current estimate of the 7-day Mean Annual Low Flow (MALF) at the proposed dam site is 0.49 m^3/s. The 7-day five year and ten year low flows are estimated to be 0.38 m^3/s and 0.33 m^3/s respectively.

2.4.3 Flood Hydrology and Probable Maximum Flood

The assessment of flood hydrology has been focussed on design flood estimation at the proposed dam site (Ch 12,430m). Three methods have been used to compute design floods for a range of return periods. The methods are:

1. Flood frequency analysis based on long-term flow records at Wairoa Gorge (allows estimation of peak flows for a range of return periods);
2. Production of a full design flood hydrograph derived from repeated frequency analysis of flood volumes for a range of durations;
3. Flood hydrograph simulation based on a design rainstorm using a rainfall-runoff model calibrated to recorded storm rainfall and flood events.

The resulting flood hydrographs are shown in Figure 2.2. The flood estimates for return periods up to 10,000 years are shown in Table 2.1.

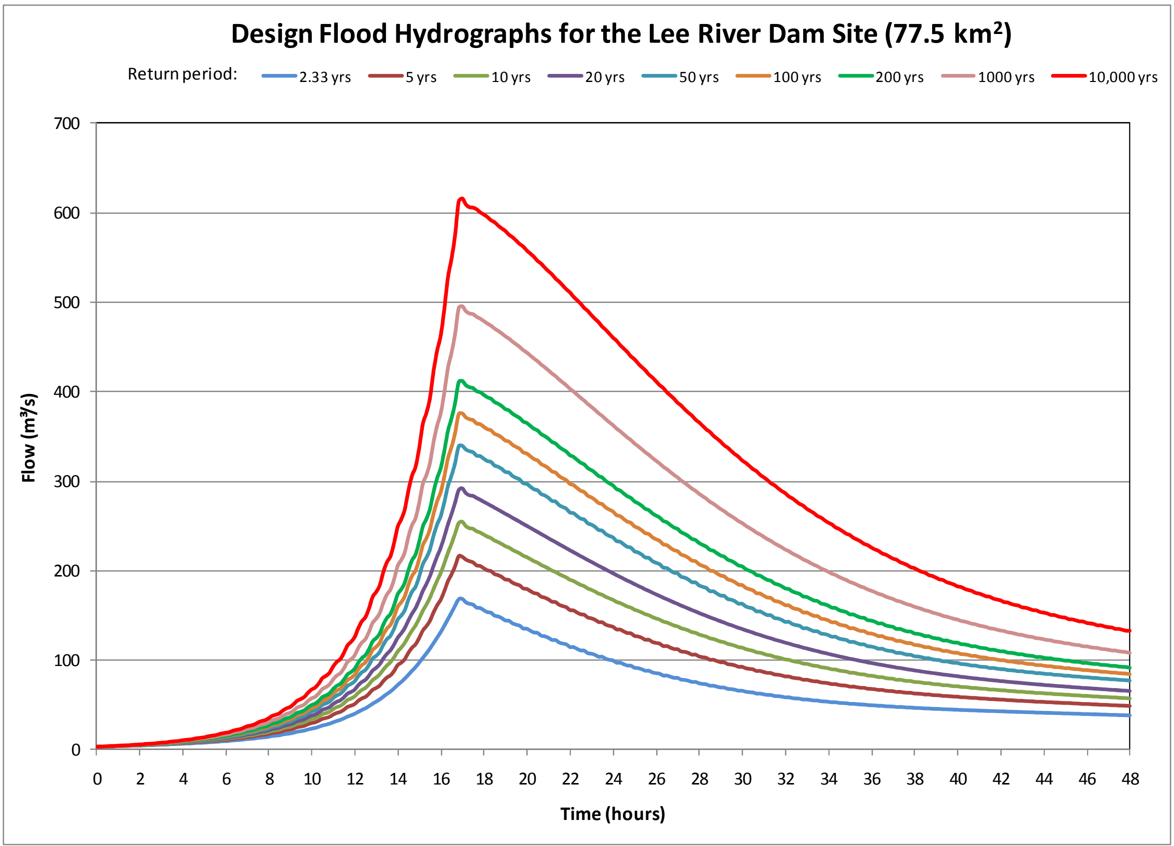


Figure 2.2: Design flood hydrographs for the proposed Lee River dam site for a range of return periods

Table 2.1 Peak inflow and flood volume at the proposed dam site on the Lee River

Flood Return Period	Peak Inflow (m^3/s)	48 Hour Flow Volume (million m^3)
2.33 years (mean annual flood)	168	10.3
5 years	216	13.8
10 years	255	16.6
20 years	292	19.2
50 years	339	22.7
100 years	375	25.0
200 years	412	27.9
1000 years	496	33.9
10,000 years	616	42.4

A Probable Maximum Flood (PMF) for the dam site has also been developed. This PMF has been computed from the Probable Maximum Precipitation (PMP) assessed for the catchment at the dam site using the 1995 NIWA approach, "A Guide to Maximum

Precipitation in New Zealand" (Thompson and Tomlinson). The calibrated catchment rainfall-runoff model was used to generate the PMF from the 24 hour duration PMP.

The peak PMF inflow at the dam site is estimated to be 1094 m^3/s and the 24 hour flood volume 48 million m^3. Thus, the PMF is almost 3 times the 100 year return period flood both in peak flow and flood volume terms; i.e. the 100 year return period flood peak at the proposed dam site is 375 m^3/s and the 24 hour flood volume 18.6 million m^3.

2.5 Dam Storage Modelling

2.5.1 Overview

The live storage required in a reservoir is dependent on the following factors:

1. Consumptive water demand (see Section 2.2.3);
2. Environmental or residual flows for protection of instream values (see Section 2.2.4);
3. Inter-annual flow variability and the level of drought security desired – flow variability has been represented by the long-term Wairoa River flow record at the Gorge/Irvines; drought security is discussed in Section 2.5.2;
4. System characteristics and response – these revolve around the catchment characteristics, its drainage pattern and rainfall-runoff response, the river-aquifer interaction and other processes.

The reservoir storage behaviour at the Lee dam site has been modelled, taking the above factors into account, over the period of the Wairoa River flow record (1958 to 2008). The key to the model is maintaining a threshold minimum river flow at the Wairoa Gorge which varies according to level of demand and natural river flow on a day to day basis. Maintaining this threshold flow at the Wairoa Gorge ensures that a residual instream flow of at least 1100 l/s will be preserved in the Waimea River at Appleby Bridge.

Predicted shortfalls in the natural river flow (less the inflow to the dam) must be met by controlled releases from the dam.

Apart from the consumptive demand and the minimum flow requirement at Appleby Bridge, other aspects taken into consideration in modelling of the dam storage requirements are: maintaining a minimum residual flow at the toe of the dam equal to the 7-day MALF; and net evaporation from the reservoir surface, which is a relatively minor component of the dam storage water balance.

2.5.2 Drought Definition and Security of Supply

For a given amount of live storage in a reservoir, the level of drought security provided by the dam and reservoir can be expressed as the ability to meet the total water demand over the entire duration of a drought that has a particular return period; i.e. the "design drought return period".

The magnitude of the storage fluctuations over time can be analysed to produce a relationship between the minimum storage and the expected recurrence frequency or return period. The required live storage or "storage drawdown" is equal to the full storage less this minimum storage.

There is an important and fundamental difference in the way the severity of a drought is defined for a river system with regulated storage and for one without (i.e. a run-of-river system). To elaborate: when required, storage is released from the reservoir to supplement natural river flows according to downstream requirements, typically under low flow conditions. In general, the highest flow releases occur when periods of high demand coincide with very low natural flows.

While the maximum rate of release is related to the magnitude of this shortfall on an instantaneous (or daily) basis, the level to which storage in the reservoir is drawn down depends on the sum of all the preceding releases made. That is, the storage drawdown is a reflection of the accumulated shortfall over time. Thus, for a storage reservoir, the critical situation is one in which the total volume of shortfall over an entire season (or longer if the reservoir were not full at the start of the season) is a maximum. The magnitude of any single short-lived shortfall episode rarely governs the storage requirement.

For a run-of-river system, the return period of a drought event is typically determined from an analysis of short-term low flow events, such as the instantaneous low flow, the mean daily low flow, or the mean 7-day low flow. So, what may be a significant drought event in a run-of-river system may not necessarily have the same level of significance when there is a storage reservoir because of the different timeframes being considered.

2.5.3 Confirmation of Storage Requirement

At a Workshop with the WWAC Technical Group in October 2007, it was agreed that the 60 year return period drought standard from the Phase 1 investigations be retained for Phase 2 initially. Phase 1 studies showed that a 13.0 million m^3 capacity storage dam (inclusive of 1.0 million m^3 dead and sediment storage) would provide security in a 60 year return period drought.

The simulated storage behaviour for a dam on the Lee River at Ch 12,430m with a gross storage of 13 million m^3 was assessed during Phase 2. This analysis indicated that for the same 60 year return period drought standard, a marginally lower (3% lower) live storage of 11.6 million m^3 would be sufficient.

Adding a 1.0 million m^3 allowance for dead and sediment storage (as for Phase 1) gives a total required storage for the proposed dam site at Ch 12,430m of 12.6 million m^3. For feasibility design of the dam, this has been rounded up to 13 million m^3, which effectively provides a 66 year return period drought security[3].

Table 2.2 summarises the storage requirements from the Phase 2 storage frequency analysis.

[3] For a gross storage capacity of 13 million m^3, the normal top water level for the reservoir would be RL 196.4m. This has been rounded up to RL 197m for the feasibility design and effects assessment. The gross water storage at this level (RL 197m) would in fact be approximately 13.4 million m^3.

Table 2.2 Required storage capacity versus drought return period

Drought Return Period (years)	Required Capacity for Lee River Dam at Chainage 12430	
	Live Storage (million m^3)	[1] Total Storage (million m^3)
10	5.53	6.5
20	7.57	8.6
35	9.48	10.5
50	10.85	11.9
60	11.60	12.6
100	13.90	14.9

Note 1 Total storage includes a nominal 1.0 million m^3 allowance for dead storage and long term sediment infill.

2.5.4 Preliminary Operating Regime

A simulation has been undertaken of the likely reservoir storage behaviour (volume) using records from 1958 to 2008 (assuming that the dam was in place).

A drawdown duration curve has been developed, which provides an indication of the proportion of time that the reservoir would be full and the proportion of time for which the reservoir is above or below a particular level. Figure 2.3 shows that the reservoir would be virtually full about 83% of the time, within 1 m of full about 90% of the time and within 5 m of full for about 96.5% of the time on long-term average assuming fully allocated supply.

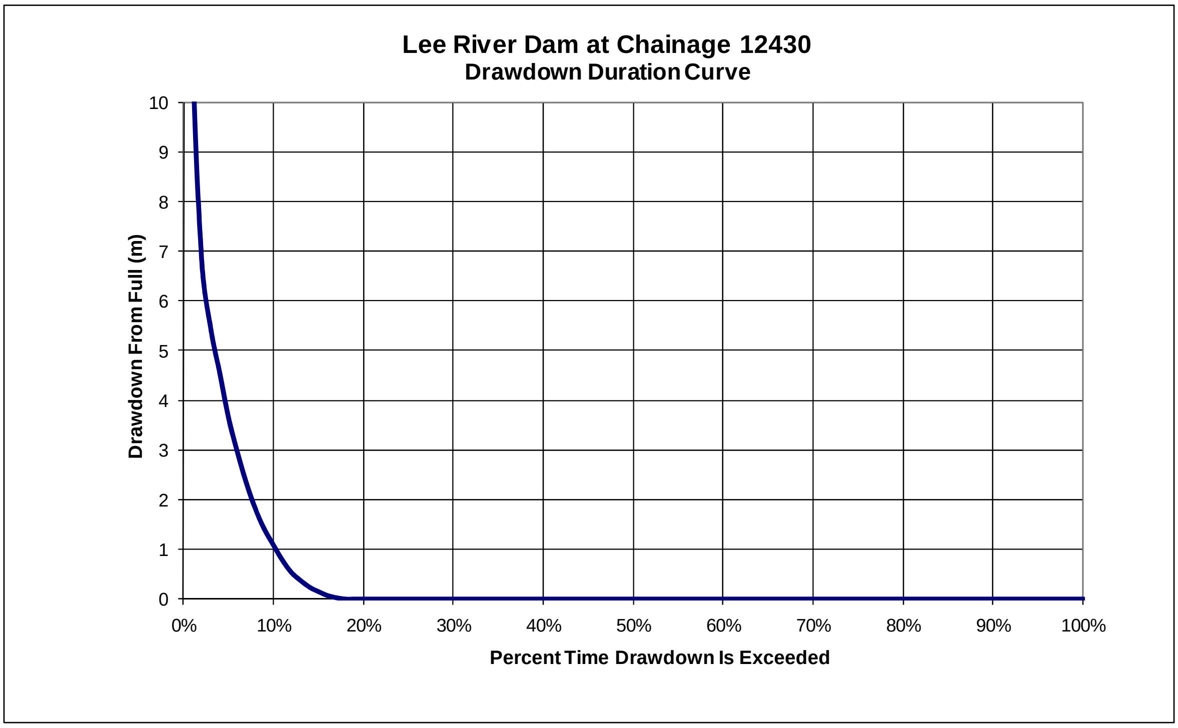


Figure 2.3: Lee River Dam at Chainage 12430 - Storage Drawdown Versus Duration

A comparison has also been made of the likely (simulated) river flows immediately below the Lee dam before and after dam implementation for a sample period (1 July 1981 to 30 June 1983). The 1982/1983 water year is a drought year with a return period of about 33 years, whereas the 1981/1982 water year is a more typical year in terms of flows. The results are shown in Figure 2.4. Note that the pre-dam flows are represented by the reservoir inflows.

As can be seen from Figure 2.4, the reservoir inflows or natural flows (blue) match the dam outflows (pink) for the majority of the time (i.e. the pink line plots over the blue line). Periods of flow augmentation provided by the dam would have occurred between late January and early April 1982, while in the 1983 drought year, flow augmentation was provided from early November (1982) to mid April (1983). Reservoir refilling would occur during periods where the reservoir inflow plots higher than the dam outflow. A clear example of this is seen in mid January 1983 where a fresh, peaking at about 10,000 l/s, is captured entirely to reservoir storage.

A similar interpretation can be drawn from Figure 2.5 on the effect of flow augmentation. That is, Wairoa River flows at the Gorge/Irvines before and after Lee dam construction are almost identical most of the time, except over summer low flow periods during which the flow augmentation can be clearly seen (pink line plotting higher than the blue line between late January and early April 1982, and from November 1982 to April 1983). However, there is a notable difference between Irvines and the dam site in terms of flow regime changes. That is, the impact of the reservoir refilling is far less obvious at Irvines. For example, the fresh that occurred in mid January 1983 and the series of smaller freshes that preceded it are mostly preserved at Irvines albeit with a slight reduction in the peak flows (15% or so less). This is not unexpected and is attributed to the natural inflows from the tributaries below the dam continuing to contribute to the overall river flow. At the dam site, these freshes were absorbed entirely into the reservoir.

Figure 2.4: Comparison of flow hydrographs at the Lee dam site before and after (simulated) storage dam implementation 1981 to 1983

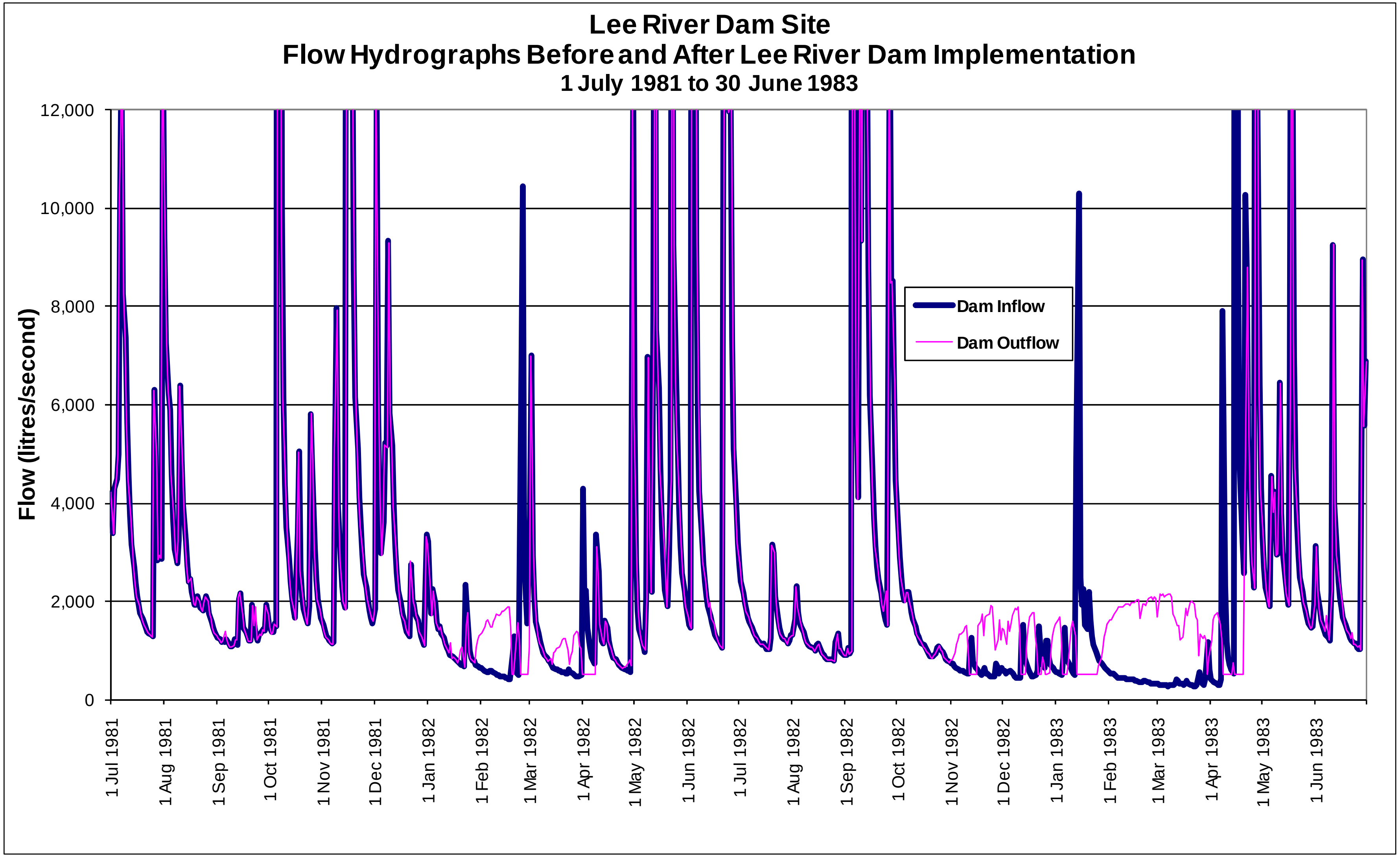
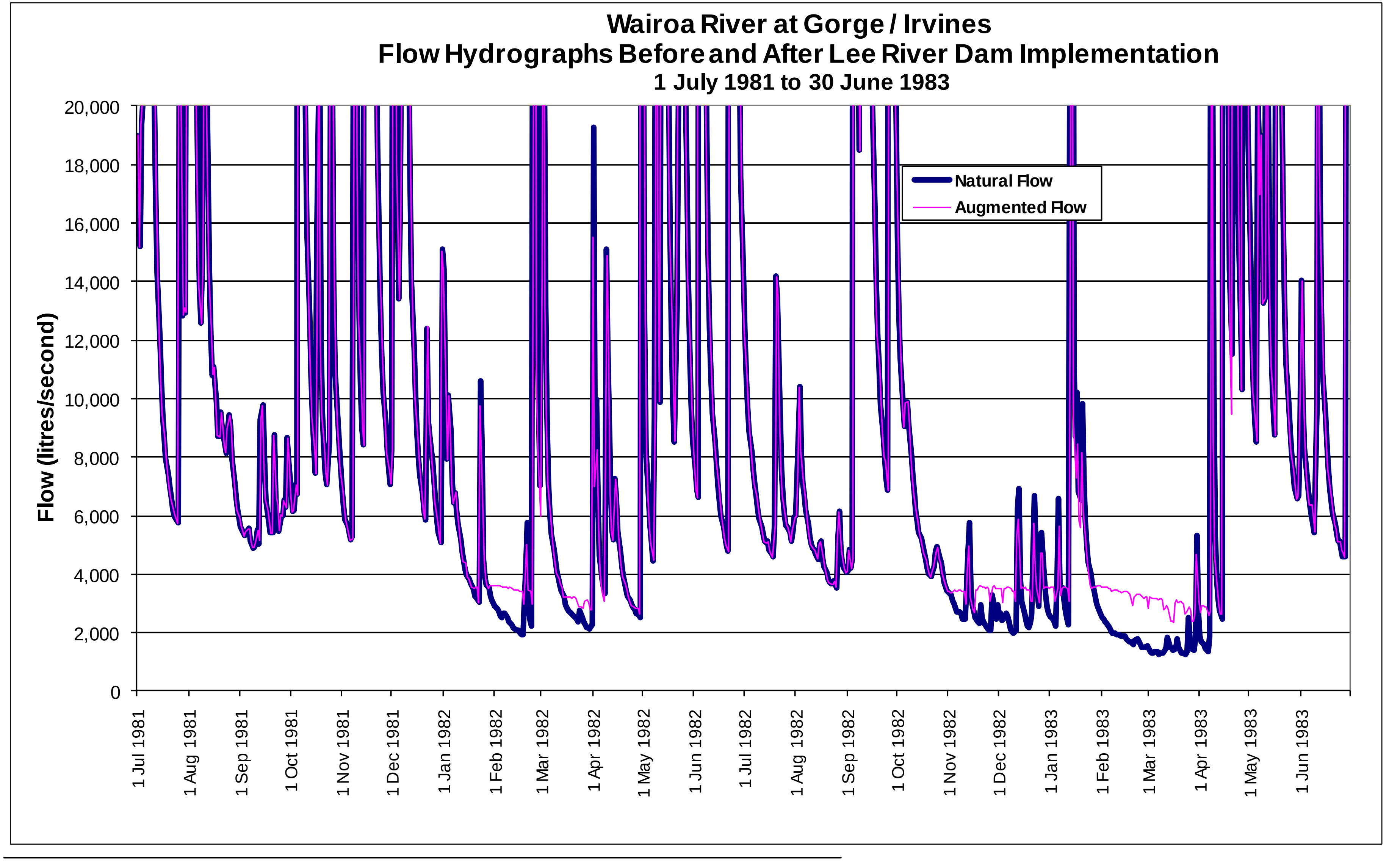


Figure 2.5: Comparison of flow hydrographs at Wairoa Gorge before and after (simulated) storage dam implementation 1981 to 1983



3 Geotechnical and Engineering Feasibility

3.1 Geotechnical Investigations

3.1.1 Scope

This section summarises the investigations and results that are presented in detail in the accompanying technical report by Tonkin & Taylor **"Geotechnical Investigation Report"**.

The issues addressed during the geotechnical investigations are:

- Overall geological and geomorphic setting of the potential reservoir and dam;
- The seismic hazard and preliminary seismic design criteria;
- Current and full reservoir groundwater regime;
- Dam embankment foundation conditions – strength, compressibility, erodibility and permeability;
- Dam foundation, abutment and spillway excavation stability;
- Current and full reservoir hill-slope stability;
- Availability and suitability of local materials for use in construction of the dam (bulk fill, core material, filters, drainage material and rip-rap).

3.1.2 Background

Geotechnical feasibility investigations have been carried out in a staged programme as part of the Phase 2 feasibility study.

Stage 1 of the Phase 2 geotechnical feasibility assessment comprised geological and engineering geological mapping of the project area. The Stage 1 study assessed geotechnical issues at eight different potential dam sites in the upper Lee Valley, from Ch 10,500 m to Ch 12,400 m upstream of the Lee River/Wairoa River confluence. As part of the Stage 1 work a preliminary assessment of 17 potential construction material borrow sites within the area was also carried out. Engineering evaluation of the various dam sites identified a site at Ch 11,010 m as being the most economical but noted that potential risks affected that site, including poor quality rock on the right abutment, potential large scale slope instability on the left bank upstream of the dam site, and lack of suitable core material and high quality rockfill.

Sampling and testing of borrow materials was carried out on selected sites as part of Stage 2A. This found that suitable plastic clay core material for an earth embankment dam was not locally available and the local bedrock would provide a lower quality rockfill, although alternative rockfill sources were available. The lack of core material in the vicinity effectively ruled out further economic consideration of earth embankment dams. Investigations continued therefore to assess the site's suitability for a concrete faced rockfill dam.

Stages 2 and 3 of the geotechnical investigation programme comprised surface mapping, test pitting and drilling based on a dam site at Ch11,010 m. That investigation confirmed that poor quality rock extended to significant depth on the right abutment and a need to provide for stabilisation of the left bank landslide. When viewed cumulatively, it was considered that these issues had an adverse effect on potential cost and programme in relation to a dam at Ch11,010m. WWAC subsequently endorsed the recommendation to investigate an alternative site located between Ch12,100 m and Ch13,000 m.

Stage 4 involved geotechnical investigations between Ch12,100 m and Ch13,000 m. On the basis of preliminary engineering geological mapping and consideration of earthworks volumes, a site at Ch12,430 m was subsequently selected for drilling investigations.

3.1.3 Geotechnical Investigations Related to Proposed Dam Site at Ch12,430m

The Stage 4 investigations covered the reach of the Lee River between Ch12,100m and Ch13,000m and were carried out in two parts. The first involved engineering geological mapping of river and track exposures and formation of access tracks to the potential dam site. This was followed by subsurface investigations including test pitting and drilling.

Drill hole locations were determined after review of the mapping phase. Access difficulties constrained the locations of where holes could be drilled. Constraints included: the steep slopes and locally very strong rock, a requirement to minimise disturbance to plantation and indigenous forest, and safety aspects associated with providing and maintaining river crossings.

The investigations for the site included:

- Defect mapping and logging of 700 m of existing and excavated track batters;
- Excavation and logging of two test pits in the vicinity of the potential dam site;
- Drilling and logging of 140 m of core in five drill holes at the potential dam site and on the spillway alignment;
- Kinematic defect plots for 171 rock defect measurements,
- 32 packer (water pressure) tests.

3.1.4 Engineering Geology

Bedrock at the dam site is predominantly greywacke, locally inter-layered with argillite and is rated as being generally fair quality. Bedding layers are closely spaced and are the predominant defect. The bedding dips generally at 30-60° downstream beneath the dam footprint. Other rock defects are present and include orthogonal sets of sheared zones that are mapped at 10 to 50 m spacing, and joints that are often spaced at 1 to 3m but which seldom persist for more than 10m.

The defect orientation beneath the dam site is considered favourable with respect to stability, and no bedrock instability has been noted beneath the dam footprint. However, deep-seated rock relaxation is evident downstream of the left abutment of the dam and locally, on the steeper right abutment slopes.

Soils, locally up to 12m deep, consisting of slope derived silt and sand and alluvial gravel, overlie bedrock on the left abutment, upstream of the dam centreline. On the right abutment scree and colluvium is generally less than 2m thick but is locally up to 5m thick along the axes of steep gullies that are spaced across the slope at about 50m.

Packer tests and groundwater response in the boreholes during drilling indicate that rock mass permeability is likely to vary between 1×10^{-7} to 1×10^{-6} ms^{-1}, with higher permeability being associated with relaxed rock and adjacent to sheared zones.

No active faults have been identified in the immediate vicinity of the dam site. Active fault traces have been mapped 8km to the west, within the Waimea Flaxmore fault system, and the Alpine Fault (Wairau Segment) is located 21km east of the site. The Alpine Fault (Wairau Segment) is likely to pose the main seismic threat to the dam.

No active large landslides have been identified in the potential reservoir footprint. However, solifluction deposits, that blanket the lower level reservoir slopes, are subject to shallow slumping and erosion. It is anticipated that groundwater levels will be raised by the reservoir inundation, and local instability associated with solifluction slopes can be expected.

3.1.5 Implications for Dam Design

The investigations indicate that geological conditions at the proposed dam site (Ch 12,430m) are generally suitable for a Concrete Faced Rockfill Dam, and that suitable construction materials exist in the vicinity.

The key conclusions from this phase of work with respect to dam design and construction are as follows:

Foundation Preparation

- There is a degree of variability in rock mass quality requiring local subexcavation and or special treatment of poor quality rock associated with crushed, shattered, sheared or dilated rock.
- Special treatment will be required to mitigate piping/erosion of fines within sheared zones.
- Soil stripping depths on the left abutment will be up to 12 m and on the right abutment will be up to 5 m.
- Provision will be required for local stabilisation of temporary slopes on the right abutment.

Cut Slope Stability

- Excavations for the plinth will daylight local wedge blocks and undercut scree infilled gullies. These deposits will be unstable when cut to slopes steeper than 40°.
- The orientation of principal defects is favourable for the provisional spillway alignment, although sheared zones and joints in some locations will limit the maximum batter angles in some rock to 45°.
- Poor quality rock in the upper section of batters will require batters to be no steeper than 40°, and in soil to be no steeper than 36°.

Leakage Potential

- Low permeability can generally be expected in unweathered to slightly weathered rock below the zone of surface relaxation, but there is a potential for high leakage along rock defects and within rock affected by deep-seated relaxation.
- Provision will be required for grouting and or near surface foundation treatment.

Construction Materials (for concrete faced rockfill dam)

- It is likely that suitable sources of rockfill can be sourced from either the spillway cut or local alluvial deposits within the potential reservoir footprint.
- Rockfill properties are likely to be strongly influenced by the degree of compaction.
- Poor quality rockfill will be produced from moderately weathered to highly weathered relaxed rock within the spillway excavation. This may not be suitable for rockfill.
- Riprap >600 mm may need to be imported.
- Aggregates for concrete/filters and drainage are likely to be sourced from local alluvium within the potential reservoir footprint. However the durability of fines may limit use for some filters.
- Local solifluction deposits can be used for non plastic fines applications.

The Geotechnical Investigations Report includes recommendations for further investigations that should be undertaken as part of the design process.

The results from the geotechnical investigations have been taken into account in the assessment of the engineering feasibility of the dam, and the proposed design, as described in the following section (Section 3.2).

3.2 Engineering Feasibility

3.2.1 Scope

This section summarises the investigations and outcomes that are presented in detail in the accompanying technical report **"Lee Valley Storage Dam – Engineering Feasibility Report"** by Tonkin & Taylor.

The report covers:

- Selection of dam site and dam type
- Design standards and inputs
- Evaluation of options at the selected dam site, including embankment options, flood diversion and routing, and an optimisation of spillway and dam crest parameters
- Arrangement and constructability of the selected dam and associated structures
- Outline of construction methodology
- Estimate of capital construction cost.

3.2.2 Selection of Dam Site and Type

In the early stages of the current (Phase 2) study an assessment of the then favoured site within the Lee Valley (at Ch 11,010m) was carried out. Twelve sites on the Lee River were selected for preliminary engineering comparison purposes. The locations were between Ch 10,200m and Ch 12,400m.

Earth embankment, concrete faced rockfill, and roller compacted concrete dams were considered. The size of dams at each location was estimated based on storage-elevation curves, and the approximate cost for each type of dam estimated, to show the relativity between sites. Initial evaluation of geotechnical conditions at each site was also undertaken, as described in Section 3.1. The evaluation indicated that a dam located at Ch 11, 010m offered the most economic solution.

As noted in Section 3.1, subsequent geotechnical investigations at that site revealed poor founding conditions on the right abutment of the dam, and potentially unstable slopes on the left bank of the reservoir. When viewed cumulatively, these issues had an adverse effect on potential cost and programme in relation to a dam at Ch 11,010m. A decision was subsequently taken to investigate an alternative site located between Ch 12,100m and 13,000m.

On the basis of preliminary engineering geological mapping, consideration of earthworks volumes, and construction materials availability a site based on approximately Ch 12,400m was selected for drilling investigations.

The preliminary dam design assessed in this report is based on a concrete faced rockfill dam at Ch 12,430m.

3.2.3 Design Standards

The standards adopted for dam design are in two main parts. One part specifies the extreme events (floods and earthquakes) that the dam must withstand, and the other specifies the factors of safety that the dam should display under the various loading cases.

Expected factors of safety are applicable to most large dams, and these are set out in the New Zealand Dam Safety Guidelines (NZSOLD, 2000).

The extreme events that the dam must withstand are dependent on the potential hazard that the dam poses in the event of an uncontrolled release of water (breach). For a dam where the consequences of failure would be relatively large, there is an expectation that it is able to withstand more extreme events prior to failure. This balance of consequence against likelihood of failure sets the overall risk profile for the dam.

Dams in New Zealand are categorised based on their Potential Impact Category (PIC). Three levels of PIC are set for large dams: Low, Medium and High. The New Zealand Dam Safety Guidelines provide guidance for selection of PIC based on the social, economic and environmental consequences of a hypothetical failure. The Building Act also now provides requirements for selection of PIC, although these requirements are now under review and may be revised.

Selection of PIC leads to definition of the extreme events that a dam should withstand.

Selection of PIC for the proposed Lee dam has been based on a dambreak assessment undertaken specifically for this project (summarised in Section 3.2.11). The results of the dambreak assessment concluded that the PIC for the proposed dam would be High. The design standards for the dam have therefore been selected on this basis.

Current dam safety standards (NZSOLD 2000) require an assessment of the response of a dam and its associated structures to seismic events. The extent of the assessment is dependent on the Potential Impact Category (PIC) of the dam and its location.

As the PIC of the Lee dam has been determined to be High, in accordance with the New Zealand Dam Safety Guidelines (NZSOLD 2000), the dam and any critical structures should be analysed for a Maximum Design Earthquake (MDE) of between 1 in 10,000 years annual exceedence probability (AEP) event, and the maximum credible earthquake (MCE). A site-specific seismic assessment should be undertaken for this dam at the detailed design stage. For the current assessment, the code AS/NZ 1170 provides a standard procedure for estimating the ground response based upon ground conditions and the AEP.

The peak ground accelerations (PGA) for different magnitude seismic events are presented in Table 3.1.

Table 3.1 Peak ground accelerations

Earthquake	Return Period	PGA
Operating Basis Earthquake (OBE)	150 Years	0.187g
Maximum Design Earthquake (MDE)	10,000 Years	0.7g

The standards that have been adopted for the feasibility level design of the Lee dam are summarised in Table 3.2.

Table 3.2 Standards adopted for Lee Dam feasibility design

Item	Value		Source	Notes
Classification and Primary Design Standards				
Item	**Value**		**Source**	**Notes**
Potential Impact Classification (PIC)	High		Estimate	*Based on dambreak assessment*
Operational Basis Earthquake (OBE)	1:150 yr		NZSOLD	*Based on PIC*
Maximum Design Earthquake (MDE)	MCE		NZSOLD	*Based on PIC*
Operational Basis Flood (OBF)	1:200 yr		NZSOLD	*Industry custom/precedent*
Maximum Design Flood (MDF)	PMF		NZSOLD	*Based on PIC*
Construction Diversion Flood (CDF)	1:50 yr		None	*Refer discussion in report*
Minimum freeboard for 100 yr wave	0.5	m		*Industry custom*
Minimum freeboard at OBF+10 yr wave	0.5	m		*Industry custom*
Minimum freeboard at MDF+10 yr wave	0.0	m		*Industry custom*
Hydrology				
Item	**Value**		**Source**	**Notes**
Live storage volume	12,000,000	m^3	Demand studies	
Dead storage volume	1,000,000	m^3	Demand studies	
Total storage volume	13,000,000	m^3	Demand studies	
Peak inflow OBF	412	m^3/s	Hydrology studies	
Peak inflow MDF	1,094	m^3/s	Hydrology studies	
Peak inflow CDF	340	m^3/s	Hydrology studies	
Irrigation Outlet Requirements				
Item	**Value**		**Source**	**Notes**
Irrigation release flow at minWL	2.25	m^3/s	Demand studies	
Irrigation release flow at maxWL	2.25	m^3/s	Demand studies	
Flushing flow outlet requirement	5	m^3/s	Cawthron	
Water elevation range for flushing	All live storage		Cawthron	
Outlet requirements				Either to river or via hydro turbine

3.2.4 Dam Arrangement Options

The arrangement of a dam includes an almost infinite number of combinations of spillway type, embankment type, freeboard allowance, and outlet systems.

In summary the following options were included as part of the assessment:

- Embankment type:
    - Zoned earthfill
    - Concrete faced rockfill
    - Roller compacted concrete
- Spillway types:
    - Combination primary and auxiliary spillway
    - Ogee weir primary
    - Labyrinth weir primary
    - Bell-mouth primary with dropshaft

The following parameters have been adopted for preliminary design and costing:

- Embankment crest at RL 202m;
- Ogee weir (adjacent to embankment centre line) with chute primary spillway;
- Auxiliary spillway with fusible embankment 19.5 m wide adjacent to the ogee weir and discharging to Anslow Creek;
- Construction diversion consisting of 3, 2.5 m x 5 m square box culverts with separate upstream coffer dam with crest at RL 163 m;
- Outlet tower with outlet via steel pipe housed in diversion culvert.

3.2.5 Arrangement of Selected Dam

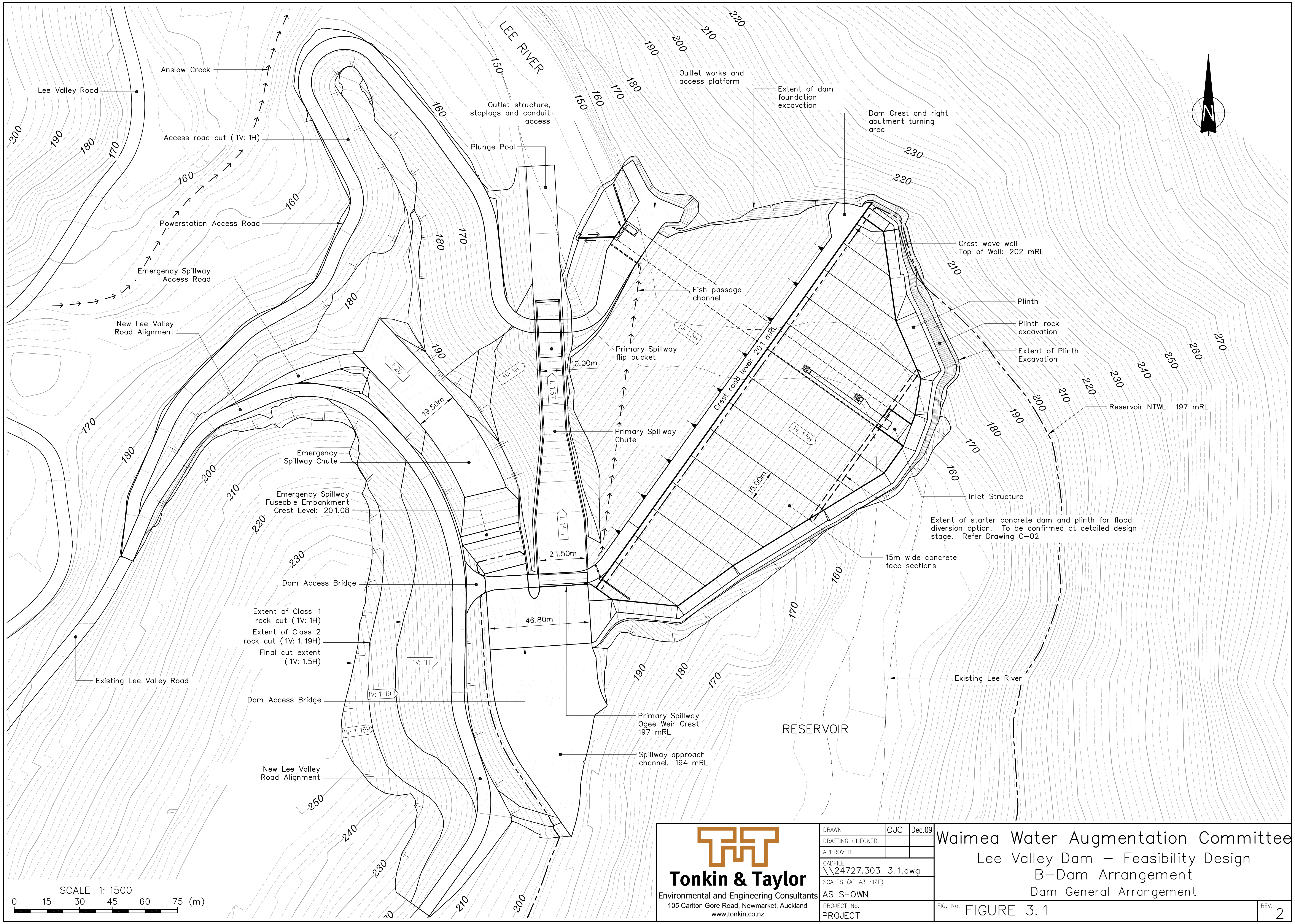
3.2.5.1 Summary

A summary of the arrangement and specifications for the selected dam and spillway are listed in Table 3.3. The general arrangement and plan are shown in Figures 3.1 and 3.2.

Table 3.3 Summary and Specifications

Embankment Characteristics		
Normal top water level (NTWL)	RL 197	m
Embankment type	Concrete faced rock fill (CFRD)	
Crest elevation	RL 201	m
Maximum flood water level	RL 201.58	m
Maximum dam height (from riverbed to dam crest)	52	m
Crest length	220	m
Wave wall height	1	m
Spillway Characteristics		
Total peak outflow OBF	372	m^3/s
Total peak outflow MDF	1036	m^3/s

Primary spillway type	Ogee Weir
Primary spillway width	22.3 m
Peak outflow OBF for primary spillway component	372 m^3/s
Peak outflow MDF for primary spillway component	449 m^3/s
Auxiliary spillway type	Fuseable Embankment
Auxiliary spillway width	19.5 m
Peak outflow MDF for auxiliary spillway component	606 m^3
Spillway Chute and Energy Dissipation Characteristics	
Chute length (plan)	105 m
Chute width, wide section	22.3 m
Chute width, narrow section	10 m
Chute minimum wall height	4 m
Dissipation type	Flip Bucket
Flip bucket radius	25 m
Bucket lip level	RL 156.58 m
Outlet Characteristics	
Number of outlets	2
Outlet type	Sloping outlet conduits on upstream face with removable screens and gate control.
Outlet level - Upper	RL 185 m
Outlet level - Lower	RL 167 m
Control gate type	Radial
Control gate size	1 x 1 m
Conveyance conduit size (under embankment)	2.5 x 5 m
Number of conveyance conduits	2 (access via third)
Conveyance conduit downstream protection	Stoplogs



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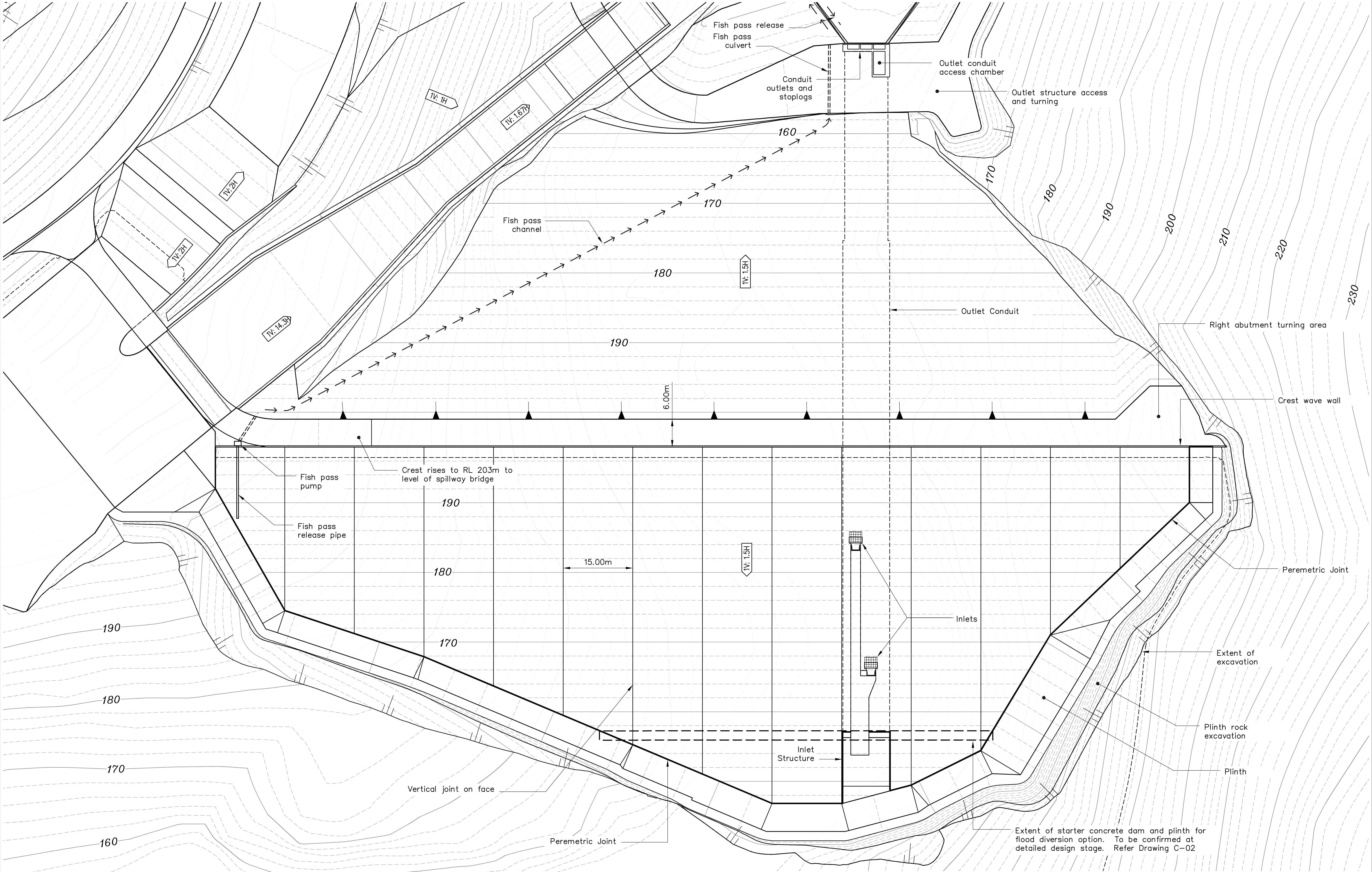
PROJECT No. PROJECT		

Waimea Water Augmentation Committee
Lee Valley Dam – Feasibility Design
B-Dam Arrangement
Dam General Arrangement

FIG. No. FIGURE 3.1

REV. 2



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PROJECT No. PROJECT		

Waimea Water Augmentation Committee
Lee Valley Dam – Feasibility Design
B-Dam Arrangement
Detailed Plan Dam

FIG. No. FIGURE 3.2

REV. 2

3.2.5.2 Embankment Arrangement

A Concrete Faced Rockfill Dam (CFRD) has been selected, which uses a concrete slab on the upstream face as a waterproofing element (see Figure 3.3).

Linking the upstream face into the foundation is a critical component of this type of dam. This is achieved by the plinth which is a concrete slab cast against the prepared foundation surface and tied to the foundation with grouted reinforcing bars. Grout is also injected into the foundation where necessary to reduce leakage to acceptable amounts.

The internal zoning of the dam is arranged to minimise settlement of the upstream face during first reservoir filling, and to manage leakage in the event cracks form through the upstream concrete face. The zoning also makes most economical use of the materials which are available locally at the dam site, and preferably from excavations required for the spillway and other related activities.

The dam foundation is formed by in-situ rock of various weathering grades, as determined during the geotechnical investigations. The target depth for subexcavation varies across the footprint as different parts of the dam require different quality materials as a foundation. The dam plinth requires the best foundation to minimise potential leakage. The size of the plinth is related to the foundation quality. This will require significant excavation in some areas, especially at the left abutment.

The rock underneath the plinth will also require grouting to minimise leakage.

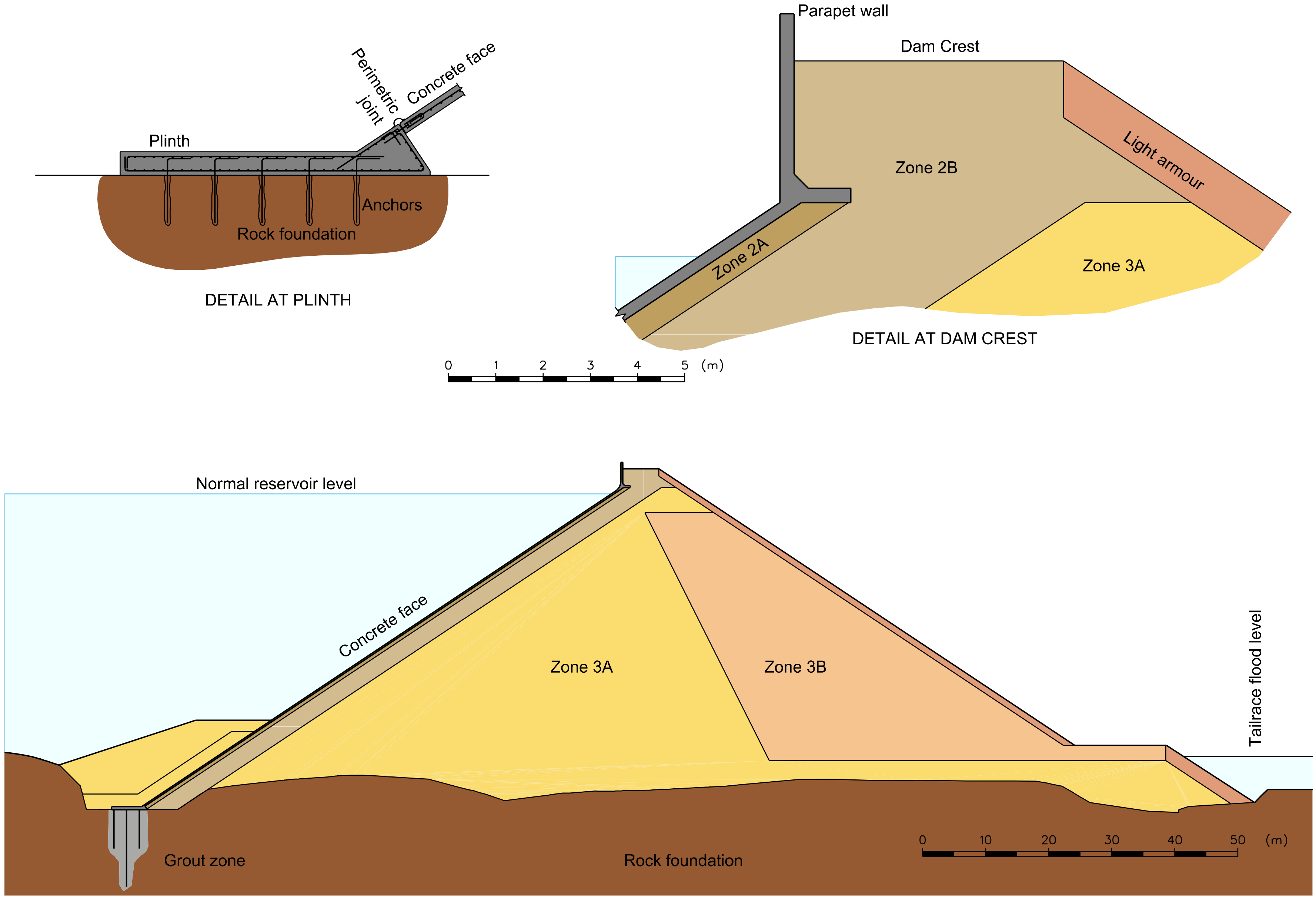
The foundation under the body of the dam has a lower requirement for quality. The main objective in this area is to remove material which could result in additional settlement of the dam embankment, or form weak planes (shear surfaces) under the embankment.

The plinth consists of a concrete cap or blanket upstream of the heel of the dam that forms a leakage resistant joint between the concrete upstream face, and the foundation rock. It includes the actual concrete cap and any grouting/remedial works in its region. The functions of the plinth are to:

1. Provide the main barrier to water flow through the foundation rock from the reservoir;
2. Prevent erosion of the foundation rock due to water flow and seepage gradients in the rock;
3. Provide a base for construction of the concrete face, and a waterproof connection of the face to the foundation.

The following approach has been adopted for feasibility level design of the plinth for the Lee dam:

Rock Weathering	Allowable Hydraulic Gradient
Fresh (Class 1)	20
Slightly to moderately weathered (Class 2)	10
Moderately to highly weathered (Class 3)	5
Highly weathered	2



Tonkin & Taylor Environmental and Engineering Consultants 105 Carlton Gore Road, Newmarket, Auckland www.tonkin.co.nz	DRAWN: OJC 02/10 DRAFTING CHECKED APPROVED FILE: Cross-Section.ppt APPROX. SCALE (AT A4 SIZE): AS SHOWN PROJECT No. 24727.600	**WAIMEA WATER AUGMENTATION COMMITTEE** LEE VALLEY DAM – FEASIBILITY DESIGN Schematic cross-section of Concrete-faced Rockfill Dam FIG. No. Figure 3.3 — REV. 1

Grouting of the rock is generally required underneath the plinth to reduce permeability and hence leakage. Three rows of grout holes have been assumed.

The internal zoning of the dam serves a number of objectives, including:

- Using the available materials to most economic effect;
- Controlling settlement of the dam to amounts that will not cause distress of the upstream concrete face;
- Allowing seepage flow through the dam body without the formation of a high phreatic surface, both in the case of normal operation and if cracking forms in the upstream face allowing larger leakage;
- Providing a bedding layer for formation of the upstream face;
- Providing stability against static and seismic loadings.

These objectives are sometimes conflicting and a compromise must be reached in developing the internal zoning.

The most upstream zone is the face slab and will be constructed from reinforced concrete 0.25m thick.

A semi pervious zone (Zone 2A) will be provided immediately downstream of the concrete slab. This is a processed rockfill or alluvium, grading from silt to cobble or gravel size. The zone provides uniform support for the face slab and acts as a semi-impervious layer to restrict flow through the dam in the event that cracking of the face slab or opening of joints occurs.

Zone 2B (downstream of Zone 2A) is a selected fine rockfill which acts as a filter transition between Zone 2D and Zone 3A in the event of leakage through the dam.

The two main rockfill zones are termed Zones 3A and 3B. Zone 3A is under the upstream face and is formed from higher quality (and hence lower compressibility) rockfill. This zone forms the main support for the rockfill and is critical in limiting settlement during the critical first filling stage.

Zone 3B is also rockfill, but can be formed from lower quality (higher compressibility) material.

Embankment settlement is one of the most important considerations with a CFRD and is a primary consideration in selecting the rockfill zoning, and materials that can be used in the zones. Settlement of the embankment has been evaluated for a number of material zoning cases and compared with historical CFRD performance. The general construction methodology for a CFRD involves placement of rockfill first, followed by placement of the concrete upstream face. This staging allows settlement of the rockfill during its construction to take place prior to placement of the concrete face. This significantly reduces deformation and loading of the upstream face.

The results of an assessment of settlement potential indicate that expected face deformations for all of the cases considered are well within the range of deformations experienced by other dams. This indicates that face deformations would be acceptable for any of the rockfill materials. This conclusion led to the development of embankment zoning.

CFRDs traditionally do not have stability analyses carried out to assess their static or dynamic stability. The rationale for this is that provided the slopes are flatter than the angle of repose of the rockfill, the embankment is inherently stable. Consideration of CFRDs already constructed of heights considerably larger than the dam proposed in the Lee Valley, and also in seismically active zones, indicates that the selected batter slopes (1.5:1) are conservative.

3.2.6 Construction Diversion

Diversion of the Lee River during construction is a critical process. Diversion is proposed through two or three concrete culverts located underneath the embankment. Each culvert has internal dimensions of 2.5m width and 5.0m height. A concrete starter dam at the upstream toe will form the coffer dam for directing flow through the culverts.

When the embankment is at design height, the culverts will no longer be required for flood diversion. They will then be converted for use as discharge of irrigation flow, and person access to the gate/valve control chamber at the upstream toe.

3.2.7 Spillway Arrangement

The ability of the completed dam to pass floods is critical to its safe operation. Two spillways are proposed:

- A primary ogee weir with a crest level of RL197m, steep chute and flip bucket at the left hand side of the dam, and;
- An auxiliary channel with fuse plug weir discharging to Anslow Creek.

3.2.8 Outlet Works Arrangements

The objective of the reservoir outlet works is to extract water from the desired elevation within the reservoir and discharge it downstream of the dam at the desired flow rate. Water quality analyses (see Section 6.2.3) have established the requirements for extraction levels and flow rates, and these have been used as design parameters for the outlet works. The design parameters are summarised as follows:

- Top extraction elevation: RL 185m
- Bottom extraction elevation: RL 167m (also dead storage elevation)
- Maximum flow rate: $5m^3$/sec (for flushing)
- Reservoir range for maximum flow: full range.

The above parameters are applicable for a release system without hydro-electric power generation addition. There is an option to include hydroelectric generation on the flow release. If hydroelectric generation is included the outlet works, design parameters will vary slightly from above. Three flow options have been considered, with maximum flow rates of 4, 6 or $8m^3$/sec.

Screening will be needed for both the base and hydro option cases. For the base case screen size is 100mm and is intended to exclude debris which could jam the outlet system. For the hydro option finer screens (20mm aperture) are needed to exclude fish (as described in the accompanying Technical Report "Aquatic Ecology– Mitigation and Management Options Associated with Storage in the Proposed Lee Reservoir", with an approach velocity of 0.3 m/s.

3.2.9 Fish Pass

T&T and Cawthron have worked together to develop dam design parameters and arrangements to provide upstream fish passage for eels and koaro. This is addressed further in Section 6.2.6.

The agreed concept is that a small pump will be installed at the dam crest to release a small flow (a couple of litres per second) down a 'naturalised' channel on the downstream face of the dam, and a release channel on the upstream face of the dam.

The indicative plan arrangements of the channel are outlined on Figure 3.2. The downstream end of the channel (at the toe of the dam) transfers into a 'fish–friendly' culvert to cross the access bench, and pipe to allow fish to re-enter the river channel as close to the water release area as possible.

3.2.10 Construction Methodology

An outline of the anticipated construction methodology for the dam, including requirements for construction facilities, borrow areas, disposal areas, etc has been developed. A critical part of this is careful control of river diversion for the safety of the dam during construction.

The construction process is a continuum, but has been broken into several nominal stages. The details are included in the Engineering Feasibility Report. In summary the stages are:

1. Preparation for and construction of diversion culverts;
2. Construction of the diversion culverts;
3. Diversion of the river through the culverts;
4. Construction of the plinth and commencement of the dam embankment;
5. Completion of the embankment and construction of the spillway;
6. Placement of the filter zones and forming the upstream concrete face;
7. Construction of upstream face intake conduits and intake gate structures, followed by plugging of the diversion. Passage of residual flows will be maintained through the irrigation outlets;
8. Construction of the fish passage structures and site restoration.

3.2.11 Dambreak Hazard Assessment

3.2.11.1 Purpose of dambreak hazard assessments

Dam break analyses are undertaken within the dam industry primarily to assess downstream hazard potential, which in turn guides the setting of standards to adopt for dam design, construction and operation, as noted in Section 3.2.3. The analyses are hypothetical and entirely divorced from the chances of a dam failure ever occurring.

Certain information generated from a dam break study, such as a map delineating the potential extent of inundation from a dambreak, may be used in an Emergency Action Plan for the dam and made available to the local Civil Defence office. The predicted time for the dambreak flood wave to reach specific downstream locations provides a helpful indication of the available warning times, and may also be incorporated in the Emergency Action and/or Civil Defence Plans.

3.2.11.2 Scope

A dambreak hazard analysis has been undertaken for the proposed Lee Dam, and the resulting report is included as an appendix to the **"Engineering Feasibility Report".**

The report:

- Introduces the concept of establishing the Potential Impact Category (PIC) of a dam.
- Sets out the scope of the dam break analysis and hazard assessment undertaken for the Lee dam;
- Describes the assessment methodology and assumptions used in making the assessment;
- Identifies and discusses the model results;
- Describes the hazard as a consequence of a dam failure;
- Recommends the PIC to be adopted for the Lee dam;
- Discusses dam break mitigation measures.

The following sub-sections summarise the outcomes of the assessment.

3.2.11.3 Potential Impact Classification System

The Building (Dam Safety) Regulations 2008 adopt a potential impact classification system to determine the appropriate design standards for a dam (for earthquake loading and safe flood passage) and the level of rigour that needs to be applied to site investigations, construction, commissioning and on-going maintenance and surveillance.

The consequences of failure, specifically the downstream harm and damage potential, are the main determinant for assessing the potential impact classification. Table 3.4 shows the definitions of Potential Impact Category (PIC) adopted by the regulations.

Table 3.4 Determination of dam classification (Building (Dam Safety) Regulations 2008)

Assessed damage level	**Population at risk (PAR)**			
	0	**1-10**	**11-100**	**100+**
Catastrophic	High PIC	High PIC	High PIC	High PIC
Major	Medium PIC (see note 4)	Med/High PIC (see note 4)	High PIC	High PIC
Moderate	Low PIC	Low/Med/High PIC (see notes 3 and 4)	Med/High PIC (see note 4)	Med/High PIC (see notes 2 and 4)
Minimal	Low PIC	Low/Med/High PIC (see notes 1, 3 and 4)	Low/Med/High PIC (see notes 1, 3 and 4)	Low/Med/High PIC (see notes 1, 3 and 4)
Notes: 1. With a PAR of 5 or more people, it is unlikely that the potential impact will be low				

2. With a PAR of more than 100 people, it is unlikely that the potential impact will be medium
3. Use a medium classification if it is highly likely that a life will be lost
4. Use a high classification if it is highly likely that 2 or more lives will be lost

The population at risk (PAR) is defined as all those people who would be affected by flood depths in excess of 0.5 metres in the event of dam failure.

Interpretative details on the assessed damage level are provided in the Building (Dam Safety) Regulations 2008. Table 3.5 reproduces the interpretation of 'catastrophic', 'major', 'moderate' and 'minimal' damages from the regulations.

Table 3.5 Determination of assessed damage level

Damage level	Residential houses	Critical or major infrastructure		Natural environment	Community recovery time
		Damage	Time to restore to operation		
Catastrophic	More than 50 houses destroyed	Extensive and widespread destruction of and damage to several major infrastructure components	More than 1 year	Extensive and widespread damage	Many years
Major	4-49 houses destroyed and a number of houses damaged	Extensive destruction of and damage to more than 1 major infrastructure component	Up to 12 months	Heavy damage and costly restoration	Years
Moderate	1-3 houses destroyed and some damaged	Significant damage to at least 1 major infrastructure component	Up to 3 months	Significant but recoverable damage	Months
Minimal	Minor damage	Minor damage to major infrastructure components	Up to 1 week	Short-term damage	Days to weeks

In relation to residential houses, "destroyed" means rendered uninhabitable.

Critical or major infrastructure includes:

1. Lifelines e.g. power supply, water supply, gas supply, transportation systems, wastewater treatment;
2. Emergency facilities e.g. hospitals, police, fire services;
3. Large industrial, commercial, or community facilities, the loss of which would have a significant impact on the community;
4. The dam, if the service the dam provides is critical to the community and that service cannot be provided by alternative means.

3.2.11.4 Scope of Assessment

It is usual practice in a dam break hazard assessment to consider the incremental damages for a "sunny day" failure and in some cases, a flood induced failure.

Incremental damages are those that occur directly as a result of the dam failure. For example if 10 houses would be flooded during a natural 0.01% Annual Exceedance Probability (AEP) (or 10,000 year return period) event and 15 houses were shown to be flooded after a dam failure during the 0.01% AEP event, then the incremental damage is the flooding of 5 additional houses.

In terms of incremental damages from dam failure, "sunny day" failures typically have greater potential consequences because all the damage is directly caused by the dam failure.

For the Lee project only a sunny day failure scenario has been assessed. It was considered unnecessary to also model a flood-induced failure as a decision was taken in the feasibility design to provide sufficient spillway capacity at the dam to cope with the Probable Maximum Flood (the largest flood that could conceivably occur at that location) without relying on mechanically controlled spillway gates.

The dam break assessment essentially consists of three parts:

1. **Dam breach outflow:** estimating the geometry and development rate of a breach; and then the rate at which water will flow out of the dam in the event of a dam break;
2. **Downstream floodwave:** modelling the downstream flow path and character of water flows from the breach in the dam to the sea, and mapping the potentially inundated area;
3. **Categorisation of potential impact:** assessment of the likely damage caused by the inundation and the potential for loss of life and environmental damage.

Results from the dam break modelling have been used in the development of an outline Emergency Action Plan for the Lee River Dam (which forms an appendix to the main dambreak hazard assessment report). That Plan will be further developed and finalised during the detailed design phase of the project.

3.2.11.5 Conclusions

The results of the dam break assessment show that the Lee dam should be categorised as High PIC. The categorisation was determined largely from the high PAR, where modelling shows that approximately 260-300 properties would be at risk of flooding from water depths in excess of 0.5 m.

In the unlikely event of breach of the Lee dam, the northern and eastern areas of Brightwater township are the most densely populated areas that would be significantly affected. Following dam breach initiation, flood waters near Brightwater would start to rise within 35 to 45 minutes, and peak flood depths would occur between 45 and 75 minutes after breach initiation.

It is essential to draw the distinction between hazard potential (that is, the effects of the dam breach were it to occur) and the risk or probability of the dam breach actually occurring. The risk of failure occurring for a dam engineered, built, maintained and monitored to appropriate standards, as would be the case for the Lee dam, would be extremely low.

3.2.12 Capital Construction Cost Estimate

Estimation of the capital cost for construction of the dam and for potential hydro-electric power generator add-on has been made (see Section 4 for a discussion of the potential for hydro power generation). The estimation process for the dam alone has been more robust and detailed than that for the hydro-power component add-on.

The process has involved estimation of quantities of materials and items, and identification of likely rates. Percentages have been allowed for contingencies, contractors' preliminary and general, and design.

The cost excludes taxes, insurance, developer related costs, financing, land purchase, access replacement, environmental mitigation, resource consents, distribution or allocation management, operation and maintenance costs, environmental compliance, construction cost variations due to high demand, increases in costs of construction-related materials, or any other items not specifically identified in the bill of quantities.

The estimates have been reviewed by experienced people in the construction industry, as well as having been subjected to internal and independent peer review.

Costs were estimated for cases of two and three diversion culverts (as noted in Section 3.2.6). This showed that a significant portion of cost is attributed to diversion during construction. The actual requirement for diversion will need to be developed during detailed design and construction methodology development as part of a risk assessment, including contractor inputs. At the current level of design the cost is estimated to lie somewhere between the two figures quoted below.

The cost estimate for the dam (water augmentation only) as of November 2009 is:

- NZ$35.5 million (GST exclusive) for 2 culvert diversion
- NZ$38.1 million (GST exclusive) for 3 culvert diversion

The incremental cost of adding a hydro power component (for either diversion arrangement) is estimated to be $4.25 million (GST excl).

4 Potential for Hydro Power Generation

4.1 Introduction

The primary purpose of the Lee scheme is to provide augmented river flow for water supply and instream benefits. However, the option is available to WWAC to utilise the head (pressure) provided by the dammed water to generate hydro power, via an added on turbine and generator at a power station.

The proposed dam on the Lee River offers an opportunity for a cost-effective hydro-electric scheme to be added since the dam and reservoir would essentially already constitute the headworks for such a scheme. In addition to this, a power station and other ancillary works (e.g. switchyard and transmission) would be required, as well as modifications to the flow release arrangements.

A preliminary optimisation has been undertaken to determine the preferred hydropower add-on arrangements, particularly the size of the power plant and the additional operational storage. Details of this optimisation and the proposed layout are described in the accompanying **"Engineering Feasibility Report".**

Based on this process, it has been determined that the optimum scheme would generate approximately 1 MW. It would comprise the following:

- A residual flow unit (turbine and generator) with a flow capacity of 0.51 m^3/s (this matches the residual flow required at the base of the dam), and power output of 0.20 MW; plus
- A main unit (turbine and generator) with a flow capacity of 2 m^3/s and power output 0.79 MW; and
- An operational storage volume of 250,000 m^3 for hydropower regulation to enhance capture of inflows (that would otherwise be spilled) to generation.

The following sub-sections summarise the process used to estimate the potential hydro energy generation and to identify an apparent optimum size of generating plant.

4.2 Hydro Energy Output

Power generated is proportional to the product of the generation flow and head, which is given by the water level difference between the reservoir and the river downstream. The height of the dam and thus the maximum generating head is more or less fixed. The energy output is thus dependent on the size of the installed plant, specifically the maximum design generation flow and, to a lesser extent, the buffering storage provided within the reservoir. When the reservoir is full or nearly full, this buffering storage allows partial capture of small floods and freshes (which would otherwise be spilled) for generation. The buffering storage is separate and additive to the live storage required for meeting water demands downstream in the design drought.

Figure 4.1 shows the relationship between expected annual energy output in GWh p.a. and the generation flow capacity in m^3/s for a range of buffering storages. Note that on the horizontal axis, the generation flow capacity may be converted to power output by using the simple conversion 0.40 MW per m^3/s.

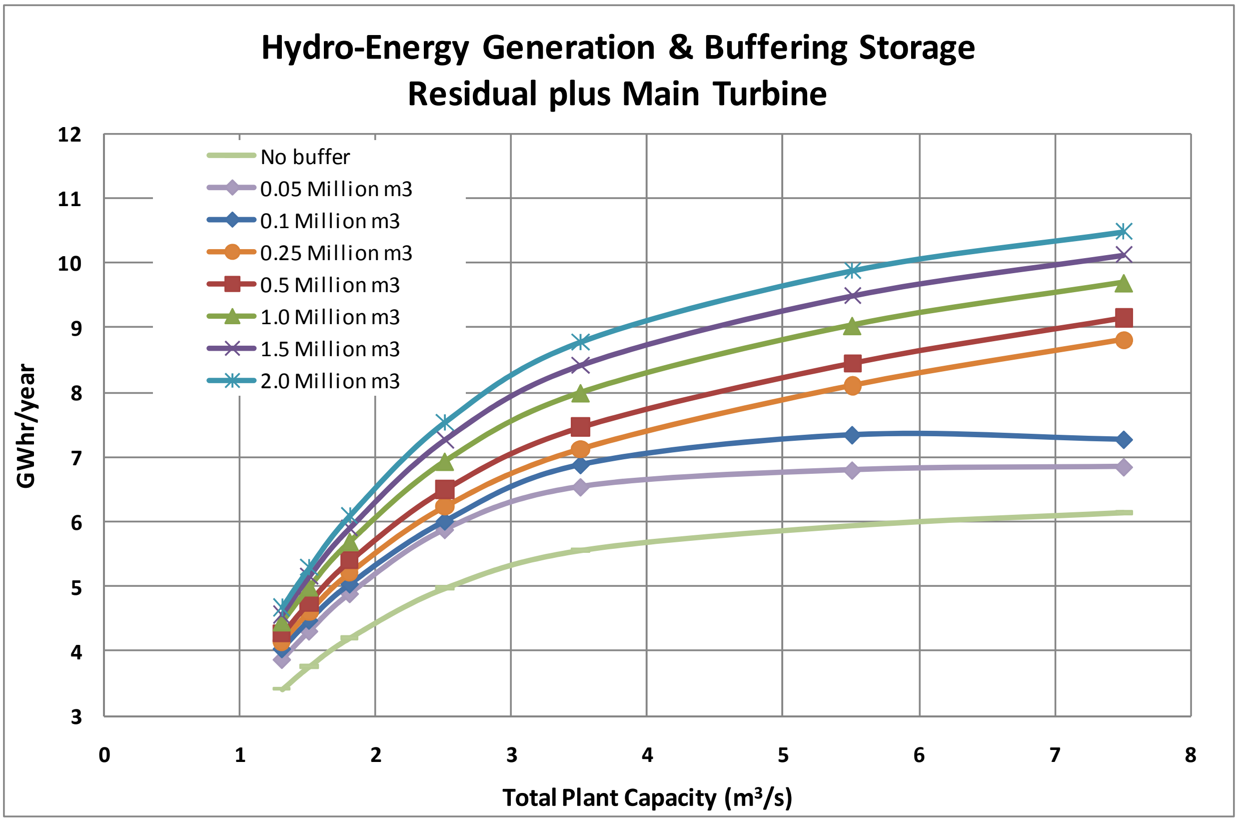


Figure 4.1: Expected hydro-energy output versus generation flow capacity and buffering storage

Other assumptions implicit in the hydro-energy calculation include:

- Tailwater level nominally at RL 150 m, thus, at a full supply level of RL 197 m, the gross head available prior to hydraulic headlosses is 47 m;
- Generating set comprising a residual flow turbine with 0.51 m^3/s generation capacity plus a main turbine (generation capacities ranging from zero to 7 m^3/s have been modelled); the total flow capacity is the sum of the capacities of the residual flow turbine (0.51 m^3/s)and the main turbine;
- A total head loss 1.5 m at peak generation for both the residual flow turbine and the main turbine;
- Generator efficiency of 0.97; the computed energy output is at generator terminals and exclude transmission line losses;
- Minimum generating head of 33.1 m and 34.2 m for the residual flow and main turbines;
- Minimum generation flow equal to 40% of the maximum generation flow for each turbine.

It is important to note that the release pattern from the dam is assumed to be governed solely by downstream water uses, and not by electricity demand (except when the storage is greater than 13 million m^3, in which case the generating plant is assumed to operate at capacity to draw the reservoir down to 13 million m^3. In this way, the minimum storage reached during a drought is not any lower than without hydro). In other words, hydropower generation is assumed to be a by-product of dam operations to meet downstream water demands.

Further, for the current assessment, the power station is assumed to operate as a constant flow as opposed to a daily peaking station. This means that the flow released from the dam is assumed to remain constant throughout each 24 hour period, but the flow may vary from one day to the next.

Peaking effects would need to be assessed in future subsequent studies if peaking operation is intended.

4.2.1 Buffering Storage

The family of curves shown in Figure 4.1 corresponds with different amounts of buffering (or regulating) storage over and above the base 13 million m^3 gross storage for meeting downstream water uses. These range from zero (no buffer) to 2.0 million m^3; for example, the 1.0 million m^3 curve assumes a total storage of 14 million m^3, of which 1 million m^3 is assumed available for power generation operation. A significant proportion of the increase in energy output with increasing buffering storage arises from the slightly higher maximum water level and thus generation head available. However, there is a cost to this; for example adding 1.0 million m^3 of storage requires the dam to be raised by about 1.5 m.

Assessments show a very steep drop off in incremental energy output with increasing buffering storage. Applying approximate costs for dam raising (for building in buffering storage) indicate that only a relatively small buffering storage is warranted, depending on the generation capacity. There is no advantage, in net present value terms, in providing more than 250,000 m^3 for a total generation capacity up to 5 m^3/s. Therefore, buffering storage is recommended to be capped at 250,000 m^3.

4.2.2 Transmission

The proposed dam site is approximately 2.4 km beyond the end of the existing overhead 11 kV line at the Lee Cement works and an extension will be required to/from the dam site. Approximate costs for transmission out of the Lee Valley have been advised by Network Tasman Ltd (pers. comm. Murray Hendrickson) and are as follows:

- 11kV - generation up to 350 kW - $330,000
- 22kV - generation up to 1200 kW - $1.85 million
- 33kV - generation beyond 1200 kW - $2.32 million.

These estimates are construction estimates only and do not include consenting or easement purchase costs, which would be minor for the 11 kV option, but more substantial for the 22 kV and 33 kV options.

4.2.3 Approximate Costs of Hydro Add-On Components

Figure 4.2 shows how the approximate costs of the hydro add-on components vary with increasing plant capacity. Separate curves are provided for the civil works and generating plant and for the transmission options described above.

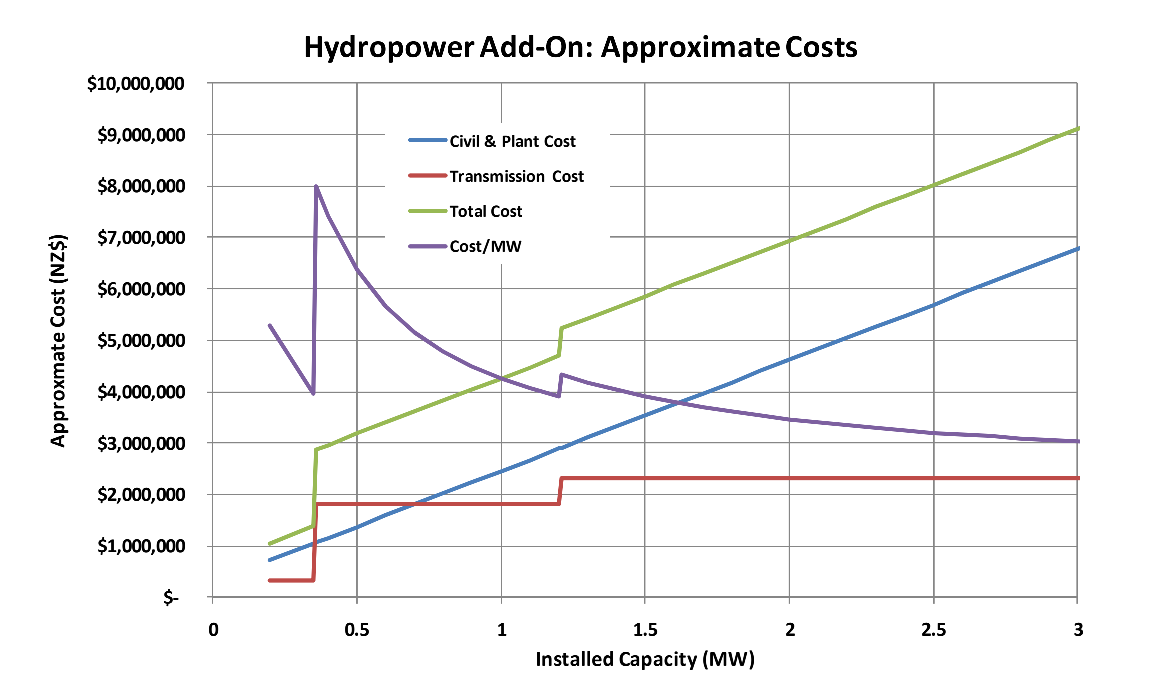


Figure 4.2: Approximate costs of hydropower add-on components

4.2.4 Apparent Optimum Design Flow and Plant Size

An apparent optimum plant size may be identified by comparing the net present value (NPV) of the expected hydro generation over the economic life of the project against the capital cost of the hydro add-on components for a range of plant capacities. In simplistic terms, subtracting the capital cost of the hydro add-on from the NPV of hydro generation provides an indication of the potential return from the hydro add-on. The analysis indicates that an installed plant capacity of about 0.99 MW (total design generation flow 2.51 m^3/s) would be close to optimum.

4.3 Operating Regime

As noted in Section 2.5.3, based on a full supply level of RL 197.0 m, the gross storage capacity available in the reservoir is actually 13.4 million m^3. This is 400,000 m^3 in excess of the 13 million m^3 targeted. The required hydropower regulation storage of 250,000 m^3 is less than the available “excess” storage. Therefore, the “with hydro” option is able to retain the same full supply level as the “without hydro” option, viz. RL 197.0 m. However, compared with the “without hydro” option, hydropower operation will result in the reservoir level fluctuating frequently within a tight band between RL 196.61 m and RL 197.0 m (a 0.39 m range) rather than remain at a relatively constant level (at RL 197.0 m).

Flow duration curves of the dam outflow for both the “with hydro” and “without hydro” options for the full simulation period 1958 to 2008 are compared in Figure 4.3.

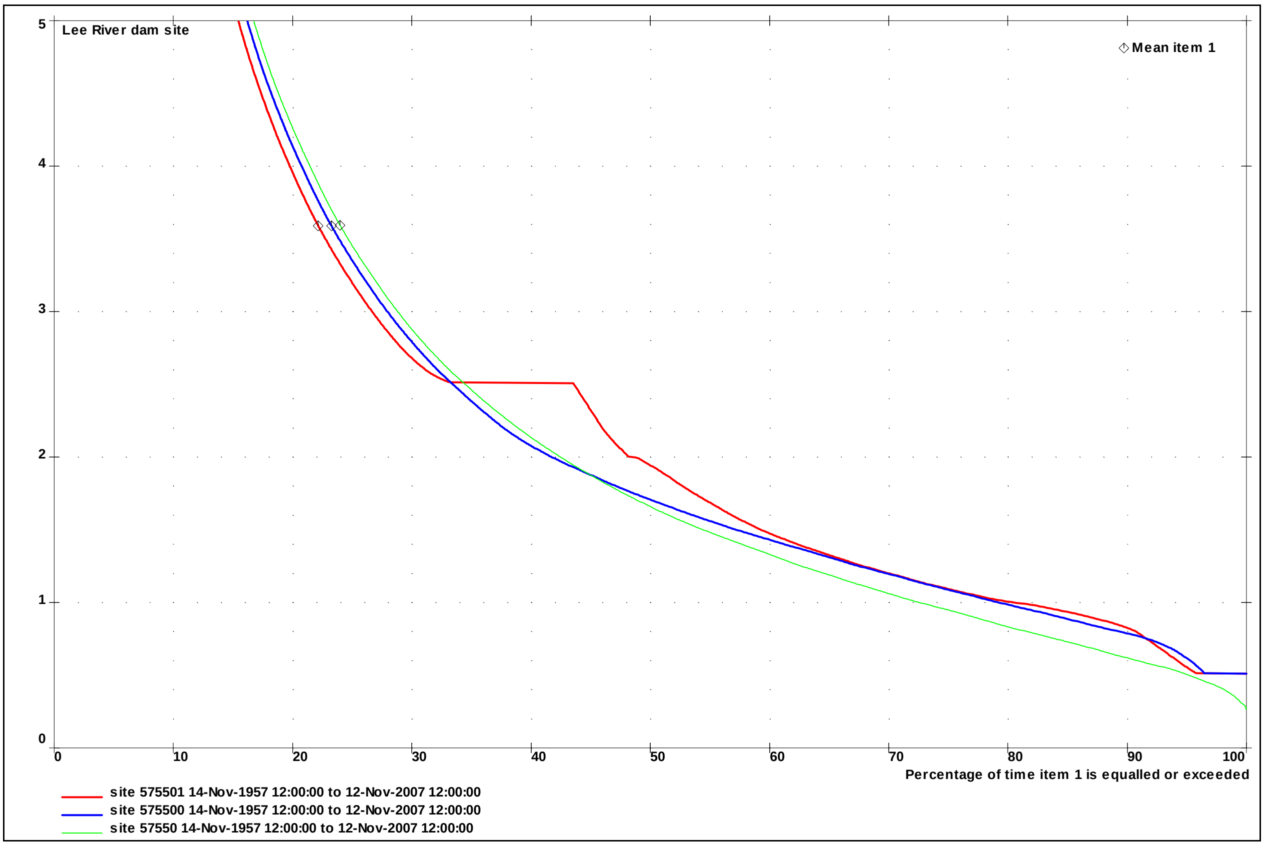


Figure 4.3 Flow duration curves representing the simulated flows at the Lee River dam site for the period 1958 to 2008: red – dam outflow from the "with hydro" option; blue – dam outflow from the "without hydro" option; green – dam inflow. All flows in m^3/s.

5 Land Tenure and Access Requirements

5.1 Land Tenure

Land ownership in the vicinity of the dam and reservoir (including associated construction areas and the reservoir) is shown on Figure 1.1.

The dam itself, the spillway and the main construction areas, are located on land that is currently privately owned. The reservoir extends over land that includes privately owned land, land under Crown Forest Licence, and Public Conservation Land (Mt Richmond Forest Park, administered by the Department of Conservation). Road reserve (Tasman District Council) borders the river on both sides.

The approximate areas involved are as follows:

- Private land – 35 hectares
- Crown Forest Licence – 23 hectares
- Public Conservation Land – 10 hectares
- Road Reserve – 18 hectares

These areas have been calculated on the basis of:

- A normal top water level to RL 197m, plus
- Provision of a 5m buffer for flood rise (to accommodate the Probable Maximum Flood) – to RL 202m, plus
- Additional 'buffer' in areas where there is potentially local slope instability.

5.2 Access Requirements

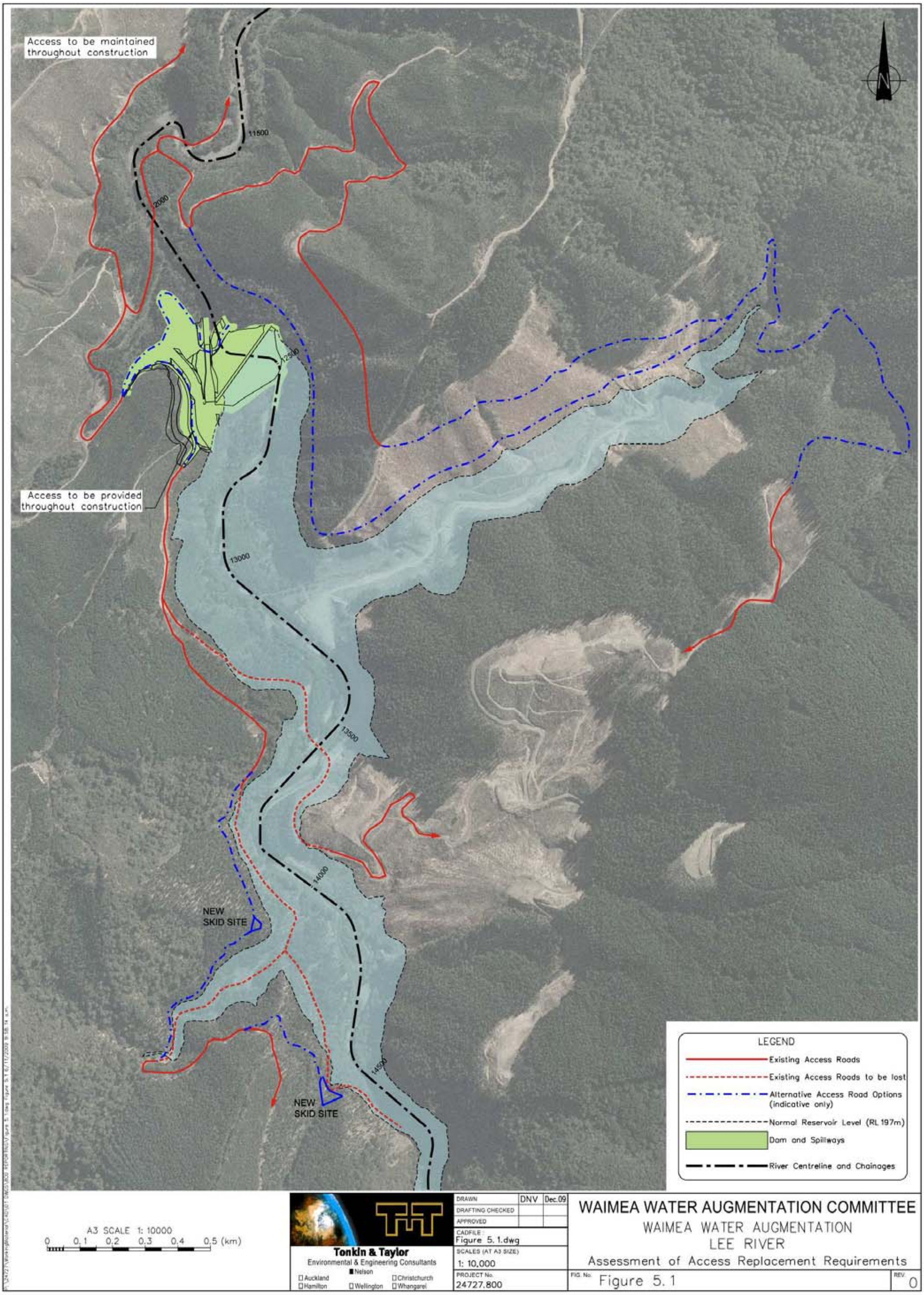
5.2.1 Introduction

The Lee dam will impact on the existing roading network that provides access to and within private land in the vicinity of and upstream of the dam. In addition, there will also be short-term impacts on the main access road up the Lee Valley during the construction phase of the dam.

To assess the extent of impacts, a series of meetings has been held with the Department of Conservation (DOC) and three landowners and occupiers.

Existing roads and slopes in the general vicinity of possible alternative routes have been inspected, although no specific walkover or subsurface investigations have been undertaken for this level of assessment.

Figure 5.1 shows the existing roading network in and around the potential dam and reservoir. Figure 5.1 also shows the roads that will be inundated or otherwise affected by the construction of the dam and reservoir.



Access to be maintained throughout construction
Access to be provided throughout construction
NEW SKID SITE
NEW SKID SITE
11500
12000
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13000
13500
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14500
N
LEGEND
Existing Access Roads
Existing Access Roads to be lost
Alternative Access Road Options (indicative only)
Normal Reservoir Level (RL 197m)
Dam and Spillways
River Centreline and Chainages
A3 SCALE 1: 10000
0 0.1 0.2 0.3 0.4 0.5 (km)
Tonkin & Taylor
Environmental & Engineering Consultants
Auckland
Hamilton
Nelson
Wellington
Christchurch
Whangarei
DRAWN DNV Dec.09
DRAFTING CHECKED
APPROVED
CADFILE: Figure 5.1.dwg
SCALES (AT A3 SIZE) 1: 10,000
PROJECT No. 24727.800
WAIMEA WATER AUGMENTATION COMMITTEE
WAIMEA WATER AUGMENTATION
LEE RIVER
Assessment of Access Replacement Requirements
FIG. No. Figure 5.1
REV 0

Three main issues have been identified:

1. Short-term access including shared access to the dam site and beyond, during dam construction;
2. Providing long-term alternative access to the forestry blocks on the left bank, upstream of the dam;
3. Providing long-term alternative access to the forestry blocks on the right bank of the dam.

Outcomes from the assessment are summarised in the following sub-sections.

5.2.2 Maintaining Access During Dam Construction

Dam construction will impact on access in two ways:

1. Daily traffic will increase;
2. Construction activities will destroy the existing road where it passes through the dam site (from Anslow Creek to a point approximately 100 m upstream of the dam).

Forest company representatives who have forest blocks in the vicinity have indicated that harvesting is likely to take place at times during the dam construction period (say 2013 to 2017). This is not likely to involve more than 30 logging truck movements per day if two logging operations are carried out concurrently.

Maintaining shared access to the road as far as the dam site is considered feasible provided vehicles have radio contact and comply with standard forestry road safety procedures.

Minor disruptions/delays to forestry traffic by-passing the dam site would be considered acceptable but prolonged and regular delays would impact on cartage rates.

Roads to be shared by construction traffic and forestry traffic will need to have good line of sight, and occasional passing bays will need to be provided in those areas where maintaining a two lane road is not feasible.

It is anticipated that major upgrade of the road into the dam site will not be necessary. However, regular maintenance involving grading and occasional metal spreading would be necessary similar to what is currently carried out on the public section of road.

In addition, it is expected that occasional slip clearing works will be required.

5.2.3 Road Replacement Upstream True Left Bank

It is estimated that approximately 1,100 m of new road will need to be constructed to provide access to private land on the true left bank. In addition, two new forestry skid sites will be required to replace those lost in the reservoir footprint. Possible replacement sites are shown on Figure 5.1.

The replacement roads will traverse moderately steep to steep slopes and will require cuts up to 10 m high. Further specific investigation will be required at design stage for this road. For cost estimating purposes a high contingency has been (and should continue to be) allowed for to account for locally challenging conditions.

5.2.4 Road Replacement Upstream Right Bank

The existing road and river crossing to the Crown Forest Lease Block will be lost in the reservoir footprint.

Figure 5.1 shows two alternative concepts to gain access to this right bank area. Other options may also exist. It is estimated that any option would require between 3 to 5 km of new road to be formed on moderately steep slopes that include localised areas of difficult terrain.

6 Assessment of Environmental Issues

6.1 Terrestrial Ecology

6.1.1 Scope

This section summarises the investigations and results that are presented in detail in the accompanying technical report "**Terrestrial Ecology Effects Assessment**" by Tonkin & Taylor. The report presents the findings of terrestrial ecology investigations that included:

1. Site visits to survey existing terrestrial habitats, vegetation (including rare and endangered plants), lizards, birds and plant and animal pests; and
2. Evaluation of habitat values and indigenous vegetation in a district, regional and national context and the effects of the proposed dam and associated reservoir on these values.

The survey was carried out within the area of the proposed water storage reservoir and dam and native forest areas surrounding this footprint. Observations were also made of vegetation quality in areas downstream from the proposed reservoir in order to evaluate the potential downstream effects of the water augmentation scheme on significant plant communities and to identify potential sites for mitigation off-sets to compensate for loss of vegetation and wildlife within the footprint of the development.

The areas potentially affected by the development include the area encompassing the dam, reservoir, borrow areas and construction and storage areas. In addition, areas of slope instability, which could in future require some management, are included in this assessment, thereby providing a conservative estimate of the area of potential vegetation and wildlife removal. Together, these areas are referred to as 'the development footprint'.

The riparian areas downstream of the proposed dam are also included as a separate element of the ecological assessment, in terms of potential indirect effects of the altered river flow regime on riparian vegetation downstream from the development.

The ecological assessment considers the actual and potential effects of the proposed Lee dam and associated reservoir on the natural values and natural resources of the site. Specific reference is made to indigenous vegetation, habitats of indigenous animals, and threatened and protected species as required under assessments of environmental effects within the context of the Resource Management Act 1991 (RMA).

The purpose of this study is to provide guidance as to the scale and degree of importance of ecological effects resulting from the proposed development. The ecological issues are evaluated and discussed in relation to levels of ecological importance (significance) as is typically interpreted from Section 6c of the RMA.

The options for ecological restoration work within the Lee River Catchment are many and varied. These options are assessed further in the accompanying Technical Report '**Enhancement Opportunities Scoping Plan**' and summarised in Section 8.

6.1.2 Vegetation Survey

The overall area within the development footprint considered for this survey is 87.7 ha of which 68.7 ha are terrestrial vegetated environments and 19 ha are river bed and roadways.

Approximately half of the land supports indigenous woody vegetation (26.6 ha) with the remainder supporting (or until recently supported) radiata pine (39.3 ha), Douglas fir (2.4 ha) or grassland (0.3 ha). The areas around the dam and the lower reservoir are dominated by exotic plantation forestry; however these areas also support some of the areas of greatest value for indigenous habitats, especially riparian and flood plain environments.

Nearly 95% of all vegetation and over 85% of the indigenous vegetation within the development footprint is on privately owned land or Crown land leased for forestry. The area of indigenous vegetation that lies within the Public Conservation Land (Mt Richmond Forest Park) at the head of the reservoir is comparatively small (less than 4 ha) by virtue of the long, yet narrow form through the steep upper catchment area.

The area of vegetation within the Mt Richmond Forest Park that would be inundated comprises approximately 0.002% of the Park. The area of indigenous vegetation within the overall Lee catchment that would be cleared for the scheme is approximately 27 ha (including woody and grass vegetation). This comprises less than 1% of the remnant indigenous vegetation (much of which is within the upper Lee catchment area).

The upper Lee River area, within the development footprint, supports a range of species of botanical significance, others of botanical interest, and four significant areas of native vegetation.

The vegetation cover in the upper Lee River Catchment has been modified greatly over much of its area, through the removal of indigenous forest cover and replacement with exotic plantation forestry. Within the development footprint indigenous forest remnants remain largely in riparian areas with increasing areas and connectivity further up the catchment towards and within the Mt Richmond Forest Park.

The Lee, as with other adjoining catchments, is characterised by high plant species diversity and local rarity – this makes most remaining and regenerating vegetation special to some degree by virtue of its existence. All of the remnant areas surveyed have been degraded through the actions of exotic weeds and animal pests, some to the point that pest animal rooting and browse may present serious threats to the continued local existence of ground-dwelling plants such as NZ shovel mint.

Vegetation communities within the proposed project footprint include: alluvial forest (high significance[4]); gorge flood-zone turf communities (moderate significance); river-bed island forest (moderate significance); riparian forest (high significance); and hill-slope beech forest (moderate-low significance)

Species of significance within the development area include four threatened plant species.

NZ shovel mint (*Scutellaria novae-zelandiae*) is endemic to the Nelson/Marlborough region and is listed as a Nationally Critically threatened plant species. The extent of shovel mint discovered during surveys associated with the proposed Lee River dam means that this area may support the largest area, and hence most nationally significant site, for shovel mint. The proposed dam and reservoir footprint will remove approximately half of the areas described during these surveys.

Sand coprosma (*Coprosma acerosa*) is listed as a Nationally At Risk (Declining) threatened species. The sand coprosma population within the project footprint is regarded as being of

[4] As assessed against the draft Tasman Significance Criteria Framework

moderate conservation significance given its distribution elsewhere, including known populations elsewhere in the Mt Richmond Forest Park.

Euchiton polylepis is associated with gorge turf communities and is listed as a nationally At Risk species which is naturally uncommon. Its distribution is not well understood through the Mt Richmond Forest Park and it is suspected that populations may exist elsewhere (S. Courtney, DOC, pers. comm.). This species was not recorded within the dam or reservoir footprint during surveys undertaken for this project. However DOC staff have sighted this species in the vicinity of the proposed dam (S. Courtney, DOC, pers. comm.). Given the uncertainty over its distribution within the proposed footprint and the likelihood that it is present elsewhere in the Lee and other nearby catchments, the significance of this species at the Lee site is considered to be low.

Scented broom (*Carmichaelia odorata)* is found throughout the riparian areas of the project footprint. Although it is found in the southern North Island and the northern and western areas of the South Island, this species is locally rare, and the size of the population found in the surveyed part of the Lee Catchment makes this site of regional significance. While several parts of the Lee population will be inundated by the proposed reservoir, there are good populations below the proposed dam that will remain and these offer opportunities for permanent protection and restoration.

Without appropriate mitigation, the likely effects of the proposed development on the vegetation elements of the Lee River will be moderate overall, with varying degrees of severity of adverse effect between plant species and communities, as described in Table 6.1.

All species of significance identified in the survey are represented elsewhere in the local area; in other words, the proposed development site does not constitute the only, or likely significant, portion of the range of this species in the region, or at a national scale. That is, there is no plant species that is threatened with extinction by the development of the Lee dam and reservoir.

Table 6.1 Summary of effects on vegetation prior to mitigation

Vegetation element	Effect of development	Overall scale of ecological effect
Indigenous vegetation	Permanent removal: 26.9 ha	Moderate – result will be a minor reduction in overall catchment indigenous vegetation, but a more substantial reduction in indigenous riparian vegetation.
Exotic vegetation	Permanent removal: 41.7 ha	Minor
Shovel mint	Removal of a large proportion of the population within the Lee Catchment	High – The Lee population comprises one of only a few populations of this regionally endemic species.
Sand coprosma	Removal of the only known population in Lee Catchment	Moderate – no other populations are currently known to exist within the Lee Catchment, although habitat appears to be present in upstream areas that could support sand coprosma. The species is nationally distributed and the Lee population comprises a small proportion of

Vegetation element	Effect of development	Overall scale of ecological effect
		known populations or individuals.
Scented broom	Removal of one of many populations within the Lee Catchment	Moderate – found in the southern North Island and the northern and western areas of the South Island, although the size of the Lee population is regionally significant.
Euchiton polylepis	Removal of gorge turf communities with which it is associated	Low – not found during survey, but may be present. Distribution is not well understood so maybe more widely distributed in Forest Park than currently recognised.
Alluvial forest	(Acutely Threatened habitat type). Removal of regenerating and mature examples in the upper Lee.	High – Removal of even small areas of this nationally significant vegetation type is significant. Areas downstream lend themselves to restoration.
Riparian kahikatea forest	(Chronically Threatened habitat type). Removal of mature forest fragments along the river, including one of the best examples of kahikatea forest in the Lee Catchment	Moderate-High – Kahikatea is present in areas upstream and downstream of the dam and reservoir, including several areas where vigorous regeneration of young kahikatea is occurring
Flood zone turf communities	Removal of substantial communities and habitat, although good quality examples exist downstream from the dam	Moderate – excellent examples exist downstream of the dam site, although the persistence of these under potentially altered flow regimes is currently uncertain
Hill-slope beech forest	Removal of stands throughout the development area	Minor – hill-slope beech forest is abundant within the Lee Catchment, adjoining Wairoa Catchment and other nearby catchments.

6.1.3 Wildlife Survey

The area surrounding the upper Lee River supports a number of native and introduced birds. The diversity of birds recorded from the site is a typical representation of species which inhabit developed landscapes, indicative of a highly modified environment with predominantly exotic birds or native species which are common in forested and farmland environments.

The threatened NZ bush falcon was recorded. The magnitude of proposed forest removal most likely comprises only a very small part of the overall range of these falcon. Any loss of foraging or nesting environment is likely to be minor in itself, given the typically large home range of the species relative to the proposed inundation area and the forested nature of the catchment, above, below and adjoining the proposed reservoir.

Other species of interest recorded historically from the wider Forest Park area, including kaka and blue duck, were not detected in this survey or by previous work by DOC on and around the proposed development footprint.

Despite this, the loss of approximately 69 ha of vegetation represents a permanent loss of food resources and nesting habitats, with native forest areas most likely providing a disproportionately higher benefit to local birdlife by virtue of nectar, fruits and diverse invertebrate food sources. The removal of this vegetation for the dam and reservoir will contribute to ongoing fragmentation of indigenous forest along the Lee River, by removing connections between the Mt Richmond Forest Park and lowland areas.

When taken in the local context (the upper Lee), the proposed development represents a moderate loss of resources, especially riparian forest, for birds.

Lizards were not detected from the site. This lack of lizards mirrors poor search results obtained by DOC from elsewhere in the local area. While lizards must surely be present on site, they are likely to be in very low densities.

Long-tailed bats have recently been recorded from the Pelorus catchment. There is circumstantial evidence and evidence from elsewhere to support the possibility of bats being present in the Lee project footprint area, particularly in the upper reaches of the proposed reservoir on Public Conservation Land (with its larger, old-growth trees). WWAC has recently commissioned a bat survey of the area. These results will be reported on separately. However, the likely effects on the overall bat populations in the Mt Richmond Forest Park from loss of habitat is considered to be minor given the comparatively large areas they are known from and the large areas of habitat in which they may be present within Mt Richmond Forest Park.

Overall, the potential or actual effects on fauna are regarded as being minor.

6.1.4 Weed and Animal Pests

The vegetation surveys identified a number of weed plants within the study area, many of which are having, or have the potential to cause, ecological impacts on natural systems.

In addition, the presence of a large number of animal pests was recorded during targeted pest surveys. Pigs, goats, deer and possums are having a large impact on the vegetation of the study area. Rats and mice were also abundant.

6.2 Aquatic Ecology

6.2.1 Scope

This section summarises the investigations and results that are presented in detail in the accompanying technical report **"Aquatic Ecology: Mitigation and Management Options Associated with Water Storage in the Proposed Lee Reservoir"** by Cawthron Institute.

The report:

- Addresses existing water quality and invertebrate communities in the Lee River;
- Examines the potential for stratification to develop in the proposed reservoir and the implications of different water outlet levels;
- Recommends appropriate minimum and flushing flows for the Lee River downstream of the proposed dam;
- Assesses the potential effect on the downstream river and ecology from an altered flow regime;
- Addresses mitigation of fish passage issues associated with the dam;

- Addresses potential issues with reservoir management that may affect fishery values in the reservoir;
- Assesses the overall balance of positive and negative effects of the scheme.

6.2.2 Existing Water Quality

Existing water quality of the Lee River at the proposed dam site is indicative of the undeveloped nature of the catchment upstream and is well within national guidelines for protection of river ecosystem health. The values for most water quality parameters at the proposed dam site remain similar further downstream as measured in the Lee River at Meads Bridge.

Stream invertebrate communities at the proposed dam site and at Meads Bridge are equivalent and are generally indicative of very good stream health. No rare species of invertebrates were recorded at either site.

6.2.3 Management of Water Quality in the Reservoir

The Lee reservoir will be up to approximately 46 m deep.

Most deep lakes will stratify during summer with a layer of warm surface water 'floating' above a cooler, denser, bottom layer. During periods of stratification, oxygen demand in the bottom of a lake can lead to reductions in dissolved oxygen concentration in the bottom waters. In severe cases this can lead to anoxic conditions. A computer model was therefore used to predict water temperatures throughout the water column in the proposed reservoir as the basis of determining reservoir management requirements.

The model predicted cool temperatures throughout the water column in winter indicating a well mixed water column. Stratification was predicted to occur in late spring, summer and autumn with the thermocline (boundary between surface and bottom waters) approximately 10 m below the reservoir surface during wet years and much deeper (over 30 m) in dry years.

The level within the reservoir's water column from which water is taken via the outlet structure and released downstream of the dam is predicted to have a large influence on where the stratification layer develops. Cawthron recommended that two outlets, at different levels, be incorporated into the scheme design:

- One outlet near the bottom of the reservoir, to be used during dry years and during floods to flush any poor quality bottom water from the reservoir;
- A second outlet at approximately RL185 m, to be used under most conditions to release good quality surface water from the reservoir during most years.

These recommendations have been adopted (see Section 3.2.8).

Given that water temperatures near the surface of the reservoir will be relatively high at times, it may also be possible to manage outlet use to limit thermal effects on the river downstream.

Assuming that the current nutrient loading in the Lee River at the dam site will remain the same after dam construction, the reservoir is predicted to be oligotrophic (ie high water quality), with low concentrations of phytoplankton biomass and relatively high water clarity. These predictions match observations from the neighbouring Maitai

Reservoir, which experiences similar climatic conditions and has similar landuse in the catchment upstream.

6.2.4 Instream Habitat Assessment and Minimum Flow Requirements

As noted in Section 2.2.4, during the Phase 1 pre-feasibility study, a minimum flow was adopted for the scheme for the lower Waimea River (as measured at Appleby Bridge). A flow of 1100 l/sec (1.1 m^3/s) was adopted to be retained in the river (after all water demands have been accounted for). This requirement has been incorporated into all water storage and river flow modelling during the Phase 2 investigations (as noted in Section 2.2.4), and is an objective of the scheme.

The Phase 1 study also suggested that a flow equal to the existing mean annual low flow (MALF) be adopted as the minimum flow for the Lee River immediately below the dam. During the current Phase 2 study, habitat modelling was conducted to provide a more robust indication of instream habitat requirements at the proposed dam site.

Minimum flows that provide habitat retention for native fish are consistently lower than those for brown trout; i.e. trout require more water. Therefore setting a minimum flow to protect trout habitat availability should also accommodate the minimum flow requirements of native fish.

Assessments were made of various scenarios of protecting percentages of the habitat available at the natural MALF for different age brown trout and spawning and incubation needs. These indicated that minimum flows ranging between 0.32 m^3/s and 0.41 m^3/s should be provided at the base of the dam.

The outcome of this work is that the natural 7-day MALF is proposed as the environmental benchmark minimum flow for the Lee River below the proposed dam. This is equivalent to 0.51 m^3/s, and will provide conservative flows for trout habitat.

6.2.5 Effects of Altered Flow Regime

Changes to the flow regime of the river downstream of the dam, including the variability of flow, can have ecological effects.

In particular, increasing the frequency and duration of the minimum flow can have adverse effects such as proliferation of periphyton to nuisance levels. This problem can be mitigated by incorporating flushing flows into the operating procedures. Modelling was undertaken to predict the maximum suspended sediment and maximum bedload particle size that will be mobilised under different flows. This analysis indicated that a flow of 4-5 m^3/sec would be required to have an appreciable effect of flushing fine sediment and periphyton. Accordingly it was recommended that provision be made for flushing flows of 5 m^3/sec. This has been incorporated into the scheme design.

Effects of an altered flow regime may also extend to invertebrates and fish. An assessment has therefore been undertaken of the proposed flow regime resulting from the presence of the dam and reservoir (see Section 2.5.4), compared with the natural flow regime. This analysis shows while there may be variations in the degree of effect in different years, overall the predicted flow regime downstream of the dam indicates that there will be changes to key ecologically relevant flow statistics, and that downstream habitat will improve with the augmentation scheme. The main effect of the scheme is to increase flow during the summer irrigation, and low flow, season, with a predicted increase in habitat availability for most of the fish species modelled. For the period April-November inclusive, it is predicted that there will be no more than a 3% change in habitat availability at the monthly median flows as a result of the scheme, for any of the species modelled.

It is possible that hydro-power generation will be incorporated into the scheme design. The effect of the indicative flow regime for a hydro option operating as a base-load station is similar to the 'no hydro' situation described above; that is, it is likely to improve habitat availability for most species during the summer irrigation and low flow season. However, any potential effects of hydro-peaking on habitat availability downstream were beyond the scope of this study. Therefore, if hydro-peaking were to be considered during a later hydro power optimisation study, then the specific effects on habitat would need to be assessed.

6.2.6 Fish Passage

Given the height of the proposed dam (approximately 52 m to the dam crest) and the relatively low status of the trout fishery in the Lee River, it is considered that mitigation of fish passage issues associated with the dam is only necessary and practical for the strongest of migrants such as elvers and young koaro. Iterative discussions on fish passage have been held between the dam designer (Tonkin & Taylor), Cawthron, Fish & Game NZ, and DOC. Several initial design options were ruled out during this process due to their incompatibility with fish passage. The currently agreed solution (which is incorporated in the proposed dam design as described in Section 3.2.9) is a nature-like fish passage channel crossing the downstream face of the dam from left to right and flowing out adjacent to the attraction flow provided by the augmentation flow release outlet. In order to ensure continual flow and fish passage through the fish passage channel, a piped flow will need to be directed into the fish passage channel at the dam crest.

The most difficult issue to deal with at this stage is downstream migration of adult eels. The flip bucket at the bottom of the spillway has the potential to cause abrasion damage and/or mortality to these fish. Trapping of migrants and manual transfer of them downstream over the dam wall may be required during peak migration periods (i.e. during autumn floods) if monitoring shows significant injury or mortality due to spillway passage.

A fish screen at the intake would only be required to protect downstream migrating eels if there are power generation turbines installed as part of the outlet. If screening is to be considered, a mesh size of 20 mm and an approach velocity around 0.3 m/s is recommended. These features have been incorporated in the current scheme design.

6.2.7 Reservoir Management

A self sustaining trout fishery in the reservoir will be reliant on adequate spawning and rearing habitat in the reservoir tributaries, while the size of the fishery will depend on the productivity of the reservoir. The availability of spawning habitat in the tributaries of the upper Lee catchment is largely unknown. Fish & Game proposes to resolve this in future studies. As noted in Section 6.2.3, the reservoir is likely to be oligotrophic with relatively low phytoplankton biomass. Therefore, reservoir productivity will depend on the extent to which macrophyte beds establish in the littoral zone around the reservoir margins.

The reservoir is likely to have a limited shallow littoral zone, due to the steep sided nature of the valley. This, as well as fluctuations in water level, is likely to limit the development of macrophyte beds to some extent. Those plants that do establish around the shallow margins of the reservoir will periodically be exposed and will probably die off during periods of draw down. However, the incidence of the water level being drawn down to extremely low levels is expected to be relatively rare. A zone suitable for aquatic macrophyte growth can be expected between approximately RL180.4 m and RL193.5 m. Based on the predicted reservoir surface, this area of productive littoral zone is likely to be approximately 32% of the total surface area of the reservoir at maximum capacity.

Excessive macrophyte growth and drifting masses of macrophytes can impair recreational values of reservoirs and clog intakes. It is predicted that there is some risk of macrophytes causing clogging issues, although the risk is toward the low end of the scale. A mitigation plan may be required to address this potential issue.

The invasive alga didymo does not generally proliferate in lakes, although it can be flushed into lakes from growths in tributaries, and then drift into intakes and cause clogging issues. The densely bush-clad nature of the upper Lee catchment means that algal proliferation in the upper catchment is unlikely. However, any management plan aimed at reducing clogging of the outlet with macrophytes is likely to also address any potential clogging issues associated with didymo.

6.2.8 Relative Effects on Instream Habitat

After weighing up the positive and negative effects of the proposed storage scheme on instream habitat availability, most species (trout, eels, torrentfish, koaro, and upland bully) are predicted to benefit from the augmentation scheme as a result of increased flows in the lower Waimea River during dry periods. The main exception is redfin bully, which tend to like slow shallow water, and thus will not benefit from enhanced minimum flows in the lower reaches of the river system. Redfin bullies will also be unlikely to negotiate the fish pass and continue to occupy habitat above the dam.

The increased minimum flows in the river downstream of the proposed reservoir are predicted to result in an increase of approximately 25% in the number of adult trout in the lower Waimea River (from approximately 15 per kilometre to 19 per kilometre).

6.3 Effects on Recreation

6.3.1 Scope

This section summarises the results of the accompanying technical report **"Assessment of Effects on Recreation"** by Rob Greenaway & Associates. The report reviews the recreation values associated with the Lee, Wairoa and Waimea Rivers, and assesses the potential effects of the proposed reservoir and dam on recreational values and opportunities.

The report:

- Describes existing recreational activities in the project area;
- Reviews the significance, level of use, scale of effects and the overall effects on recreation of the project on different parts of the project area;
- Identifies potential for the project to enhance recreation.

6.3.2 Existing Recreational Use

The main existing recreational use in the project area is swimming in the Lee, Wairoa and Waimea Rivers, with (based on historic data) tens of thousands of users days per year. Activity is concentrated where access and ancillary recreation facilities (such as picnic sites and toilets) are located. There are two reserves owned by the District Council on the banks of the Lee River above the Roding River confluence, as well as a regional Girl Guide Camp and a DOC reserve below the Roding confluence. The swimming site at Max's Bush (adjacent to the Waimea East Irrigation weir) also provides a very popular swimming site. The Wairoa and Waimea Rivers provide many accessible swimming sites wherever public access allows. Picnicking and general terrestrial recreation are associated with the swimming activity. The swimming values are regionally significant throughout the catchment.

The Lee River was reported in the mid 1980s as being the second-most used river recreation setting in the Nelson Bays region. There is no more recent data, but there is no indication that use has declined.

The Waimea and Wairoa Rivers are the main trout angling destinations in the catchment. The Lee River is not particularly noted for trout fishing, and is not specifically mentioned on the Fish & Game regional information website for Nelson/Marlborough. The Lee River currently experiences low existing use for trout angling.

The Wairoa River (particularly upstream of the Lee confluence) is the key kayaking river in the study area. The Lee River provides some limited options particularly for slalom training.

There are several walks identified in the lower catchment, incorporating the riverbank areas. The Waimea River berm lands form part of the Waimea River Park. The upper Lee Valley (which extends into Mt Richmond Forest Park) has no practical public access and no longer provides formal walking opportunities. While road reserve and the riverbed provide legal access into the upper Lee Valley, the route is in the riverbed itself, and is not easy. The north-western side of the Richmond Range generally has limited public access, being largely bounded by large blocks of private forestry and forest lease land. DOC is continuing to investigate options increasing the access options, but the Lee area is not a priority in this review.

Due to difficult access and difficult terrain, there is limited hunting in the upper Lee Valley.

The Nelson Branch of the Girl Guides owns and operates Paretai, a regional camp in the lower Lee Valley. The river itself is an important element of the camp experience and is used for swimming, tubing and stream crossing practice.

The Lee River is not identified as a jet boating river. The Waimea River requires a fresh to be boatable and it is not run under normal flow conditions. This is 'short notice' boating when conditions suit.

6.3.3 Effect of Water Augmentation Scheme on Recreation

Swimming in the Lee and Waimea River occurs at a range of river flow levels. Periods of very low flow have not been identified as being either particularly restrictive or beneficial. The flow regime that is predicted to occur as a result of the water augmentation scheme is within the normal river flow regime. As a result, the net effect of the proposal on swimming in the Lee River will be minor or less: in more than 50% of years, flows in the river will only be augmented infrequently; in 20% of years, flows will be augmented occasionally, and only in approximately 6% of years will flows be consistently augmented over the spring and summer periods. Some peak flows will be removed from the Lee River flow regime, at times when the reservoir is being refilled, but these are likely to occur during rain events when it is less likely that the river will be used for swimming.

In the first few years after the reservoir is initially filled there may be some increased growth in periphyton in the Lee River downstream of the dam as a result of short-term nutrient enrichment. Provision has been made in the dam design and operating regime to release additional flows for flushing if this becomes an issue.

The scale of change in base flows in the Wairoa and Waimea Rivers during dry and moderate years will be insufficient to be noticeable by river users compared with wet years, although the current extreme low flows will no longer be experienced.

Maintaining a minimum flow of 1100 l/sec in the Waimea River at Appleby Bridge (up from the previous requirement of 225 l/sec) is estimated by Cawthron to improve adult trout numbers by approximately 25% (from 15 per km to 19 per km). The potential improvement in trout habitat in the Lee River (reported by Cawthron) will only have marginal effects on the catchment's level of angling amenity.

Current access for tramping and hunting in the upper Lee Valley from the west is dependent on agreement with landowners and managers, and does not represent a long-term solution to recreational access to the western side of Mt Richmond Forest Park. The Lee dam and reservoir do not represent an important impediment to organisations seeking a long-term solution to access.

Jet boating slalom events in the Waimea River may be enhanced by increased base flows.

The Wairoa River is kayaked mostly above the Lee confluence. The proposed scheme will occasionally remove or reduce the scale of the peak river flows in the Wairoa River below its confluence with the Lee at times when the reservoir is being refilled. Effects of the proposal may not in fact be noticed. Augmented base flows would be likely to support additional enjoyment of the Lee River for kayaking.

The new reservoir presents a new recreation opportunity, although it will be predominantly located on private land with no public vehicular access. The existing (albeit difficult and limited) public foot access via the legal road bounding the river will effectively be terminated by the dam.

It is unlikely that the proposed setting will allow or warrant the development of special facilities or access for recreation on a large-scale basis. Some recreational users will be more likely to want to satisfy their curiosity rather than develop habitual visiting patterns due to the limitations of the setting, particularly the relatively small area and narrow configuration of the reservoir surface.

There is potential for the reservoir to be opened up for casual canoe and kayak uses over a confined period of weeks in early summer. This may satisfy recreation demand. Limited jet and power boating opportunities could arise, including for water-skiing, although the size of the reservoir will be a handicap and launching facilities would need to be provided. Should a quality recreational fishery result, provision for angling access could be of value.

There is some concern from neighbouring landowners that increased public access to the area may pose risks to the predominant landuse (forestry), particularly related to the potential for fire.

6.3.4 Summary

The net adverse recreation effect of the proposal on the existing recreation setting, without mitigation, will be to limit public access along the bed of the upper Lee River, although access is currently difficult, limited to foot, and used very infrequently.

The key mitigating effect is the improvement in trout habitat in the Waimea River, and the increase in adult trout numbers, as well as minor positive effects on jet boating and kayaking. This may be considered a fair balance, and other developments for recreation will represent an enhancement to the net level of existing recreation amenity in the area.

Short-term effects relate to a minor reduction in water clarity and potential increase in periphyton growth in the Lee River downstream of the dam for the first three to four years of operation. These effects will have minor adverse effects on swimming, although flushing provisions will minimise the effects of periphyton.

The net effect of the proposal on recreation without mitigation is likely to be slight, but potentially positive. Enhancements to recreation amenity may be gained by the management of the reservoir for recreation and via increased recreation access provision to the upper Lee Valley.

7 Tangata Whenua Perspective

7.1 Scope

This section summarises the outcomes that are presented in detail in the accompanying report **"A Management Plan for Lee Valley – A Tangata Whenua Perspective"** by Tiakina te Taiao. The report explores and develops several of the recommendations that were made in the cultural impact assessment undertaken by Tangata Whenua during the Phase 1 investigations.

The report covers:

- The outcome of a taonga survey;
- Desires and opportunities for the management of taonga;
- Development of a harvest management plan for the removal or transfer of native trees and other taonga;
- Assessment of public access issues and options for continued access;
- Determination of potential restoration sites;
- Identification of iwi indicator monitoring sites for monitoring cultural and environmental health.

7.2 Taonga Survey

A taonga survey was carried out in the project footprint area. The survey was of ngahere (native trees), kohatu (stone/minerals, including argillite (pakohe)), birds and lizards.

The ngahere survey identified several compartments of native forest. Timber volumes were estimated for each compartment and for specific tree species. Based on an estimated area of 15 hectares of native forest being affected by the project, the timber volumes for various species were calculated as follows:

- Black beech: $136m^3$
- Red beech (including 1 hard beech): $573m^3$
- Silver beech: $65m^3$
- Rimu: $49m^3$
- Kahikatea: $33m^3$
- Matai (including 1 miro): $146m^3$
- Totara: $3m^3$
- Kanuka: $380m^3$

Pakohe (argillite) was commonly observed in the bed of the Lee River with boulders typically scattered every 50-100 metres, and relatively evenly spread through the riverbed area surveyed. The quality of the pakohe surveyed varied somewhat, with much of it being heavily fractured and considered to be of low quality. There were significant numbers of boulders of high quality particularly below the Lee River - Anslow Creek confluence. With modern tools this quality of pakohe can be made use of.

It is likely that Tangata Whenua would take the opportunity to gather/harvest kohatu (stone/minerals including pakohe) both within and adjacent to the project area. Once the dam is constructed and the reservoir filled, opportunities for kohatu recovery will be reduced.

The other two taonga surveyed (birds and lizards) revealed disappointing results. The iwi members at the time described the area as dead or sterile. There were surprisingly few birds present in the surveyed areas. This may have been due to the time of year or the adjacent forest harvesting. No lizards were found at any site despite suitable habitat being present. Their absence was attributed to the effects of predation by rats and possums.

7.3 Biodiversity Restoration and Management

A list of opportunities has been developed by Tiakina te Taiao for biodiversity restoration and management of the proposed dam and reservoir area. They are purposefully labelled opportunities rather than recommendations, as not all (apart from the first one) are set in stone. They will take into account any other restoration and management opportunities put forward for the project.

The opportunities are as follows:

1. To maintain, enhance, or restore the mauri and wairua of the Lee Valley;
2. To harvest, as part of any salvage operation, taonga species such as indigenous timber, seedlings, kohatu (stone/minerals) that may be inundated by the reservoir or otherwise affected by the project;
3. To enhance or restore the same or greater area of indigenous forest lost under the proposed reservoir footprint;
4. To strengthen current natural ecosystems and ecological functions within the catchment in general and more specifically within the vicinity of the reservoir;
5. To manage and harvest on a long-term basis some taonga species such as timber, eel and harakeke;
6. To reduce the number of pest animal species within the catchment in general and more specifically within the vicinity of the reservoir;
7. To build into the project funding mechanism for the ongoing maintenance of restoration efforts and the management of biodiversity;
8. To allow for the passage of fish and eels past the finished dam;
9. To maintain public access rights to Mt Richmond Forest Park as well as provide access for the management of biodiversity within the catchment;
10. To establish and maintain scientific and cultural monitoring sites.

7.4 Harvest Plan

There are three items of interest in terms of harvest: ngahere (trees), seedlings, and kohatu (stone/minerals including pakohe (argillite)). The harvest plan outlines the possibility of harvesting these items. It is noted that for water quality reasons vegetation is likely to be cleared in the reservoir footprint area regardless of the harvest of taonga.

Access into the area for harvest is reasonably good, albeit that access over private land would need to be negotiated. The taonga survey identified approximately 15 hectares of harvestable native trees. Some of this is on land that is currently privately owned and at this stage it is unclear whether the land (assuming it is purchased for the project) would be cleared by the existing owners prior to sale.

The harvest plan identifies the compartments, and assesses access requirements as well as harvest methods.

There are plenty and a good range of seedlings of native tree species in some compartments. These could be wrenched several months prior to removal, and relocated.

Most of the best pakohe is located downstream of the proposed dam site, and therefore does not fall within the project footprint. Much of the rest of the pakohe within the footprint is either too large to move easily or is of low quality. However there are some good quality boulders around and upstream of Ch 14,000m that have reasonably easy access and would be worth retrieving.

7.5 Potential Restoration Sites

Fourteen sites have been identified for potential restoration. They have been chosen based on the number of hectares that should be restored, proximity to the reservoir, proximity to vehicle access, proximity to reasonably intact ecosystems, slope instability, slope, connectivity/bird pathways.

Opportunities for wetland development were also explored. However due to the lack of flattish land around the edge of the reservoir, this is unlikely to be easy, and an alternative solution is to see if and where wetlands develop naturally and enhance these areas.

7.6 Monitoring

Six indicator sites for monitoring of cultural and environmental health have been identified within the catchment of the reservoir. The choice of locations is linked to sites where biodiversity could be actively managed. The sites will be monitored at regular intervals in order to detect changes in environmental health of the reservoir and river valley.

8 Environmental Enhancement Opportunities and Outline Mitigation Plan

8.1 Scope

This section summarises the outcomes that are presented in detail in the accompanying technical report "**Enhancement Opportunities Scoping Plan**" by Tonkin & Taylor. The report presents the results of an assessment of environmental enhancement and mitigation investigations.

The primary objective of this work has been to identify potential or actual environmental effects (both positive and negative) based on the specialist studies reported in the previous sections of this report, identify environmental enhancement options, and outline management considerations for recommended initiatives in order to provide adequate mitigation to compensate for any potential or actual adverse environmental effects of the proposed water augmentation project. The report describes a proposed management framework, restoration principles, and key ecological design issues to consider. It also recommends timeframes for putting these in place.

The information has been derived from the technical reports regarding the potential effects of the proposed development on ecological, recreational and cultural values. A workshop was held with members of WWAC, and staff of DOC and Fish & Game to identify constraints and opportunities that can be applied for this enhancement plan. Discussions were also held with technical specialists from DOC and independent experts regarding biodiversity management options for providing compensation of values removed from the proposed development site.

Information from these discussions that has assisted with developing mitigation opportunities includes:

1. Land tenure and the ease of land purchase in strategic areas surrounding the proposed dam and reservoir;
2. Best practice mitigation including keeping mitigation local and replacing like-for-like environments;
3. The relative merits of site-orientated enhancement now compared to development of a financial fund of equivalent value which will direct expenditure of mitigation in the future;
4. Biological and management constraints and opportunities for vegetation community and species- orientated management; and
5. Calculation tools for estimating the financial value of sites based on relative ecological value.

The work considers mitigation and offset compensation. The distinction between the two follows definitions from international literature as follows:

- **Mitigation** – minimisation of adverse effects of a proposed development by the adoption of practices or processes within the development area to reduce the overall adverse effect;

- **Offset compensation** - also widely called 'mitigation compensation' in New Zealand. Offsets are defined as 'Conservation actions intended to compensate for the residual, unavoidable harm to biodiversity caused by development projects, so as to ensure a no net loss of biodiversity'.

The scoping plan provides an indicative framework and programme for mitigation and offsets for the scheme design described in the technical reports. The plan is neither final nor is it formally agreed by the various stakeholders who have contributed information and technical advice. Rather it has been developed to agree a general approach and to enable an indicative cost to be identified that can be incorporated in the financial modelling for the overall project. The details of the plan are expected to be confirmed and agreed at later stages of the project. The discussions undertaken to date are without prejudice on the part of all parties (WWAC, DOC and F& G).

8.2 Effects of the Proposed Project

The potential environmental effects of the project are summarised in the "Enhancement Opportunities Scoping Plan", based on the information in the preceding sections of this report. They cover the following subject areas:

- Vegetation
- Birds
- Lizards
- Bats
- Reservoir water quality
- Instream habitat
- Flushing flows
- Fish
- Cultural values
- Recreational values.

8.3 Mitigation and Offset Approaches

The proposed mitigation and offset opportunities incorporate the following best practice principles:

1. Design, management and methodologies should be investigated that avoid, minimise and mitigate potential adverse effects on site before considering the need for offset compensation outside of the immediate project footprint. For this project, design considerations for the dam and operating regime of the reservoir provide the means to minimise or mitigate many of the potential adverse effects on aquatic systems. Other mitigation proposed includes salvage of plants, merchantable timber and argillite as cultural materials for iwi;
2. Where offset compensation is required, offsets should be undertaken locally where possible. Offsetting at remote sites should only be considered if no feasible opportunities exist within the general project area;

3. Mitigation and offsets should use methods that have been tried and tested elsewhere with a high probability of success (i.e. low risk of failure). For this project, techniques include baseline flows, fish pass construction, pest plant and animal control, plant relocation and propagation, and forest establishment through tree planting. All of these techniques have been used elsewhere in New Zealand, often over many years, with established track records of success;
4. The new values created by offsets should be similar to the values removed i.e. offsetting should replace like with like values; and
5. Offsetting, where required, should be based on a transparent and robust framework that provides quantification of adverse effects and values achieved through compensation.

The timeline for this project is likely to follow that typical of most projects in New Zealand, where offset mitigation is implemented following the construction process. This means that opportunities to provide offset compensation ahead of the removal of ecological values are limited. As a result, the time gap that will likely result between the loss of existing values and the maturation of offsets (e.g. planted trees) and their ability to provide replacement values to those removed needs to be recognised in the offset calculation methodology.

For each of the offset mitigation areas and types of opportunity identified in the following sections, there are potentially many different outcomes that will each satisfy the need for a required level of compensation. The opportunities presented here represent the results of discussions with WWAC and stakeholders which have narrowed the range of options to those which best satisfy the needs for local and like-for-like compensation and which take into consideration additional issues such as land tenure, access, economic cost-benefit and social and cultural considerations. WWAC have indicated that, where offset compensation cannot feasibly be achieved within the project area, the creation of a compensation fund may be warranted based on the proposed scale of offsets required. The fund would used to achieve offset compensation in keeping with the intention of the offset principles in areas of identified conservation priority outside of the project area.

8.4 Aquatic Mitigation and Offsets

The majority of aquatic ecology effects of the proposed development have been able to be addressed and incorporated as mitigation measures within the design of the proposed dam and reservoir management regime.

Mitigation measures that are included as part of the dam and reservoir design, and which provide mitigation within the footprint or compensation due to flow-on benefits elsewhere are as follows:

- Augmentation of flow downstream;
- Manual transfer of logs etc during large flow events;
- Variable height water offtake structures;
- Provision for flushing flows;
- Construction of fish pass;
- Preparation of Construction Management Plan.

The creation of the reservoir, restriction of fish passage and changes in the flow regime downstream of the proposed dam potentially have positive and negative effects on instream habitat availability and aquatic life. In summary, most species are predicted to benefit from the storage scheme. The main exception is redfin bullies, which tend to like slow shallow water and thus will not benefit from enhanced minimum flows in the lower reaches of the river. Redfin bullies will also be unlikely to negotiate the fish pass and occupy habitat above the dam.

8.5 Terrestrial Mitigation and Offsets

The majority of terrestrial ecology effects of the proposed development are addressed as offset compensation measures as the construction and operation of the dam and reservoir offer few benefits for terrestrial ecology within the development footprint.

8.5.1 Wildlife Habitat

8.5.1.1 Mitigation measures

1. Undertake vegetation clearance outside of the peak bird breeding and nesting season (October – February);
2. Obtain cuttings, seed and, where appropriate, wild seedlings for propagation and raising in a nursery for future planting into offset compensation planting sites around the proposed dam and reservoir.

8.5.1.2 Offset compensation measures

Priorities for the control of weed and animal pests are:

1. Removal as far as possible of ecological weeds and pest animals (including possums, feral deer, goats and pigs) over a land area of 110 ha surrounding the proposed reservoir, dam site and downstream to Lucy Creek.

8.5.2 Vegetation Communities

8.5.2.1 Alluvial Forest

Priorities for offsets to compensate for the removal of this vegetation type are:

1. Enhance the quality of the existing alluvial forest at Site 1 below the dam;
2. Restore the alluvial flat upstream of Site 1 currently planted in Douglas fir to alluvial forest;
3. Enhance the quality of the alluvial flat upstream from Lucy's Creek;
4. Plant new alluvial forest at suitable sites downstream from the dam, such as on the Wairoa River and Waimea lowlands;
5. Assist landowners with the restoration of alluvial forest on private land.

8.5.2.2 River-bed Island Forest

There are no potential sites within the vicinity of the development for offset mitigation. The best opportunity for offset mitigation is off-site as part of river restoration projects elsewhere in the region.

Priorities for offsets to compensate for the removal of this vegetation type are:

1. Plant new river-bed island forest at suitable sites elsewhere on the Lee or in suitable areas elsewhere in the region.

8.5.2.3 Riparian Forest

Priorities for offsets to compensate for the removal of this vegetation type are:

1. Enhance the quality of the riparian margin from the proposed dam to Lucy Creek, including the regenerating indigenous forest at the confluence of the Lee River and Lucy Creek and including a buffer zone around the patch of pine plantation reverted to indigenous forest;
2. For the area of riparian margin described in Priority 1 above, change the land tenure to public conservation land and add this area to the Mt Richmond Forest Park;
3. Plant and restore the buffer area of land around the proposed reservoir to indigenous riparian forest;
4. Plant new riparian forest at suitable sites downstream from the dam or in suitable areas elsewhere in the region.

8.5.2.4 Hill Slope Forest

Priorities for offsets to compensate for the removal of this vegetation type are:

1. For the removal of 3.4 ha of public conservation land within the Forest Park, offset compensation is proposed as the purchase and addition to the Forest Park of approximately 10 ha of remnant matai forest and plantation forest. Plant hill-slope beech forest within the areas of plantation forestry following their removal. Undertake weed and pest animal control through the area for 15 years to assist with the establishment of planted indigenous forest;
2. For the removal of 6.5 ha on private land, part of the offset compensation is proposed as the planting of hill-slope indigenous forest over the approximately 5 ha of cleared pine forest used for construction and borrow areas associated with the construction of the dam.

8.5.2.5 Gorge Flood-Zone Turf Communities

Priorities for offsets to compensate for the removal of this vegetation type are:

1. Monitor the potential adverse effects of the dam on the persistence of flood-zone turf communities downstream from the dam;
2. For the removal of 0.84 ha on public conservation land, restore riparian margin forest downstream of Lucy Creek and change the ownership of this land to public conservation land and add it to the Mt Richmond Forest Park.

8.5.3 Threatened Plant Species

8.5.3.1 Shovel mint

This species is of greatest conservation significance within the proposed development area, with a significant portion of the known population in the Lee River proposed to be removed by the dam and reservoir. The Lee River population around the proposed development site likely represents the greatest area of shovel mint known to exist (anywhere) and therefore even its partial loss is of great significance.

Priorities for offsets to compensate for the removal of shovel mint populations are:

1. Within the 2.5 km riparian margin and alluvial flat areas from the dam to Lucy Creek, improve shovel mint habitat by removing weeds and controlling pigs, goats and deer to low levels;
2. Trial planting of new populations in the Priority 1 site using stock rescued from inundation areas;
3. Secure genetic stock from the inundation areas, propagate and undertake trial plantings in areas of suitable habitat that are created or managed as recipients of the monies used to create the off-site compensation fund.

8.5.3.2 Sand coprosma

This species is of moderate conservation significance although populations exist elsewhere in the Nelson region and elsewhere in New Zealand. The area of sand coprosma that is proposed for removal represents all of the known individuals in the Lee River catchment found during studies associated with this dam.

Priorities for offsets to compensate for the removal of the sand coprosma population are:

1. Secure genetic stock (seeds, cuttings) from all known individuals within the inundation area;
2. Trial plantings of cultivated stock within the restoration area from the dam to Lucy Creek. Monitor the results of the trials;
3. Survey adjoining catchments (e.g. Roding and Wairoa) for suitable habitat in which sand coprosma could be planted without obvious commitments to ongoing management of weeds. Monitor the results of the plantings;
4. Identify potentially suitable planting sites in adjoining catchments which may require site preparation (e.g. weed removal) and ongoing weed control to establish populations of sand coprosma.

8.5.3.3 Euchiton polylepis

Little is known of the distribution of this At Risk species, although it is likely that the proposed development will remove populations along part of the Lee River.

Priorities for offsets to compensate for the potential removal of *Euchiton polylepis* populations are:

1. Survey for *Euchiton polylepis* in other areas of the Mt Richmond Forest Park.

8.5.3.4 Scented broom

The population of this species in the vicinity of the Lee dam and reservoir is regarded as being of regional significance. While a part of this population will be removed under the proposed development, a large portion will not be removed.

Priorities for offsets to compensate for the potential removal of scented broom populations are:

1. Collect seed and cuttings from scented broom within the proposed development area and include as part of the plant-raising programme.

8.5.4 Threatened Animal Species

There are currently no threatened animal species within the development footprint that will be directly affected.

Priorities for offsets to compensate for the removal of foraging and potential nesting habitat for NZ bush falcon are:

1. Plant replacement indigenous forest as future nesting habitat and control possums to low levels over the project area to improve potential food supplies for falcon.

Should bats be found within the proposed development footprint, the following measures could be considered as mitigation and offset compensation:

1. Survey large trees within the footprint to establish the presence or absence of bats prior to vegetation clearance; and
2. Clear vegetation outside of the bat breeding season, and confirm the likely absence of bats from sites prior to clearance; and
3. Undertake possum and rat control over the area encompassing the reservoir and dam surrounds, and the downstream corridor to Lucy Creek in order to improve the habitat quality, food supply and opportunities for successful breeding by bats.

8.5.5 Recreation

No significant adverse effects are predicted on the recreational values of the Lee River from the project. Rather, a net benefit is predicted for recreational users of the Waimea River and lower Lee River through the improvement in downstream flow rates.

No offset mitigation is proposed, although enhancements for recreation access to and beyond the reservoir have the potential to increase the net benefit of the proposal beyond that required for mitigation.

8.5.6 Cultural Values

The ecologically-based concerns over cultural effects are addressed by the preceding mitigation initiatives for aquatic systems and offset compensation measures for terrestrial ecology.

The remaining outstanding issues of access and cultural harvest of argillite and merchantable trees are addressed as follows:

1. To retain the potential for public access to the upper Lee catchment, create a buffer strip of vegetation along the perimeter of the proposed reservoir. There is an intention to provide this as part of the ecological buffer to the proposed reservoir;
2. Iwi have indicated that they may wish to salvage up to 20-30 tonnes of argillite, mostly from the area around the proposed dam, prior to the start of construction works. Access for iwi to salvage argillite blocks from the footprint of the project should be facilitated;
3. Iwi have indicated that they wish to harvest up to 2,000 m^3 of merchantable timber from the project footprint prior to the start of vegetation clearance. The salvage of this timber should be facilitated within the footprint below the gorge prior to the

start of vegetation clearance works. For the proposed inundation area above the gorge, merchantable timber may be easier and less expensive to salvage once the reservoir is filling by using a barge or floating it to a vehicle access point further down the reservoir.

9 Enhancing the Distribution of Water

9.1 Scope

This section summarises the outcomes that are presented in detail in the accompanying report "**Enhancing Water Distribution from the Waimea Water Augmentation Project**" by Landcare Research and AgFirst Consultants Nelson.

The conclusion reached in Phase 1, and upon which Phase 2 investigations have been based, is that the most economic and environmentally acceptable system of water distribution would be to release and allow stored dam water to flow down to the Plains in the existing river bed. From here some of the extra flow will infiltrate into the three river-connected aquifers to replenish depleted aquifer storage.

However it was also recognised that a run-of-river scheme would require water users on the Waimea Plains to be able to access water released from the Lee dam and into the Wairoa and Waimea rivers. Without reticulation, water users would need to access the additional river flows either via groundwater bores (where the groundwater yields were enhanced or maintained by flow release from the reservoir) or direct river takes (for example, via the Waimea East Irrigation Company or TDC reticulation).

In Phase 2 a scoping investigation was undertaken of water distribution infrastructure that may be needed to make the augmented river flows and groundwater resources available to all potential water users within and adjacent to the Waimea Water Augmentation Service Area.

In summary, the purpose of the water distribution assessment has been:

1. To map the 'zone of effect' in the Waimea Plains aquifers for proposed flow releases from the Lee Valley dam;
2. To identify areas outside the 'zone of effect' which may require water distribution reticulation, quantify the areas involved and identify possible pipeline routes;
3. To provide, for each area, an indicative costing for water reticulation which would supply water at pressure to the 'farm gate', based on updated costings from similar local water schemes;
4. To comment on other opportunities to enhance water distribution within the service area.

9.2 Zone of Effect for Released Water

The response of the groundwater system to the augmented river flows was modelled and compared with the system without the augmentation scheme to determine the 'zone of effect' of the augmentation. That showed the areas that are expected to be able to access water through existing or new groundwater bores or through new river pumping.

The 'zone of effect' essentially comprises the parts of the aquifers:

- Where increased river flow is predicted to raise the water table or piezometric levels of the aquifers during a design drought year; or
- Which already have adequate well yields (even if the water table is not projected to rise); or

- Which have adequate reticulation to supply part of the projected water demand (for example, the Waimea East and Redwoods Valley irrigation schemes).

The 'zone of effect' comprises mainly the Appleby Gravel Unconfined Aquifer plus the Waimea East Irrigation Company irrigation area. Its indicative extent is shown on Figure 9.1 (Note: the dashed lines show areas where the boundary may be adjusted slightly, based on knowledge of actual well yields). For the north-eastern shaded area, provision of improved access to water is likely to be restricted to existing bores only (predominantly within the Upper Confined Aquifer and Lower Confined Aquifer), although further investigations may conclude that additional bores within these boundaries (but away from the coast) would also be able to be approved as benefitting from the augmentation scheme.

Six 'distribution areas' that are **outside** this 'zone of effect' and that are amenable to additional reticulation infrastructure have been identified. These are:

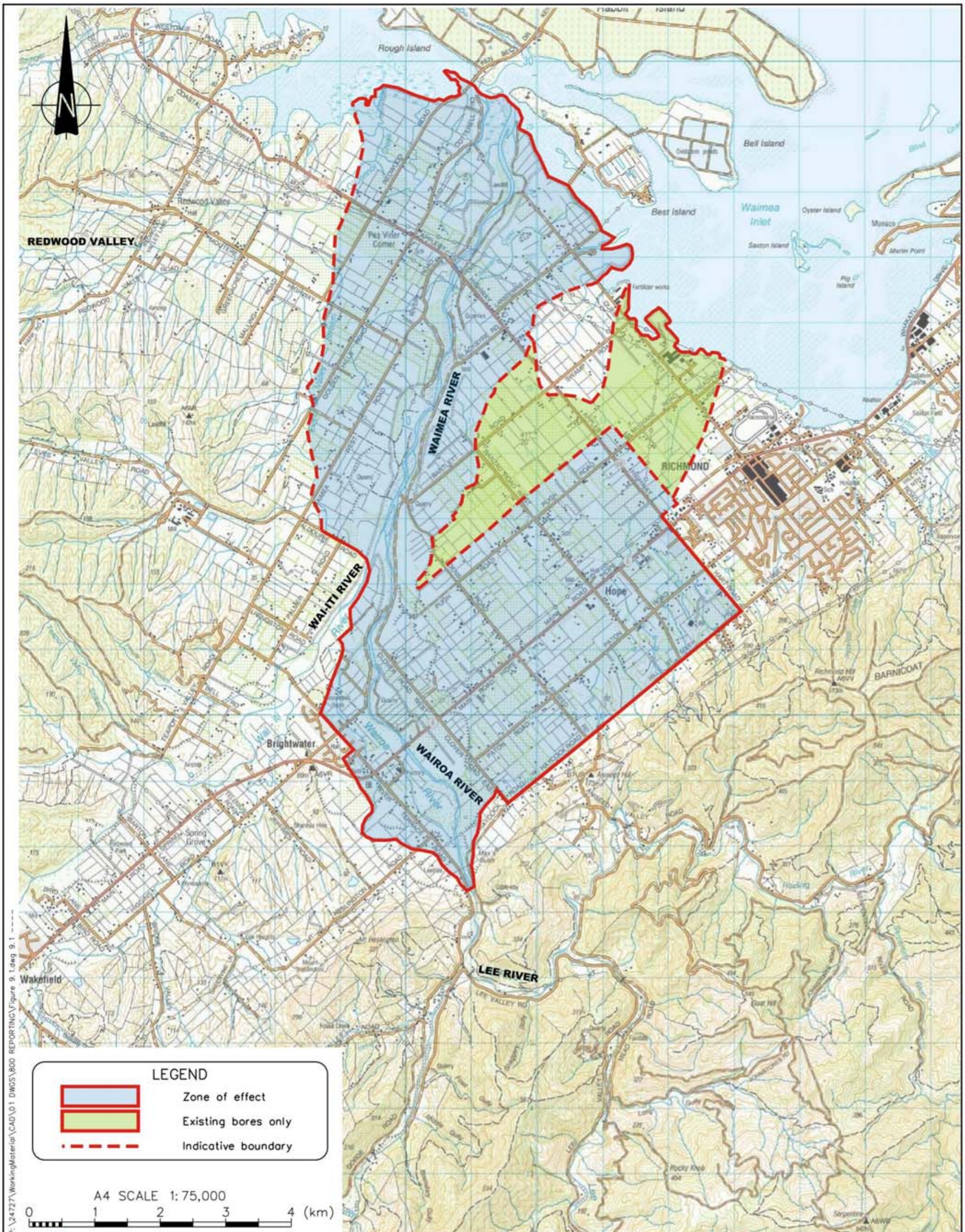
1. 300 ha in the lower Wai-iti Valley;
2. 625 ha in the Redwood Valley/Waimea West area;
3. 250 ha on Rabbit Island;
4. A smaller area (about 120 ha not currently irrigated) west of the proposed Richmond West town extension (from McShane Road to just west of Swamp Road);
5. 50 ha at the southern end of Haycock Rd;
6. Potential regional water demand for use beyond the proposed service area.

9.3 Distribution Systems and Cost Estimates

Options have been identified for providing reticulation to pump water to these six distribution areas outside the zone of effect. This included identifying a conceptual mainline layout in order to assess the off-farm costs for providing pressurised water to the farm gate.

The total irrigable area within these distribution areas is 1275 hectares, which is 22% of the 5850 hectare area assessed as irrigable from the scheme. Capital costs for irrigation distribution (which would need to be added to the overall per hectare capital cost of the scheme for those users outside the 'zone of effect') within the six distribution areas range from $1,500 per hectare to $5,900 per hectare, and average $4,700 per hectare.

The implications of these costs are addressed in Section 12.



Tonkin & Taylor
Environmental & Engineering Consultants

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WAIMEA WATER AUGMENTATION COMMITTEE

WAIMEA WATER AUGMENTATION – PHASE 2

INDICATIVE 'ZONE OF EFFECT' FOR ACCESS TO AUGMENTED WATER SUPPLY

FIG. No. FIGURE 9. 1 REV. 0

10 Water Allocation and RMA Issues

10.1 Scope

This section summarises the outcomes that are presented in detail in the accompanying report "**Water Allocation Options and Resource Consents**" by Landcare Research and Tonkin & Taylor.

The report:

1. Canvasses options for initial and ongoing allocation of water among consumptive users;
2. Suggests ways to encourage efficient and sustainable use of allocated water;
3. Summarises the likely resource consent requirements under the Resource Management Act (RMA) for gaining approvals for the scheme to proceed;
4. Identifies potential changes that may need to be made to the Tasman Resource Management Plan (TRMP) to appropriately provide for scheme components and facilitate ongoing operation of the scheme.

10.2 Water Allocation

The proposed water augmentation scheme will release water from the dam into the Lee River to augment the natural flow of the Wairoa and Waimea rivers, for two purposes:

1. Consumptive water use by irrigation, industry and urban users, including an allowance for future water demand. This component of the flow equals about 70% of the water released. This consumptive portion can be further divided into water available within the 'Zone of Effect' and that available for consumption further from the rivers only with additional water distribution infrastructure (see Section 9);
2. Enhancement of environmental flows within the Wairoa and Waimea rivers. This component of the flow equals about 30% of the water released. The management objective is to improve low flows by maintaining a minimum flow of 1100 l/sec in the Waimea River at Appleby Bridge. This non-consumptive portion can be divided into the flow and water quality requirements for the various values and uses from the Lee Valley dam down to the Waimea Inlet.

The following principles should guide design of a water allocation system, whether for a catchment or a reticulated water scheme. The proposed scheme has elements of both:

- Efficiency, comprising *allocative efficiency* (the water resource is allocated in a way that allows the maximum possible nett benefit from its use, i.e. optimal allocation of uses), *productive or technical efficiency* (maximum output from a given set of inputs, i.e. best practice), and *dynamic efficiency* (achieving an efficient allocation of resources over time, i.e. adaptive);
- Equity, meaning that all those who benefit from the scheme contribute to its cost in proportion to the benefits they receive;

- Adaptability, meaning the scheme should be managed so its operation can adapt to changing returns from the various water uses, and to changes in community preferences for the water;
- Consistency where possible with current water allocation practice, because that is what existing water users are familiar with.

10.3 Scheme Participation

WWAC has indicated a preference that the scheme owner holds the resource consents for the taking and use of the water on shareholders' land. This is similar to the existing Waimea East Irrigation Company structure. WWAC has also indicated a preference for a governance arrangement based on a community-owned scheme managed by a board of water users and relevant representatives (see Section 11). This would imply an allocation structure with shareholders owning and liable for the costs of saleable shares of the consumptive 70% allocation.

Implementation of the water augmentation scheme will bring a transition from the current arrangement that some properties hold a water permit allowing them to take and use water, and others do not. It is envisaged that the TRMP would be changed to facilitate this transition from existing water permits into the scheme.

WWAC has indicated a preference that there should be mandatory membership of the scheme and allocations of water to landowners within a prescribed zone. Twelve options have been identified for initial and ongoing allocation of the consumptive water component of the scheme. Based on WWAC's indicative preferences, the following options warrant further discussion:

- Option 1: Mandatory allocation of and payment for irrigation water for irrigable land on land parcels exceeding 1 hectare within a prescribed 'zone of effect' for water released from the reservoir;
- Option 7: A second tier allocation and charging regime within the catchment boundary but beyond the Zone of Effect of released water;
- Option 8: The option for investors such as iwi, electricity generators, forestry companies, construction companies, or private investors to hold and trade allocations, or alternatively to fund specific infrastructure components on a commercial basis;
- Option 9: For ongoing flexibility of allocation, to facilitate transfers of allocations to water users, along with cessation of 'bona fide reviews' which currently allow the unexercised portions of water permits to be cancelled by TDC.

10.4 Efficiency of Water Use

If WWAC wishes to hold consents for use of water by scheme shareholders, it will need (for consent application purposes) to demonstrate how the scheme will achieve efficient and sustainable use of scheme water. Scheme water would include both release of stored water as well as the component of natural flow allocated to consumptive users.

As used in other recent irrigation scheme proposals, the scheme could meet these obligations through:

- A sustainability protocol: This could summarise how water users are required to achieve and demonstrate efficient and sustainable use of allocated water. Elements may comprise irrigation management to assure efficient use, soil management, nutrient management to minimise nutrient losses, and relevant riparian and biodiversity management;
- Individual water use plans: At a minimum, water use plans for irrigators would require best practice irrigation management approaches to be followed. For example, such as soil moisture monitoring to schedule irrigation, monitoring of actual water used (likely via meters, as at present), avoidance of drainage losses and remedying of breakdowns to prevent wastage.

10.5 RMA Implications

An initial assessment has been undertaken of the likely resource consents required for the scheme under the RMA. The resource consents required for the scheme can be divided into the two phases of the scheme: construction, and ongoing operation and maintenance.

In addition, an assessment has been undertaken of the potential changes that may be needed to the TRMP to accommodate the scheme.

10.5.1 Resource Consents Required for Construction of the Scheme

In summary resource consents will be required for:

- The temporary diversion of water;
- The temporary damming of water;
- Temporary structures in the riverbed and associated disturbance of the riverbed (the coffer dams and diversion culverts);
- The construction of the dam in the riverbed, and the associated disturbance of the riverbed;
- The placement of fill material for construction of the dam;
- Discharge of sediment from earthworks activities and construction of the dam;
- Discharge of washwater;
- Discharge of dust to air;
- Land disturbance and vegetation clearance within the Rural 2 Zone;
- Vegetation clearance within the Conservation Zone;
- Taking of water from the Lee River for use during construction

10.5.2 Resource Consents Required for Ongoing Operation and Use of the Scheme

In summary resource consents will be required for:

- The operation and ongoing maintenance of the dam and reservoir within the riverbed, including use and disturbance of the riverbed;
- The diversion of water;

- The damming of water;
- Discharge from the reservoir and discharges via the spillway;
- Subdivision of existing land titles for the dam and reservoir;
- The taking and use of water released by the scheme.

10.5.3 Potential Changes to Tasman Resource Management Plan

Changes will be needed to Part V of the TRMP to accommodate the water augmentation scheme.

It is not considered appropriate (nor probably necessary) to seek to change existing water allocation policies, apart from the more administrative issues.

Policy changes may be needed to:

- Formally recognise the status and ownership of the augmentation scheme;
- Update interim policies aimed at preventing increased water allocation;
- Make any changes to the security of supply targets for the scheme.

Changes to rules will be needed to reflect the new information on appropriate minimum flows that can be achieved and the new hydrological regime that the scheme will deliver. This gives the ability to enhance the values of the river. Specific changes required will be to:

- Implement the increased minimum flow in the Waimea River;
- Increase allocation limits (potentially in all water management zones), and
- Link allocation to payments for the scheme.

11 Ownership Structure

WWAC commissioned Northington Partners Limited (investment bankers) to identify options with respect to the ownership structure and charging regime for the proposed water augmentation scheme. Northington Partners have provided the following information (pers. comm.).

In broad terms, there are three alternative structures that may be adopted:

1. Entity Owned by Water Users: All scheme assets are owned and operated by a limited liability, community-based entity. The ownership and capital contribution for the scheme construction is based on expected water usage by all users, including irrigators, domestic and industrial users, and other “community” users as reflected by environmental flows;
2. Entity Owned and Operated by a Third Party on a Commercial Basis: The scheme assets are owned and operated by one or more entities on a commercial basis. Long-term access to water by all users is contractually secured, with water charges structured to include an allowance for a commercial rate of return on the investment in Scheme assets;
3. TDC Owned and Operated: All scheme assets are funded and owned by the TDC on behalf of the water users. All capital and operating costs are recovered from water users via a targeted rate for irrigators and through the general rating base for regional and environmental uses.

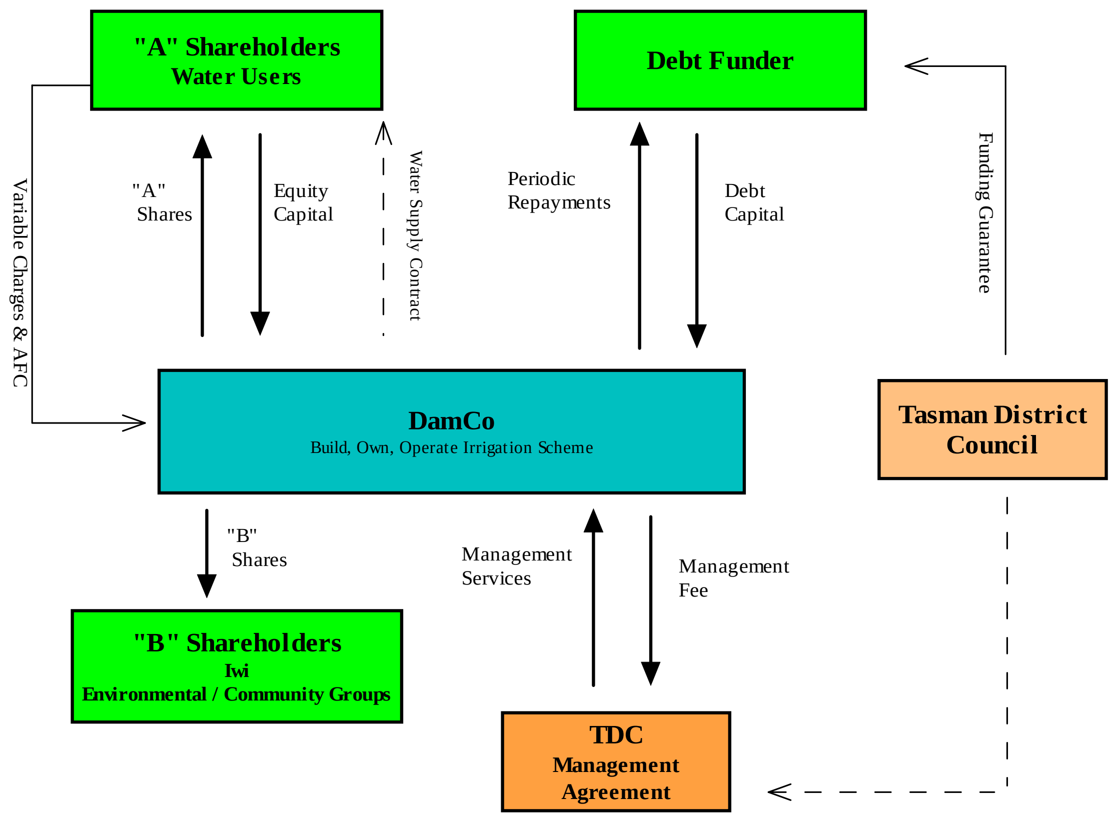
WWAC has advised that the key objectives and requirements of the adopted ownership structure are as follows:

- The scheme should be operated on a cost recovery basis;
- Ultimate control over access to the water should vest in all water users, including the consumptive and environmental users;
- An allocation of the capital and operating costs should be made for environmental flows, broadly reflecting the incremental cost of building a larger storage reservoir than that needed to meet consumptive demand;
- All remaining capital and operating costs should be shared between consumptive users on the basis of water demand. Costs allocated to the urban and industrial demand within Tasman District would be met by the TDC, and future regional demand would be met by another party.

Considering the likely objectives and requirements of all potential stakeholders in the scheme, it became apparent that Option 1 (a limited liability entity owned by the water users) would be likely to represent the most appropriate structure.

Accordingly, it was agreed that an initial assessment should be made of Option 1 as the basis for further discussion. If it is subsequently determined that this framework does not adequately meet the objectives of the stakeholders, then the remaining alternatives can be further explored.

The following diagram sets out the potential framework for the entity that will own the scheme assets. For convenience, the entity is nominally called “DamCo”.



Key features of the recommended structure for each group of stakeholders are as follows:

- The entity is owned and controlled by the "A" shareholders, with each shareholders' ownership stake based on the proportional water usage. The TDC and/or other third party is expected to own shares representing the projected urban, industrial, and regional water demand volumes as well as the environmental flows;
- The agreed proportion of the total capital cost for environmental flows is funded by the issue of "B" shares;
- Iwi and other environmental groups are issued "B" shares at a nominal price. The "B" shares provide these groups with protection against specified future activity via the entity's Constitution;
- The scheme capital cost is funded via equity capital from the "A" shareholders and external debt funding. The debt repayment term is set to match the life of the initial resource consent;
- In exchange for a water supply agreement with DamCo, all "A" shareholders commit to paying a pro-rata share of the entity's operating costs and an Annual Fixed Charge ("AFC") which is designed to meet DamCo's external debt servicing requirements;
- The TDC is contracted to provide administration and management services for the scheme at an agreed annual charge;
- The TDC guarantees DamCo's debt (potentially in exchange for an annual fee).

12 Financial Modelling

12.1 Scope

This section summarises the outcomes that are presented in detail in the accompanying report by Northington Partners **"Financial and Economic Assessment of Water Augmentation"**.

A high-level economic analysis of the proposed development has been undertaken on the basis of the following three factors:

- Capital Cost of Augmentation: The capital cost of the proposed augmentation option is estimated on a per hectare basis. Total capital costs are also expressed as an equivalent annual charge per hectare. Costs expressed on this basis can be used as a convenient benchmark for assessing the affordability of the proposed scheme.
- Cost Benefit Analysis for Irrigation Users**:** Water resources on the Waimea Plains are currently over-allocated. Without an investment in storage for augmentation, both the current volume of allocation and the security of allocation for existing water users will continue to be threatened and new users' water demands will be unable to be accommodated. There is also the potential that a minimum flow could be imposed on the Waimea River system under the Resource Management Act (RMA), either through the Tasman Resource Management Plan (TRMP) process (and associated decisions including potentially courts of law) or through the imposition of a national environmental standard.

  Accordingly, for the purposes of this assessment, it has been assumed that irrespective of whether or not the scheme goes ahead, there is a requirement maintain a minimum flow in the Waimea River at the Appleby Bridge to 1,100 l/sec, based on the ecological assessments undertaken for this project. This would result in existing users either having their allocations cut back, or being subject to more frequent rationing. A high level assessment has therefore been undertaken of the effect on water users under both these scenarios. The financial impact of the restrictions can be compared directly to the indicative charges levied to irrigators to determine whether their investment in the scheme is financially worthwhile.
- Regional Impact of Non-Augmentation: If the scheme does not proceed, restrictions on access to water will reduce agricultural and horticultural output from the area, not only from existing irrigators but also from the adjoining dryland areas that could potentially be serviced by the scheme. The region will also be affected by the 'lost opportunity' cost associated with the inability to meet future demand from urban and industrial uses that is currently allowed for in the scheme design.

Water demand and the required dam storage volume have been estimated on the basis of "hectare equivalents", with the benchmark based on demand for pasture production with an assumed requirement of 30 mm/ha/wk. This standardisation process takes account of the differing water volumes required for different land uses, as well as allowing the demand for future urban and industrial uses to be expressed on a consistent basis with irrigation demand.

The assumed area equivalents for the analysis are set out in Table 12.1.

Table 12.1 Assumed Water Demand

Water Demand Component	Gross area (hectares)	Area Equivalent (hectares)
Existing Irrigation Area – Waimea Plains	3800	3800
Potential new irrigation area – Waimea Plains	1500	1500
Potential new irrigation area – Wai-iti	300	300
Potential new irrigation area – Rabbit Island	250	250
Existing TDC Urban and Industrial Use	NA	620
Allowance for Future TDC Urban and Industrial Use (100 years)	NA	780
Allowance for Future Regional Supply	NA	515
Total	5,850	7765

For this analysis, indicative capital costs have been allocated between potential users on the basis of the estimated number of area equivalents.

12.2 Financial Assessment of Augmentation Scheme

12.2.1 Introduction

The financial implications for water users were assessed for a range of cases as follows:

- The indicative costs for water users for the "Design Base Case"; ie a water supply reservoir with a storage volume of 13 million m^3. Within this case annual costs under various scenarios were assessed, related to the assumed number of water users;
- The impact on the indicative costs to water users if provision is incorporated in the scheme for hydro-power (as well as water supply);
- The impact on the indicative costs to water users if reductions are made to the reservoir storage volume on the basis that the scheme is redesigned to service a smaller number of users.

12.2.2 Indicative Costs for Water Users – Design Base Case Results

Indicative charges for prospective users of the augmentation scheme have been determined using a series of high level assumptions. Key assumptions are outlined in Table 12.2.

Table 12.2 Design Base Case assumptions for economic analysis

Assumption	Discussion	Adopted Value
Total capital cost	Includes: • Design and construction of the dam and associated structures - $38,100,000 • Allowance for land purchase and access replacement - $2,000,000 • Environmental mitigation package - $1,000,000 • Obtaining resource consents - $500,000 Excludes any costs associated with distribution infrastructure. For any percentage change in capital costs the indicative annual charges will change by about the same percentage amount.	$41,600,00
Construction period		2 years
Funding method and cost	Assumed 25 years	7.2%
Taxation treatment	Standard corporate tax regime	
Operating costs	Per year	$400,000
Cost allocation of environmental flows	Represents an indicative cost split between consumptive (abstractive) uses and non-consumptive (instream/environmental) uses. The incremental storage capacity required for environmental flow reasons is 3.8million m^3 which is equivalent to approximately 30% of the overall storage volume.	30%

Indicative charges are expressed on the basis of total capital cost per hectare as well as an equivalent annual charge per hectare. Initially, estimates have been determined for the following three charging scenarios:

1. **Scenario 1: User Base Case:** Costs are assumed to be met by existing irrigators, the TDC (for both its present and future consumptive demand), as well as other landowners who are within the "Zone of Effect" who do not currently have a water permit. The total User Base Case therefore consists of current irrigators (3,800 ha), the un-irrigated area within the Zone of Effect (in the order of 475 ha out of the 1500 ha on the Waimea Plains), existing TDC urban and industrial use (620 ha), and the allowance for future TDC urban and industrial use (780 ha). This is the area equivalent of apportioning costs over 5,675 hectares.
2. **Scenario 2: User Base Case Plus Future Regional Supply:** All costs are met by User Base Case consumptive water users (5,675 hectares) and the entity

responsible for future regional supply (515 ha). Total effective demand equals 6,190 hectares.

3. **Scenario 3: All Potential Users:** Annual charges are estimated on the basis that the capital cost is evenly allocated among all users listed in Table 12.1. Total effective demand equals 7,765 hectares.

Assuming 70% of total cost is met by consumptive users, the indicative capital costs and annual charges for each of the three scenarios are presented in Table 12.3. Table 12.3 presents two options for charges to water users: either a one-off payment (Capital Cost per Hectare) plus an Annual Operating Charge, or an overall Annual Charge (Fixed and Operating). The Annual Fixed Charge would apply for the term of the repayment period (assumed to be 25 years). The Annual Operating Charge would apply in perpetuity to both options as well as to the Community Charges.

Table 12.3 Indicative Annual Costs for Design Base Case Scenarios

	Scenario 1 **User Base Case**	**Scenario 2** **User Base Case + Future Regional Supply**	**Scenario 3** **All Potential Users**
Effective hectares	5675	6190	7765
Option 1: Capital cost per hectare (one-off, upfront payment) plus Annual Operating Charge per hectare	$5130 $70	$4700 $65	$3750 $50
Option 2: Annual Fixed Charge per hectare plus Annual Operating Charge per hectare Total Annual Charges (per hectare per year) – pre-tax	$510 $70 $580	$465 $65 $530	$370 $50 $420
Total Annual Community Charges (comprising environmental flow, urban/industrial use, and future regional supply)	$1,900,000	$2,110,000	$1,900,000

Costs per hectare for consumptive users decrease as the costs are spread over a larger area. The indicative charges for current irrigators are far more affordable if all potential users are part of the scheme from day one; ie a reduction from $580 to $420 per hectare per year. Factors that may affect whether those potential users join the scheme, and the implications of varying uptake, are as follows:

- Delivery of water to irrigable areas outside of the Zone of Effect will require a substantial investment in distribution infrastructure, with the average estimated capital cost per hectare for distribution being approximately $4,700 (see Section 9). If the new potential irrigators beyond the Zone of Effect are charged for the full costs of both the scheme and distribution infrastructure, the overall capital cost to those users would be more than double the capital costs to those users within the Zone of Effect. Assuming that the investment in distribution infrastructure is funded on the same basis as the scheme itself, annual charges for the potential irrigators outside of the Zone of Effect would be in the vicinity of $830 per hectare (in the best case scenario where all potential users join the scheme);
- At least some of the current landowners could consider regard these as too expensive and may choose not to join the scheme. In this case, the capital and on-going servicing costs for the remaining potential users will increase commensurately; in the worst case scenario where all of the potential new irrigators outside of the Zone of Effect withdraw, the indicative annual charge would increase from $420 per hectare to $530 per hectare (as represented by Scenario 2 in Table 12.3 above).

It is therefore in the best interests of all remaining users to ensure that the pool of participants is as large as possible. If a large number of the potential irrigators outside of the Zone of Effect will not join the scheme if they are charged the full allocation for the scheme capital costs, it may be appropriate to consider some discount so that a greater uptake is encouraged. Alternatively, those users within the Zone of Effect (but who do not currently hold water permits) could be charged a premium.

12.2.3 Impact of Hydro Power Development

The proposed augmentation scheme potentially includes a small-scale hydro electric generation plant. It is estimated that the realisable value of the hydro scheme when completed will be approximately $2.2 million - $3.5 million.

The indicative impact that the hydro development may have on annual charges for all prospective scheme users has been estimated (based on an assumption that the hydro opportunity is sold to a third-party as soon as the scheme is completed, and that proceeds from the sale are used to reduce the effective capital cost that must be funded by all scheme users).

If hydro power is incorporated, the indicative annual charges for irrigation users would reduce by between $25 and $30 per hectare compared to the base case scenario summarised in the previous section. It is unlikely that the potential hydro development will materially affect the overall feasibility assessment of the augmentation scheme.

12.2.4 Impacts of Variations to Scheme Design

A high level investigation has also been undertaken of the potential cost savings if a number of scheme variations are implemented, to determine the likely reduction in charges to users and the community. The variations are:

- Reduction in the number of diversion culverts during construction (subject to further engineering assessment) – cost reduction of $2.6 million;
- No allowance for future regional water supply, with a commensurate reduction in size of dam – cost reduction of $2.9 million;
- Reduced allowance for new irrigation areas with a commensurate reduction in size of dam - cost reduction of $2.0 million.

The potential annual reduction per hectare arising from the reduced number of culverts ranges from $20 - $35 depending on the numbers of scheme users.

The potential cost saving associated with different size dam (storage volume) is more complicated to assess as the variations affect the number of potential users. These reductions will be optimal if uptake from potential new users does not reach certain levels.

12.3 Cost-benefit Analysis for Irrigators

A high level assessment has been undertaken of the potential benefits that current irrigators will get from the scheme. This assessment is mainly based on the financial impact if the scheme does <u>not</u> proceed.

Although many of the potential participants in the scheme already have access to water, this is subject to seasonal restrictions, and the fact remains that the Waimea Basin water resources are currently significantly over-allocated. The financial impact of non-augmentation is therefore critically dependent on what means are put in place to deal with the over-allocation.

For this assessment therefore, it has been assumed that regardless of whether the scheme goes ahead, a minimum flow requirement could be imposed for the Waimea River system under the Resource Management Act process, to deal with the current over-allocation of water. For the current assessment it has been assumed that the minimum flow required to be retained in the Waimea River at the Appleby Bridge is 1,100 l/sec.

In the event of a water shortage (under the current situation of there not being an augmentation scheme), there are two allocation response options:

- A worst-case scenario where the total volume allocated to water permits is reduced (Scenario A);
- A reduction in security of supply; ie impose rationing more often (Scenario B).

The potential effects of these two options are summarised as follows:

- Scenario A: Cancellation of Water Allocations

  In this 'worst case' scenario, it is assumed that the minimum flow of 1100 l/sec would be met by TDC having to cancel enough current water allocations to maintain the current security of supply (a 35% cut in allocations during a 10 year drought). This could require a cut in current allocations of approximately 70% (J. Thomas, TDC, pers. comm.). Such cuts would likely apply only to irrigation consents, because urban and industrial allocations would have higher priority for continuation.

  In this case, water allocations would be reduced to a level which leaves sufficient water to irrigate just 705 hectares of the 3800 hectares that are currently irrigated.

Intensive land uses would no longer be viable for landowners who lose their access to their water allocations, resulting in a shift to dryland farming and the prospect of considerable losses in capital values. It is estimated that the total loss would be approximately $165 million.

Another way to express the potential loss of regional income under this scenario is to consider the reduction in on-farm profitability that would result from a 70% reduction in water allocation. This results in an estimated total annual loss of $17.5 million. Over a 25 year period, this would amount to a loss of about $440 million.

- Scenario B: Increased Water Rationing for Existing Allocations

  The second scenario assumes that TDC would implement more severe rationing cuts based on the current 3-step regime (in order to attempt to maintain the much higher minimum flow in the river).

  Based on current land use and return levels, the indicative cost of a 1 in 25 year drought is estimated to be between $14.4 million and $19.1 million, depending on when the water shortages occurred in a season. These estimated losses represent between 45% and 65% of total net earnings from the irrigated land during an "average" year.

Given that the estimated maximum capital cost allocation to existing irrigators under the proposed scheme is approximately $22.5 million, the cost-benefit assessment for users when viewed under either scenario is quite compelling.

12.4 Regional Impact of Non-augmentation

An estimate of the potential regional impacts of non-augmentation (ie if the scheme does not proceed) concludes that the consequences for the Tasman District will be significant, affecting three broad groups:

- Existing Irrigators: The worst-case scenario outlined above (Scenario A) would result in a total loss of value of approximately $165 million for the existing irrigators.
- Potential New Irrigators: It is estimated that the lost output from the land that is potentially irrigable by the scheme is around $40 million per year.
- Urban and Industrial Users: There would be significant effects on both industrial users and on TDC. The (lost) opportunity cost of non-augmentation for these users can be measured as the increased cost of delivering the required water using the next best alternative. It is understood that it is likely to be considerably higher than the proposed Lee scheme.

13 Applicability

This report has been prepared for the benefit of the Waimea Water Augmentation Committee with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

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