REPORT

WAIMEA WATER AUGMENTATION COMMITTEE/TASMAN DISTRICT COUNCIL

Assessment of Water Augmentation Options for the Waimea Plains - Final Report - Summary

Report prepared for:

WAIMEA WATER AUGMENTATION COMMITTEE/TASMAN DISTRICT COUNCIL

Report prepared by:

TONKIN & TAYLOR LTD

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EXECUTIVE SUMMARY

In November 2004, Tonkin and Taylor Ltd (T&T) was commissioned by the Waimea Water Augmentation Committee (WWAC) and Tasman District Council (TDC) to undertake Phase 1 of a feasibility study of water storage in the upper parts of the Wairoa/Lee catchments in Tasman District. The specific brief was to address the recurrent water shortages experienced on the Waimea Plains and to investigate enhancing water availability for consumptive and environmental/community/aesthetic benefits downstream on the Waimea Plains and surrounds.

This report comprises the final reporting for the Phase I (preliminary) feasibility three year project, and summarises all stages within Phase I.

The basic principle behind the project has been to develop an augmentation scheme that would capture river flows (leaving an appropriate residual flow in the river), store the water in a reservoir, and then allow release of that stored water into the river system during periods of high water demand and/or low natural river flows to augment those supplies, either directly or via a recharging of the groundwater system.

The project has been multi-disciplinary, with four main components:

1. water demand and availability analysis
2. identification of site storage options, and water delivery methods and costs
3. environmental assessment, and economic analysis of scenarios with and without augmentation
4. water allocation for optimisation of water use, environmental/community benefits/funding.

The work has been undertaken in a staged way.

Following initial identification of the likely water demand, a range of potential water storage sites was identified by T&T. With staged input from a range of technical studies undertaken by T&T and its specialist subconsultants, WWAC narrowed the storage options down from an initial 18, to five, and eventually two. More detailed assessment followed of the two sites (Site 11 (Upper Lee River) and Site 15 (Left (eastern) Branch Wairoa River). In August 2006 WWAC took the decision to focus further investigations on Site 11 Lee River as the preferred option for possible water storage.

This report summarises all work undertaken on the project in Phase I. It is accompanied by four technical reports, one addressing each Component as follows:

- Component 1: Water Demand and Availability
- Component 2: Storages Assessment
- Component 3: Environmental and Economic Assessment
- Component 4: Water Allocation Issues.

Each of the Component reports includes a series of technical Appendices that comprise reports on earlier stages of the Phase I project plus specific technical studies. The outcomes of each of those reports is summarised in this report. The reader is referred to the four accompanying Component reports for details.

The following are the main points representing the stage the project has reached at the end of Phase I, based on the preliminary investigations undertaken to date:

- Site 11 is within the main stem of the Lee River, approximately 2km upstream from the end of the public road (locked gate adjacent to the former quarry site).
- The potential dam would be an on-river structure.
- Any reservoir storage capacity would need to be in the order of 13 million m^3 of water to meet the foreseeable demands for water over the next 50 years for irrigation, domestic, and industrial purposes in the eastern part of Tasman District, as well as ensuring appropriate flows remain in the river for instream uses.
- Based on the current level of investigations, the above storage capacity is sufficient to supply water for a drought security of approximately 1 in 50 years.
- Dam embankment height: approximately 49m from riverbed level to crest.
- Dam type: the site appears to be best suited to an earthfill dam construction
- The modelling undertaken to date incorporates provision for a higher residual flow to remain in the river for instream ecology purposes than is currently provided for under existing allocation policies.
- The dam would be designed and constructed according to the highest industry standard for a high potential impact category dam (hazard potential).
- Tangata Whenua have commenced a cultural impact assessment process for the project and have recommended a range of mitigation measures should the project proceed.
- Further consideration needs to be given to how native fish will navigate the dam structure.
- The effect on water quality, aquatic ecology and native vegetation has been assessed in preliminary investigations.
- The water augmentation scheme has the potential to improve instream habitat for freshwater ecology.
- The land that would be directly affected by the dam and reservoir comprises some private land and other areas owned by the Crown (including the Department of Conservation).
- The indicative capital cost of the project is currently assessed as being in the range of $20 – $25 million, subject to further investigation outcomes.
- A preliminary economic assessment indicates that the annual charge to users of the scheme could be approximately $305 per hectare. This assumes that 70% of the capital costs are shared by all potential users of the scheme, with 30% covered by the community at large (potentially through rating by TDC). With other cost sharing scenarios, the annual charge to users of the scheme could be up to approximately $565 per hectare.
- Should the scheme not proceed, it is estimated that the "lost opportunity" cost for a 1 in 25 year drought could be in the range of $14.3 to $24.8 million, depending on the timing of the water shortages.

- A survey undertaken by WWAC indicates that there is good community support for a dam storage scheme to address the water shortages currently being experienced.
- Options exist for allocating the water to users equitably, and making changes to current allocation policies.

The work completed during this contract comprises one phase in the investigation of augmentation options for the Waimea Plains. Based on this work, it appears that a water augmentation scheme based on a storage dam at Site 11 Lee is a feasible option, and that a further investigation phase based on this site is warranted to satisfactorily address the issues raised in Phase I.

T&T recommends, and it is indeed envisaged by WWAC, that further phases of work be undertaken to investigate particular aspects in more detail. T&T has, at WWAC's request provided an indicative scope of work for Phase II.

We specifically record our appreciation of the input by WWAC's Project Manager, Joseph Thomas (Tasman District Council). In addition, the contributions by members of WWAC (who include various stakeholder groups) have been invaluable to the process.

1 Introduction

In November 2004, Tonkin and Taylor Ltd (T&T) was commissioned by the Waimea Water Augmentation Committee (WWAC) and Tasman District Council (TDC) to undertake Phase 1 of a feasibility study of water storage in the upper parts of the Wairoa/Lee catchments in Tasman District. The specific brief was to address the recurrent water shortages experienced on the Waimea Plains and to investigate enhancing water availability for consumptive and environmental/community/aesthetic benefits downstream on the Waimea Plains and surrounds.

The basic principle behind the project has been to develop an augmentation scheme that would capture river flows (leaving an appropriate residual flow in the river), store the water in a reservoir, and then allow release of that stored water into the river system during periods of high water demand and/or low natural river flows to augment those supplies, either directly or via a recharging of the groundwater system.

The project is multi-disciplinary and Phase 1 (preliminary) feasibility has extended over a three year period. It has four main components:

1. water demand and availability analysis
2. identification of storage options, and water delivery methods and costs
3. environmental assessment, and economic analysis of scenarios with and without augmentation
4. water allocation for optimisation of water use, environmental/community benefits/funding.

T&T has undertaken this project in a staged way. The overall project stages are generally described as follows:

- identify potential water demand
- identify range of potential storage sites
- work with ESR to assist them to identify community values of the Waimea Catchment
- assess broad-scale physical, engineering, and environmental constraints to refine the list to small number of practical storage sites
- refine hydrological, physical, engineering, and environmental issues and conduct Workshop with WWAC to determine up to three possible storage options
- develop hydrological model of Wairoa and Lee Catchments including relationship between surface and groundwater resources in the Waimea Basin
- identify opportunities to enhance surface and groundwater resources from management of storage scenarios
- undertake initial dambreak and environmental assessment studies of (up to) three scenarios
- determine appropriate water allocation and distribution parameters
- consider community feedback, water demand, distribution requirements etc and determine preferred option(s)

- undertake geotechnical investigations, and dambreak analysis for feasibility of preferred option
- work with WWAC/ESR for them to assess community response to water augmentation
- develop overall solution (or scenario) including distribution and allocation.

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 - T&T
- Potential storage site identification - T&T
- Determination of irrigation demand - Agfirst Consultants
- Assessment of community/industry water demand - Tasman District Council
- Aquatic ecology, water quality and fish passage – Cawthron
- Modelling of groundwater system – GNS Science
- Catchment hydrology – T&T
- Modelling of surface water system (incorporating water demand and groundwater requirements as above) to determine reservoir storage requirements – T&T
- Storage dam design – T&T
- Operating regime – T&T
- Geology of potential sites – Dr M Johnston
- Geotechnical investigations of preferred site - T&T
- Preliminary dam breach hazard assessment – T&T
- Costing of capital works – T&T
- Assessment of land tenure – information provided by Tasman District Council
- Comparative assessment of indigenous vegetation – Uruwhenua Botanicals (Dr Philip Simpson)
- Blue duck (whio) survey – Dave Barker
- Cultural impact study – Motueka Iwi Resource Management Advisory Komiti (MIRMAK)
- Assessment of options for allocating water – Landcare Research
- Preliminary economic analysis of preferred scheme – Crighton Anderson (Corporate Finance), with input from Agfirst Consultants and Landcare Research

This report summarises all work undertaken on the project. It is accompanied by four technical reports, one addressing each Component as follows:

- Component 1: Water Demand and Availability
- Component 2: Storages Assessment
- Component 3: Environmental and Economic Assessment

- Component 4: Water Allocation Issues.

Each of the Component reports includes a series of technical Appendices that comprise reports on earlier stages of the project plus specific technical studies undertaken by the various consultants. The outcomes of each of those reports is summarised in this report. The reader is referred to the four accompanying Component reports for details.

The work completed during this contract comprises one phase in the investigation of augmentation options for the Waimea Plains. T&T recommends, and it is indeed envisaged by WWAC, that further phases of work be undertaken to investigate particular aspects in more detail.

Clarification Note: The NZMS topographic map names the branches of the Wairoa River as follows:

- Left Branch – this is the eastern branch
- Right Branch – this is the western branch

This naming is opposite to the usual convention of referring to right and left branches (or banks) to reflect the orientation when facing **downstream**. To avoid confusion in this report we have endeavoured to make it clear by including reference to the east or west in our descriptions.

2 Assessment of Potential Storage Sites

2.1 Selection Process

The assessment of potential storage sites has been undertaken in a staged way, starting with a large number of sites, and gradually narrowing the list down through an assessment of engineering, environmental and social factors.

The assessment has been undertaken in conjunction with WWAC and its Project Manager.

The following sub-sections summarise the process and outcome.

Refer to accompanying "**Component 2 Report: Storages Assessment**" for detail.

2.2 Initial Site Identification

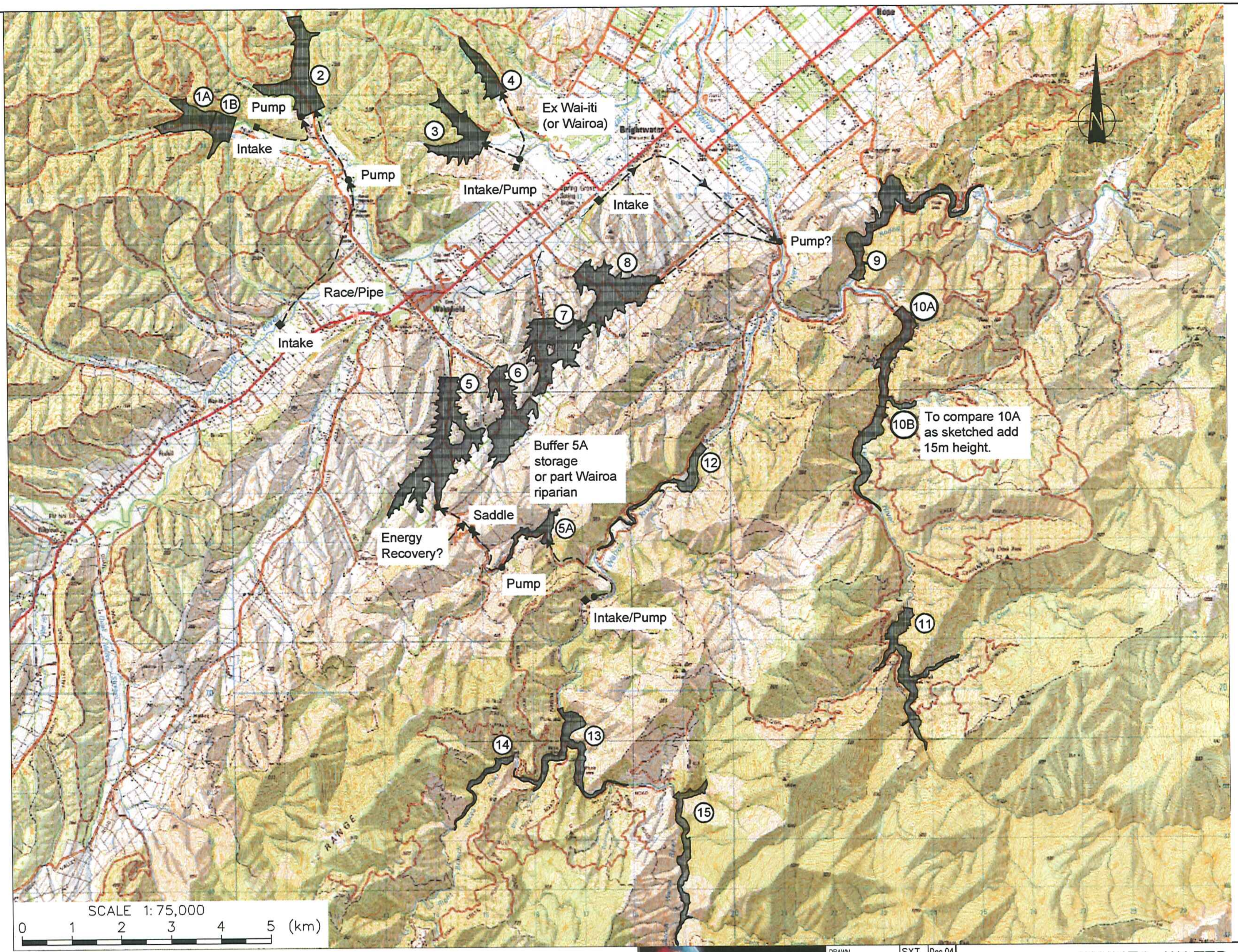
In December 2004 T&T completed a preliminary scan of possible storage (and infill) options in and adjacent to the study area. This exercise excluded those possible sites that had less than about 5 million m^3 storage capacity. Identification of options was essentially desk-based, but involved inspection from public vantage points of those sites able to be accessed by specialist members of the team. Eighteen possible sites were identified (see Figure 2.1) and provided to WWAC's project manager for advice on any which should be excluded.

WWAC's technical team discussed the options, and requested the removal of eight sites from the list.

2.3 Selection of Short-list

T&T's technical team undertook a ranking exercise of the remaining 10 sites, based on a range of initial technical and environmental criteria. These included:

- storage characteristics
- geological/seismic risk
- reservoir filling
- constructability
- hazard potential
- power generation potential
- flexibility for staging
- cultural acceptability
- land use
- effect on infrastructure
- aquatic ecology
- terrestrial ecology
- recreation
- archaeology



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Options

FIG. No. Figure 2.1 — REV. 0

The following five sites ranked highest:

- Site 2 – Pigeon Valley North
- Site 10A – Middle Lee
- Site 11 – Upper Lee
- Site 13 – Wairoa Forks
- Site 15 – Left (eastern) Branch Wairoa

A report setting out the characteristics of the above sites was prepared and discussed with a Technical Group of WWAC, and the formal Committee.

A broad ranking exercise assessed each of the five sites according to general criteria covering environmental, engineering, and consentability/public acceptance issues. The outcome was as follows:

- Site 11 (Upper Lee) – highest (best) ranking
- Site 2 (Pigeon Valley)
- Site 15 (Left (eastern) BranchWairoa
- Site 10B (Middle Lee) and Site 13 (Wairoa Forks) – lowest equal ranking

There was little difference between Sites 2 and 15 in terms of their relative ranking.

Accordingly, Sites 11, 2, and 15 were selected by WWAC for ongoing investigation.

Site 2 was then investigated further to determine relative costs. WWAC representatives also met with Pigeon Valley residents to gauge community response. On the basis of the results of both those processes, Site 2 was eliminated from further investigation at that stage. Accordingly T&T was instructed by WWAC to continue a comparative assessment of Site 11 (Upper Lee) and Site 15 (Left (eastern) Branch Wairoa.

2.4 Comparative Assessment of Two Sites

A preliminary and comparative investigation was undertaken for Sites 11 and 15, as a basis for WWAC to choose a preferred option on which to focus preliminary feasibility investigations.

The key comparative issues are summarised below.

Feature	Site 11 - Lee	Site 15 – Left Branch Wairoa
Water demand	No difference	No difference
Storage capacity	No difference	No difference
Reservoir area (hectares)	Larger	Smaller
Materials availability	Majority available on-site	Expect most to be imported
Construction access issues	Effects less apparent	Effects more apparent
Operating regime	Effects more apparent	Effects less apparent (Right Branch Wairoa provides buffering)
Sedimentation potential	No significant difference	No significant difference
Downstream hazard	Lower	Higher

Feature	Site 11 - Lee	Site 15 – Left Branch Wairoa
potential		
Required design standard	No difference	No difference
Comparative cost (base price)	No significant difference (within current order of accuracy)	No significant difference (within current order of accuracy)
Cost (piped delivery)	Lower cost	Higher cost
Land tenure	More owners (7)	Fewer owners (4)
Land administered by DOC	Less	More
Potential electricity generation	Little difference (1.2 MW; 6.8 GWh/annum)	Little difference (1.7 MW; 9.8 GWh/annum)
Aquatic ecology	Little difference	Little difference
Water quality (effect of ultramafic geology in catchment)	No issue	Potentially an issue
Indigenous vegetation	More significant	Less significant
Blue duck (whio)	No difference	No difference
Cultural impact	Difference not known at this stage	Difference not known at this stage
Trout fishing	Little difference	Little difference
Informal recreation	Little difference	Little difference
Kayaking	No issues	An issue – development would be opposed
Access to Richmond Forest Park	Lesser effect	Greater effect
Archaeology/heritage values	No difference apparent at this stage	No difference apparent at this stage
Community preference	Not gauged	Not gauged
Enhancement opportunities	No difference apparent at this stage	No difference apparent at this stage

It appeared from the above table (without weightings being applied to any criteria) that the Lee may have more positive points than the Wairoa.

A Draft Discussion Document on the investigations was presented to WWAC at its meeting on 19 July 2006. Following that meeting, WWAC undertook further consultation with various components of the community, and considered the issues further at a second WWAC meeting on 21 August 2006. At that second meeting, WWAC took the decision to focus further investigations on Site 11 Lee River as the preferred option for possible storage.

The sections of this Final Report for the Phase 1 feasibility study that specifically relate to dam site and reservoir location focus on the preferred site selected by WWAC; ie Site 11, Upper Lee.

The accompanying report **Component 2: Storages Assessment** contains all information relating to the comparative assessment between Sites 11 and 15, including all collated information (engineering and environmental) on the alternative site (Site 15 Left (eastern) Branch Wairoa River).

3 Water Demand

3.1 Introduction

A required reservoir storage capacity of between 15 to 20 million m^3 was initially estimated based on a simple and approximate analysis and mainly for site comparative purposes. The demand associated with this estimate was equivalent to full irrigation of 4055 hectares of pasture at the rate of 35 mm/ha/week at 100% plant ground cover over a continuous 15 week period. Included in this figure was an urban and industrial demand allowance (within the Waimea Basin) equivalent to 380 ha of pasture. As an initial and conservative estimate, and based on the information available at that stage of the project, this storage estimate did not allow for the existing recharge and storage available in the Waimea groundwater aquifers or any incident rainfall during the irrigation season which may offset some of the demand.

A technical workshop on water demand was held to refine and agree the demand assumptions on which to base the live storage requirement for the proposed dam and, critically, the detailed input requirements for the complex groundwater model. This modelling in turn was designed to lead to a refinement of the water demand.

Details of the demand assumptions, including the assumed geographical distribution and seasonal pattern of take for different soil and crop types, are provided in the accompanying **Component 1 Report: Water Demand and Availability**. A summary covering both consumptive and in-stream water demand and the dam storage modelling is provided in the following sub-sections.

3.2 Consumptive Water Demand

Refer to **Component 1 Report: Water Demand and Availability** for detail.

The equivalent net irrigable area in the Waimea Basin has been assessed as follows:

- Existing irrigated area: 3800 hectares
- Additional potentially irrigable area: 1500 hectares
- Provision for additional area in the lower Wai-iti (from Wakefield to Aldourie Rd): 300 hectares
- Total: 5600 hectares

In addition to irrigation water, there is also a need for the Waimea augmentation project to provide for urban and industrial demand – both existing, and future expected demand. These demands are as follows:

- Existing urban allocation (TDC): 540 hectare equivalents (note that actual current *demand* (as distinct from *allocation*) is approximately 420 hectare equivalents)
- Future TDC demand: 280 hectare equivalents
- Total urban/industrial demand for Tasman District for projected timeframe (50 years): 820 hectare equivalents

Table 3.1 presents the approximate areas and corresponding demand.

Table 3.1: Expected Water Demand (by Water Zones) from Proposed Waimea Augmentation Scheme (50 year projection)

Zone	Net Irrigable Area (Ha)	Urban Allocation (Area Equivalents - ha)	Total Hectare Equivalents	Approx. Demand (Peak Daily Flow) l/s
Upper Catchments	Minimal		Minimal	5
Reservoir	580	56 (Brightwater & Wakefield)	636	316
Waimea West	385	23 (Redwood*)	408	202
Hope & Eastern Hills (includes Upper and Lower Confined)	2,170	154 (Richmond)	2324	1345
Golden Hills	300		300	149
Delta	1,246	307 (Waimea)	1553	693
Redwood*	625		625	258
Wai-iti: Aldourie Rd to Wakefield	300		300	174
Future urban demand		280	280	162
TOTALS	**5,606 ha**	**820 ha**	**6426**	**3304 l/s**

Note: In this table, the demand figures are based on the zone in which the land needing to be irrigated actually lies. The demand has been based on the predominant soil type making up that zone.

* For the purposes of this exercise it has been assumed that all Redwood supply is provided from the Waimea West Zone

The actual irrigation usage depends heavily on the actual rainfall pattern over the season, and to a lesser extent on other climatic variables (wind, solar radiation, etc.) Clearly, 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. This is because both variables are driven by rainfall patterns to a large extent – low rainfall generally equates to low flows and high usage. In terms of reservoir storage utilisation, low inflows to the reservoir and high irrigation usage are compounding factors, and so must be captured appropriately in the reservoir simulation. Otherwise the result would be unconservative. Thus, an irrigation usage pattern which corresponds with a drought year must be used.

Modelling was undertaken to identify the theoretical water demand pattern that would occur in a drought year. The modelling used an actual year for which soil moisture and aquifer recharge data for groundwater are available. Thus, the 1982/83 year was selected as the design drought year. The 2000/01 year is more severe and likely to be too conservative (see Section 3.6) while the 1990/91 year appears to be an average year (i.e. not a high usage year).

In summary, over the full season from 1 July 1982 to 30 June 1983:

- total theoretical water usage for the future assumed allocations is about 32 million m^3
- the total actual water usage was about 22 million m^3
- the theoretical peak daily demand is about 3300 l/s or 280,000 m^3/day, inclusive of Waimea East Irrigation Scheme abstraction.

Note that these demand figures exclude additional allowance for any "future regional need". The additional demand for this future regional need (based on regional figures and provided to us by TDC) is approximately 22,000m^3/day. This equates to a constant year round take of 254 l/s, and an annual take volume of about 8 million m^3. The modelling, for simplicity (and to be on the conservative side) the supply for such a need is assumed to be a surface water take above the Waimea aquifers rather than a groundwater take from the Waimea Basin.

3.3 In-Stream Requirements

Refer to **Component 1 Report: Water Demand and Availability** and **Component 3 Report: Environmental and Economic Assessment** for detail.

Cawthron undertook an assessment of the minimum flows required to provide instream habitat in the Waimea River and immediately below the potential dam sites. This included both Sites 11 and 15. Three 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.

The results 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 two potential dam sites:
   - existing MALF (environmental benchmark)
   - 1 in 5 year low flow
   - 1 in 10 year low flow

WWAC subsequently took a decision to assess the live storage requirements necessary to maintain flows covering much of this range, specifically requesting T&T to assess two scenarios for flows at Appleby:

- 600 l/sec
- 1100 l/sec

At each of the dam sites being considered at that stage, a residual flow immediately below the dam equal to the mean annual low flow (MALF) was conservatively assumed.

3.4 Groundwater Modelling

Refer to **Component 1 Report: Water Demand and Availability** for detail.

Groundwater modelling was undertaken by GNS to determine the flow releases required from a storage reservoir in either the Upper Lee River or Upper Wairoa River in order to sustain a pre-determined residual flow at Appleby Bridge while meeting unrestricted abstractive demands from the Waimea aquifers. This entailed multiple runs of the existing Waimea Plains groundwater model (which has been developed and calibrated by GNS in collaboration with TDC over the past few years) using the future allocation regime based on the 1982/83 theoretical demand profile and soil moisture (drainage) data.

Results from the groundwater modelling were then analysed by T&T to determine what volume of storage capacity would be required to meet the demands for irrigation and community/industrial water needs, as well as the minimum flow required at Irvines to maintain a particular residual flow at Appleby Bridge for instream requirements.

At the completion of dam reservoir storage and flow augmentation modelling a third groundwater modelling exercise was undertaken by GNS as a forward simulation check as to whether the augmented river flow identified by T&T could maintain the required water demand, minimum flows and the need for groundwater recharge. The modelling results confirmed that on all but a few occasions the required water demand could be met. The river flow augmentation model was subsequently adjusted by T&T to meet the requirements.

An important part of the groundwater model is the representation of the river – aquifer interaction and recharge process. While the groundwater model has been well calibrated based on observed groundwater level and river level data, there remains a level of uncertainty in the results. In particular, the sensitivity of the aquifer recharge to riverbed level changes and potential for seawater intrusion in certain areas would need further assessment in subsequent study phases.

4 Reservoir Storage and Flow Augmentation Modelling

Refer to **Component 1 Report: Water Demand and Availability** for detail.

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

- water demand – this has been discussed in Section 3.2 earlier
- environmental or residual flows for protection of instream values – this has been discussed in Section 3.3 earlier
- flow variability and the level of drought security desired - in the current system, year to year flow variability has been represented by the long-term record of Wairoa River flows at Irvines from 1958 to 2005; drought security is discussed in Section 4.1.
- system characteristics and behaviour – these revolve around drainage pattern of the catchment, its rainfall-runoff response, the groundwater-aquifer interaction and other processes

A simulation method which takes into the account the parameters and characteristics above was used to model the dam storage behaviour at each dam site over the period of the Wairoa River flow record (1958 to 2005). The key to this model is the maintenance of a threshold minimum flow at Irvines whereby predicted shortfalls in the remaining natural river flow must be met by controlled dam releases. The same water demand pattern, based on the theoretical usage for the 1982/83 drought year (Section 3.2), was assumed for each year of record.

4.1 Drought Definition and Security of Supply

For a given amount of live storage, the level of service provided by the reservoir is expressed as the level of security with regard to a drought with a particular return period, viz. the "drought return period". This drought return period has been assessed from the simulated storage inflow-outflow behaviour described in Section 3.2.

By using a standard approach similar to that applied to estimating floods or low flows, an analysis of the magnitude of the storage fluctuations over time (specifically the minimum level attained in each year of record) produces 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.

Note that there is an important and fundamental difference in the drought definition for a river system with controlled storage and 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 dam were not full at the start of the season) is a maximum. The magnitude of any one short-lived shortfall episode rarely governs the storage requirement.

For a run-of-river system, such as the Wairoa River currently, 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 in terms of the security of supply from a reservoir, due to the different timeframes being considered.

4.2 Total Water Demand/Storage Requirement

The outcome of the modelling for the determination of storage volume requirements was that the required storage volume to meet the identified target drought security (1 in 10 years) was found to be lower than the initial assessment of 15 million m^3 (which had been based purely on water demand). Accordingly T&T sought instructions from WWAC on whether to:

- Retain the originally requested drought security (1 in 10 years) with consequential savings in cost and (potentially) effects OR
- Provide additional storage to increase the drought security (but potentially still within the original cost estimate range)

The decision also needed to include:

- Which downstream residual flow scenario to adopt (for instream habitat purposes)
- Whether the reservoir is to perform any function additional to irrigation water supply; eg recreational resource, habitat provision, cultural purposes etc (incorporating provision for dead storage)

WWAC's decision was to determine a total storage volume that was large enough to provide flexibility to respond to certain events, to take into account the uncertainties in modelling and climate change, and to manage the storage in response to those events.

The volume chosen by WWAC for further study was:

- 12 million m^3 live storage
- Plus provision for an additional 1 million m^3 dead storage (allowing for 0.6 million m^3 for 100 years of sediment infill).
- Total of 13 million m^3 storage capacity

This volume was considered sufficient to provide storage to allow for the equivalent of approximately a drought security of 1 in 50 years plus provision for a residual instream flow at Appleby of 1100 l/s, as well as supply a potential future regional need of in the order of 22,000m^3/day. Alternatively, the volume could be managed to provide a higher security of supply under drought conditions with a lower residual instream flow at Appleby, but still within environmental guidelines.

As noted in Section 3.4, the results of the forward simulation groundwater modelling indicated that the storage model needed to be adjusted slightly to ensure the water demand could be met. This adjustment has been made in the model.

5 Site 11 – Upper Lee River – Engineering Characteristics

5.1 Location/Site Topography

Site 11 is within the main stem of the Lee River. The storage dam would be an instream dam.

Initially a site approximately 700m downstream from the confluence with Anslow Creek was identified as being suitable for a storage dam. However, following on-site geotechnical investigations, an alternative site approximately 250m downstream was identified as potentially being more suitable. Figure 5.1 shows the likely location of a dam and reservoir based on Site 11.

The head of the reservoir would extend upstream for approximately 3.5 km, and would incorporate the lower reaches of Anslow Creek and Waterfall Creek. Initial delivery would be by release into the river.

5.2 Catchment Hydrology

Refer to **Component 1 Report: Water Demand and Availability** for detail.

Key hydrological parameters for this dam site are as follows:

- Catchment area to dam site = 84 km^2
- Estimated mean flow ≈ 3.6 m^3/s, equivalent to 113 million m^3 per annum
- Estimated mean annual low flow (MALF) ≈ 470 l/s , which is also assumed to be the minimum residual flow required at the foot of the dam
- Estimated 7-day 5-year low flow ≈ 360 l/s
- Maximum controlled dam release = 2070 l/s, based on 1100 l/s Appleby Bridge residual, full future allocations and 22,000 m^3/day future regional supply
- 10 year AEP flood peak 270 m^3/s
- 100 year AEP flood peak 400 m^3/s
- 10,000 year AEP flood peak 650 m^3/s

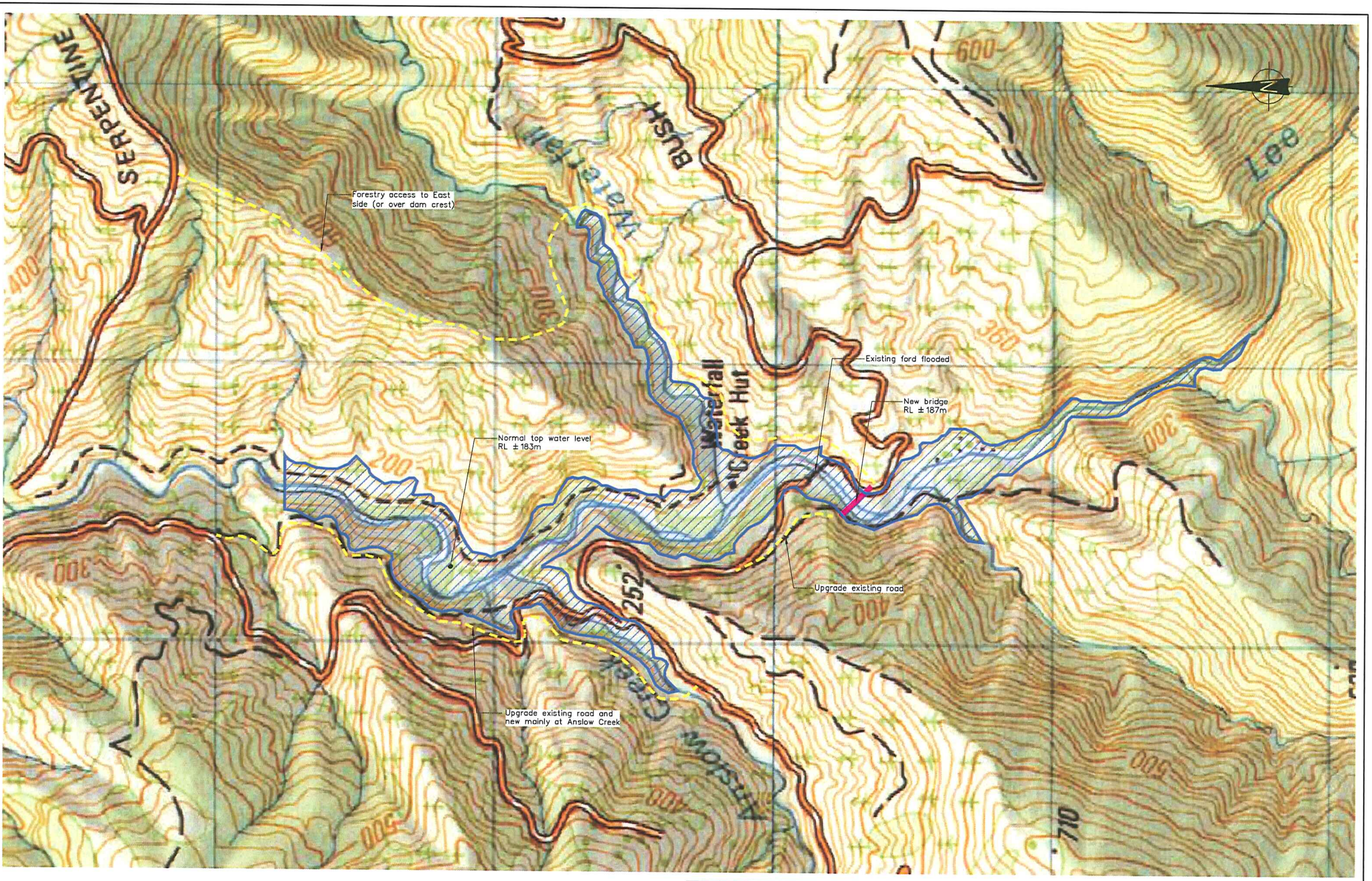
5.3 Dam/Reservoir Characteristics

Refer to **Component 2 Report: Storages Assessment** for detail.

The brief received from WWAC following consideration of water demand and security of supply issues (see Component 1 Report) was to provide for a dam capable of creating a reservoir with storage capacity of 13 million m^3 of water (12 million m^3 live storage plus provision of 1 million m^3 dead storage).

Site 11 is considered (on present information) to be best suited to earthfill dam construction.

Preliminary geotechnical investigation of Site 11 has been undertaken (see Section 5.4) and the results of this work have been incorporated into the engineering assessment.



SCALE 1: 12,500

0 100 200 300 400 500 600 700 800 (m)

NOTE:

1. Map sourced from Land Information New Zealand, Crown copyright reserved.

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LEE RIVER STORAGE (13 MCM)
INDICATIVE RESERVOIR
EXTENT AND ROADING

FIG. No. Figure 5.1

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Based on the 20 m contour data currently available, the indicated top water level is RL 183 m to store 13 million m^3 of water. However, more accurate survey data could result in a modest change in normal top water level. About 4 m extra height will be required to enable passage of floods and provide safety freeboard to the dam. Thus the dam crest will be at about RL 186.5m. The total height for the dam would be approximately 48.5m (Nelson City's Maitai dam, by comparison, is about 40 m high).

It is estimated that the plan area of the reservoir will cover around 90 hectares. For water quality reasons, vegetation below normal top water level will need to be cleared plus a small margin, prior to inundation.

Figure 5.1 illustrates the reservoir at normal top water level along with anticipated new roading to maintain access up valley and connections to existing main forestry tracks.

5.4 Site Geology and Geotechnical Conditions

Refer to **Component 2 Report: Storages Assessment** for detail.

A preliminary geotechnical assessment was undertaken of two adjacent dam sites on the Lee River (both based on a nominal Site 11). The two sites, Site 1 (upstream) and Site 2 (downstream) are approximately 250m apart. Initially it was considered that Site 1 would provide a better layout. However during site investigation work, remnant gravel terrace materials of reasonably extensive depth were encountered in test pits on the true right (eastern) abutment, which led to a reconsideration of site. The downstream site (Site 2) is therefore the currently preferred site.

The investigation has involved geological and geomorphic mapping, subsurface pitting and Scala probing of the dam sites and potential borrow areas.

At Site 2, both banks are steep although the west/right bank is much steeper.

The valley floor and side slopes (of either sites) are underlain by bedded siltstones and minor sandstones of the Rai Formation.

The siltstone and sandstones (commonly known as greywacke) outcrop in the riverbed and lower slopes, and are exposed in access tracks in the vicinity.

There is no evidence of faulting (at either site). However, there are two active faults in the vicinity: the Whangamoa Fault, 2.5km to the west and the Alpine Fault, 23km to the south-east.

There are remnants of at least three river/outwash terraces on the sides of the valley above the river. They are the:

- Riverbank Terrace which is 4 to 6m above river level (arl);
- Middle Terrace approximately 15m arl; and
- Upper Terrace about 40m arl.

These terraces are capped with gravels, and minor sands, silts and clays.

The current riverbed is covered with coarse gravels, cobbles and boulders.

The side slopes of the valley are overlain with thin (1 to 2m thick) residual and colluvial soils. These are typically gravelly silts derived from weathering and down slope transport of the underlying siltstone and terrace deposits.

A large scree deposit has been identified on the west/right abutment of Site 2. It extends 250m along the river bank and 60m upslope from the river level. This scree slope may overlie a landslide.

Marshy ground and groundwater springs were identified in places on the river/outwash terraces.

A number of geotechnical factors have been identified. These factors will need to be addressed in further design phases and construction of the dam. These factors are:

- nearby active faulting and associated earthquake shaking
- abutment and reservoir slope instability
- settlement of compressible surface soils
- leakage through surface soils and terrace deposits and possibly bedded greywacke
- the quality of locally available low permeability fill and transitions zone material. This will need to be confirmed by further investigation and laboratory testing

There is one key issue which requires further investigation; namely the large scree slope/landslide on the right/eastern bank of the river which covers the right abutment of Site 2 (and the downstream toe of Site 1).

5.5 Preliminary Layout

Refer to **Component 2 Report: Storages Assessment** for detail.

The preliminary general layout that appears at this stage to be best suited to the site is roughly similar to that adopted for Nelson City's Maitai Dam.

It should be noted that the preliminary layout (and associated costing) does not provide for any additional large controlled release, which may possibly be required for the likes of flushing macrophytes from the riverbed in prolonged dry spells.

Principal components of the dam works are:

- a diversion culvert with twin barrels on the right bank terrace, founded on rock after subexcavation, initially to pass diversion flows during construction, and later one barrel carrying controlled discharges
- an intake tower with entry ports at about 8-10 m vertical intervals to allow highest quality water to be selected for controlled discharges
- the zoned embankment dam structure, including internal filters and drainage and wave armour or riprap over higher levels on the upstream face
- a left abutment concrete-lined chute spillway with terminal bucket, directing flow back into the river via an armoured plunge pool and taking flow from up to about a 200 year flood event prior to calling on the auxiliary spillway
- a left abutment auxiliary spillway channel with fuse plug embankments excavated at 1.25:1 slope up the ridge line (matching steepest natural slopes locally), the excavated material going into the embankment.

5.6 Construction Material Sources

Refer to **Component 2 Report: Storages Assessment** for detail.

The principal requirements for construction materials are as follows:

- concrete for structures, some 3500 m^3
- dam fill:
    - filter material: approx 15,000 m^3
    - riprap: approx 9000 m^3
    - low permeability fill: approx 45,000 m^3
    - bulk fill: 450,000 m^3

From the preliminary investigations it appears that most of the terrace gravels at the right abutment will need to be removed to provide a suitable foundation. Slip debris here will also need to be removed.

Based on the preliminary investigation work, these gravels appear to have potential to be processed and used as filters in the dam. However, after detailed investigation, that may prove not to be the case and a proportion of the required filter material may need to be imported from established quarries. This possibility has been factored into preliminary costing.

There is judged to be sufficient boulder material within the river bed at and upstream of the dam site, to satisfy riprap needs.

A substantial excavation will be required at the left abutment to provide for spillways and this area will be the prime source of borrow material (particularly bulk dam fill) for the dam embankment. The geotechnical investigations have indicated that there is in the order of 125,000m^3 gross of low permeability material available, compared to 45,000m^3 required.

It is expected that aggregates for concrete will be imported from established quarries, but depending on the quality of the right abutment gravels and extent of processing required for them, a contractor may consider using the local gravels and establishing a concrete plant on site.

5.7 Preliminary Operating Regime

Refer to **Component 1 Report: Water Demand and Availability** for detail.

Preliminary modelling shows that the Lee reservoir would be virtually full about 85% of the time, within 1 m of full about 91% of the time and within 5 m of full for about 97% of the time on long-term average assuming fully allocated supply.

Modelling has examined selected years for which hydrological data exist, and assessed what effect the presence of the dam and reservoir would have had, had the scheme been in existence at that time. A comparison of flows immediately below the Lee dam before and after dam construction for a sample period (1 July 1981 to 30 June 1983) shows that the pre-construction flows are represented by (and are the same as) the reservoir inflows. That is, the reservoir inflows or natural flows match the reservoir outflows for the majority of the time. Periods of flow augmentation provided by the reservoir in 1982 would have occurred between late January and early April, while in the 1983 drought year, flow augmentation would have been provided from early November (1982) to mid April (1983). Reservoir refilling would have occurred in periods where the reservoir inflow is higher than the reservoir outflow. The modelling showed a clear example of this in mid January 1983 where a fresh, peaking at about 10,000 l/s, would have been entirely captured to reservoir storage.

Modelling of the Wairoa River flows at Irvines before and after Lee dam construction shows little change most of the time, except over summer low flow periods during which the flow augmentation effects were apparent (outflow was higher than inflow 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 would have been 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.

5.8 Sedimentation Potential

Refer to **Component 1 Report: Water Demand and Availability** for detail.

The Wairoa River overall (as measured at Irvines) has a relatively low to moderate sediment load in comparison with other comparable rivers in New Zealand. The river transports the great majority of its sediment load during flood events. Flows below mean flow are virtually free of suspended sediment.

Over a 100 year period, the amount of sediment that would be trapped within a Lee reservoir (based on Site 11) is estimated to be about 600,000 m^3. This estimate assumes that the factors which control sediment generation, notably land-use, currently or in the future, are not significantly different from those in the immediate past.

5.9 Potential for Electricity Generation

Refer to **Component 2 Report: Storages Assessment** for detail.

There is potential for generating electricity as part of the scheme. The indicative economic potential is 1.2 MW capacity and 6.8 GWh/annum average.

5.10 Potential Effects on Existing Infrastructure

Site access up the Lee Valley is relatively straightforward and should present few difficulties for safe operation of construction traffic. Some upgrading of the final 3km of private access roading may be required.

TDC's Manager Property reports (April 2006) that there is legal road reserve extending on both sides of the river along the extent of the reservoir, including the main tributaries of Anslow Creek and Waterfall Creek. These roads would need to be stopped and would become esplanade reserve, provided that agreement could be reached with the affected parties. However legal access to several properties would disappear and the practicalities of obtaining alternative access would need to be investigated in later stages of the project.

Based on current information the following formed roads would potentially be affected by the proposed storage:

- Approximately 4-5km of formed road on the true left side of the river. However this road is largely private access to forest land, with public access being restricted by locked gate.

- Anslow Road - approximately 500m of this forestry road would be potentially affected by the reservoir. This road provides access to forestry land, and to Bush Road. The latter potentially provides access to Richmond Forest Park.
- Ford and forestry access road upstream of Waterfall Creek.

5.11 Alternative Water Distribution System – Piped Delivery

An assessment has been made of the potential for piping the abstractable flow from the dam to the existing Waimea East Irrigation Scheme pump station at the end of the Wairoa Gorge. This piped flow has been assessed at being approximately 1 m^3/s excluding environmental and groundwater component.

It has been assumed that the pipeline substantially remains in the road reserve, apart from a more difficult river edge alignment near the old cement works where the road is locally high. There would also be a need to cross the Lee River at the bottom end.

To deliver 1 m^3/s, a pipeline of about 750mm diameter is required for the first 5 km, reducing then to 600mm diameter.

5.12 Construction Period

It is estimated that the construction period would be at least two years.

6 Land Ownership – Site 11 Upper Lee

Information in this section is taken from a report from TDC's Manager Property dated 3 April 2006. It is based on an affected area to RL 195m, slightly higher than the current provisionally assessed affected area to RL 187m.

Owner	Approximate area affected by dam/reservoir (hectares)
David Leigh Irvine	0.87
Alexander Grant Irvine	7.98
Stanley Mitchell Irvine	28.61
JWJ Forestry Ltd	4.46
Land Information NZ	0.49
Forest Manager Crown	25.90
Department of Conservation	6.22

There appear to be no residences within the footprint of the dam and reservoir.

Phase II investigations should include optimisation studies of the dam site and top water level to assess the potential for avoiding key land areas (such as Department of Conservation estate and significant indigenous vegetation sites).

The Department of Conservation has separately advised that it has no record of any esplanade reserves adjacent to the Lee River in the area potentially affected by the dam and reservoir.

7 Preliminary Dam Breach Hazard Assessment – Site 11 Lee

Refer to **Component 2 Report: Storages Assessment** for detail.

7.1 Introduction

A preliminary dam breach analysis was undertaken by T&T based on the proposed dam site, dam type, and size (including reservoir capacity) for Site 11 Lee River.

The purpose and significance of carrying out a dam breach analysis for any proposed dam is primarily to help assessment of downstream hazard potential, which in turn guides the setting of standards to adopt for dam design, construction, operation, and ongoing monitoring and maintenance. The analyses are hypothetical and entirely divorced from the chances of a dam failure ever occurring.

Further, the Resource Management Act requires consideration of an effect of low probability but high potential impact. The key point which has to guide any decision under the Resource Management Act is the low probability of occurrence, and ensuring that the probability is indeed extremely small related to the degree to which the potential impact is "high". Consent conditions can be specified (i.e. adoption of NZSOLD Guidelines) to achieve this objective and meet the requirements of the Act.

The current issue of the New Zealand Dam Safety Guidelines (November 2000) adopts a potential impact classification (PIC) system to determine the appropriate design standards for the dam (for earthquake loading and safe flood passage) and the level of rigour 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 7.1 shows the definitions of Potential Impact Category adopted by the Guidelines.

Table 7.1 **Potential Impact Categories for Dams in Terms of Failure Consequences (New Zealand Dam Safety Guidelines, November 2000)**

Potential Impact Category (PIC)	Potential Incremental Consequences of Failure	
	Life	Socio-economic, Financial & Environmental
High	Fatalities	Catastrophic damages
Medium	A few fatalities are possible	Major damages
Low	No fatalities expected	Moderate damages
Very Low	No fatalities	Minimal damages beyond owner's property

Interpretative details on definition of the potential impact categories and their significance in terms of dam safety requirements are contained in "Regulations for the Dam Safety Scheme: Discussion Document" released by the Department of Building and Housing in

May 2006. Figures 6 and 7 from this document, reproduced below as Tables 7.2 and 7.3 respectively, provide an interpretation of both the classification categories and descriptors of 'catastrophic', 'major', 'moderate' and 'minimal' damages. It should be noted that these tables are currently going through some change but they provide a snapshot indication of likely categories.

Table 7.2 Incremental Consequences for PIC Categories for Use in Dam Classification Regulations

Population at risk (PAR)	Severity of damage and loss			
	Minimal	**Moderate**	**Major**	**Catastrophic**
0	Low	Low	Medium	High
1-10	Low (see notes 1 and 3 below)	Low (see notes 3 and 4 below)	Medium (see note 4 below)	High
11-100	(see note 1 below)	Medium (see notes 2 and 4 below)	High	High
More than 100		(see note 2 below)	High	High

The shaded area indicates the classification or PIC that should be chosen.

Note 1: *With a PAR of five or more people, it is unlikely that the severity of damage and loss will be 'minimal'.*
Note 2: *'Moderate' damage and loss would be unlikely where PAR exceeds 100.*
Note 3: *Change to 'medium' PIC where the potential for one identifiable life being lost is recognised or where the loss of itinerant lives is reasonably likely.*
Note 4: *Change to 'high' PIC where it is reasonably likely two or more non-itinerant lives will be lost.*

In the Discussion Document, the population at risk is defined as all those people who would be directly exposed to flood waters within the natural flood or dam break affected zone if they took no action to evacuate. An inundation depth of 0.3 metres or higher can be used as an indication of the area where population is at risk. This definition allows the incremental population at risk to be considered for flood conditions.

The Discussion Document states that in estimating the population at risk, consideration needs to be given to:

- groups of dwellings
- camping areas and occupancy rates
- allowance for itinerants, such as authorised fishers, trampers, picnickers, casual visitors or people travelling across the floodplain
- river crossings and bridges

- occupation of schools, factories, retirement homes, hospitals, institutions, and commercial and retail areas.

Table 7.3 Incremental Damage Descriptors Associated with Table 4.2 for Use in Dam Classification Regulations

Descriptor	Residential	Costs: socio-economic and financial	Environment	Recovery time
Catastrophic	More than 50 houses destroyed	Greater than $10 million	Permanent widespread ecological damage	Many years
Major	4-49 houses destroyed and a number of houses damaged	$1-10 million	Heavy ecological damage and costly restoration	Years
Moderate	1-2 houses damaged	$100,000-$1 million	Significant but recoverable ecological damage	Months
Minimal	No damage	Less than $100,000	Short-term damage	Days to weeks

The following sub-sections summarise an approximate and preliminary assessment of the potential flood hazard in the event of a breach of the potential storage dam on the Lee River, which is a tributary of the Wairoa and Waimea Rivers.

The dam currently being considered is an earthfill embankment which would impound a full storage of 13 million m³ with a normal top water level of about RL 183 m, which is about 46 m above the river bed level. This current analysis is based on those essential characteristics.

Brightwater and Wakefield are the closest towns and lie to the north and north-west of the dam site respectively.

7.2 Hydraulic Assessment

As is normal practice for dam breach analyses, a "sunny day" failure scenario (resulting from an event such as an extreme earthquake) rather than a flood-induced failure, has been considered. In terms of incremental damages from a dam failure, the former has significantly greater potential consequences. Part of the reason for this is that there is little or no warning of the sunny-day event, whereas the flood-induced failure occurs in the context of a major meteorological event with consequently more warning and heightened awareness for potential dam failure. Warning and evacuation time can dramatically influence the loss of life in such an event.

Despite this, given the extensive stopbanking in the lower reaches of the river (Waimea River floodplain), a dam failure induced by an extreme flood event could result in significant incremental damages (i.e. damages over and above that caused by the flood by itself without the dam failing). That is, the flow surge released on dam failure added to a natural flood flow would likely result in overtopping and breaching of the stopbanks. This secondary or consequential failure scenario has not been considered in the current assessment but should be investigated in subsequent more detailed hazard studies in subsequent phases of the overall investigation programme.

For this phase of the investigation, two breach options have been considered. The first, more severe scenario (Upper Bound Case) assumed that the period to develop the full breach was 1.0 hours. This is a very short time (worst-case) for a well-constructed earth embankment built using from high strength greywacke material as proposed here. The Base Case scenario considered a more moderate (and perhaps more credible) failure scenario, which assumed the full breach developed over 2.5 hours. The reservoir was assumed to be full but not spilling at breach initiation. These two breach scenarios are expected to encompass the potential flood wave from a full reservoir in the event of dam failure.

The Upper Bound Case (1 hour failure) resulted in a peak discharge at the base of the dam of 6,210 m^3/s. In the Base Case (2.5 hour failure) the simulated peak flow was about a third lower at 4,170 m^3/s.

The HEC-RAS hydraulic modelling package, produced by the US Army Corp of Engineers, was used for routing the flood wave down the Lee River to the Wairoa Gorge and to the sea.

It should be noted that the available data for setting up the model is very limited and there is considerable uncertainty in the ground surface representation, particularly in the flatter and wider floodplain areas downstream of the Wairoa Gorge. Nevertheless, the modelling still gives a reasonable indication of the flood wave attenuation down the valley and the peak discharges at various locations. Since the narrower sections of the valley have generally been used in the model representation of the river channel, the model would likely under-predict the attenuation in the flood wave as it progresses downstream and over-predict the maximum flood heights. Thus, the peak water level and peak flow results are likely to be conservative (i.e. high, tending towards worst-case).

At the confluence of the Wairoa and Lee Rivers, the peak flow of 4,830 m^3/s in the 1 hour dambreak and 3,620 m^3/s in the 2.5 hour dambreak is, respectively, 3.1 and 2.3 times as great as the natural 100 year return period flow (1570 m^3/s). Such flows are likely of the same order of magnitude as the Probable Maximum Flood. Further downstream, the model predicts significant attenuation in the peak flow in the 5 km reach between the Gorge exit and Aldourie Road. Peak flows in both scenarios are between 1800 m^3/s and 2200 m^3/s in the lowermost reach from Aldourie Rd to the sea, which would be comparable with the natural 100 year return period flood.

In the Upper Bound Case (1 hour dam failure), the outflow from the reservoir increases rapidly, and very high flows last for about one hour. The reservoir effectively empties in 1 hour and 20 minutes.

In the Base Case (2.5 hour dam failure), high outflows from the breach persist for about 1.5 hours, and the reservoir empties in about 2 hours.

In comparison to these historic floods, the peak flows from the two dam failure scenarios considered here are some 2.5 to 3.3 times as great as that recorded in the 1986 flood (at the Wairoa Gorge).

7.3 Potential Impact Categorisation

The following is a discussion and assessment of the downstream hazard potential <u>if</u> the dam were breached. To put this discussion into proper context, it is essential to draw the distinction between hazard potential (that is the effect of the dam breach were it to occur) and the risk or chances of the dam breach actually occurring. As noted earlier, the failure risk for a dam engineered and built to appropriate standards (per NZSOLD Guidelines), as would be the case for this proposal, would be extremely low.

A dam breach creates a flood wave that rises very rapidly, has a high peak flow but is relatively short-lived. As such there would generally be a short lead time for warning and for people and any stock to be evacuated to safer ground.

In the 13 km reach of river between the dam site and the Wairoa Gorge the river is relatively confined, and the maximum flood level above normal water level ranges from 12.5 m to 18 m. Therefore, several of the few building sites flanking the river, which may appear to be above natural flood inundation levels, could be at risk if the dam breach were to occur. Peak flow velocities would also be very high.

Down as far as the guide camp (Paretai Lodge), which is located about 10 km downstream from the dam site, there are a further 8 to 12 habitable buildings on the flanks of the Lee River. Between the guide camp and the confluence of the Lee and Wairoa Rivers, there are possibly 5 to 8 more dwellings sited close to the river. Detailed survey and more refined hydraulic modelling will be necessary to determine how many and to what extent these dwellings would be at risk from inundation in a dam breach. However, it is clear that several buildings (as distinct from dwellings) would definitely be at risk.

Parts of Mead Road, which serves a number of properties on the right bank of the Lee River, are very low-lying (in the context of inundation from a dam breach) and would likely be severely damaged in the event of a dam breach. Thus, access to these properties would be cut-off.

Below the confluence of the Lee and Wairoa Rivers, many more habitable buildings are potentially located within the floodpath of a dam breach. It is anticipated that there will be widespread flooding and property damage, and this would include the township of Brightwater. However, except for the 1.5 km long reach between the confluence and the gorge exit, the general expectation is that flooding would not be to life-threatening levels in most areas. Detailed survey and sophisticated hydraulic modelling will be required in subsequent phases of the project to ascertain and map the hazard in the floodplain below the Wairoa Gorge.

From the foregoing assessment of breach scenarios and discussion on damage potential, it appears that **if** a dam breach were to occur, there is potential for fatalities to occur, as well as very major damages. Accordingly, it is recommended that the potential dam on the Lee River be classified as a **High** Potential Impact Category dam. Design, construction, maintenance and ongoing monitoring should therefore be undertaken in accordance with the requirements set out in the NZSOLD Dam Safety Guidelines for a High Potential Impact Category dam.

7.4 Dam Break Avoidance or Mitigation

The Resource Management Act requires that any adverse effects on the environment from the proposed development, potential or actual, be avoided, remedied or mitigated. In this context, dam breach, as a potential adverse effect, may be avoided or mitigated as far as practicable by adopting the suitably conservative design standards for a High Potential Impact Category per the NZSOLD Dam Safety Guidelines.

8 Cost Estimate – Site 11 Lee

An assessment has been made of the raw capital cost of the potential scheme as described in Section 5. The indicative cost based on information available at this stage of the project, is as follows:

- Between $20 - $25 million confidence limits. This range represents a range in contingencies of 10% to 30% respectively.

This provides for:

- Access road upgrade and contractors' working area
- Power supply/communications to site
- Stripping to waste/stockpile, dam footprint and borrow areas
- Rehabilitation of exposed borrow areas and dam surrounds
- Dam fill, drainage and armour (six sub-items)
- Extra allowance for special drainage zones adjacent
- Clearing of reservoir area
- Reservoir access road upgrading
- New bridge at head of reservoir
- Cofferdams/dewatering and flood risk allowance
- Plunge pool armouring
- Diversion/conveyance structure
- Diversion structure headwalls, furniture
- Temporary energy dissipation during construction
- Spillway works
- Access bridge over spillway
- Extra for spillway chute anchoring/drainage
- Dam instrumentation
- Intake tower
- Pipework valving, ventilation, screens and ancillaries ($2m^3/s$ max discharge)
- Miscellaneous small items allowance
- Contractor establishment, engineering and 10-30% contingency/uncertainty allowance.

This cost excludes:

- financing costs
- legal and developer administration
- land acquisition

- RMA process
- any hydro add-on costs
- extra flow release requirements for flushing purposes

Should the piped option be adopted (see Section 5.11) there would be an additional cost of about $6.5M (pipeline from the dam to the existing Waimea East Irrigation Scheme pump station at the end of the Wairoa Gorge).

This overall cost estimate is based on Phase I (preliminary) level investigations only – further refinement is dependent on the outcome of feasibility level investigations which requires more refined sizing of components as part of Phase II investigations. Major identifiable uncertainties at this stage include:

- The accuracy of contour information (influencing dam height and earthworks volumes)
- Any requirements imposed on diversion and flood capacities
- Outcome of any independent peer review
- The outcome of more detailed geotechnical investigations confirming abutment conditions (potential for right abutment geology to be more complex than indicated to date)
- Whether the right abutment gravels can be utilised for filters after processing or whether some filter material may need to be imported to site
- Whether new reservoir roading proves more extensive than assumed
- The requirement for mitigation measures involving significant cost
- Price fluctuations for fuel or other materials which affect schedule item prices
- Contractor availability/demand at the time of tendering which may impact pricing and/or programme
- Local (district) specific issues relating to contractor pricing and timing.

9 Cultural Impact Assessment

Refer to **Component 3 Report: Environmental and Economic Assessment** for detail.

The Motueka Iwi Resource Management Advisory Komiti (MIRMAK) has commenced a cultural impact assessment for the project. The report of the work for this phase of the investigations addressed generic issues facing a potential development in either the Lee or the Wairoa catchments. It did not focus on any differences between the sites.

Tangata Whenua have advised WWAC in their report that the process of cultural impact assessment will continue at least until such time as the issues raised by Tangata Whenua have been fully addressed.

A summary of some of the main issues raised is as follows:

- The potential for the scheme to improve flows, life-supporting capacity & spiritual values is queried unless appropriate measures are put in place
- CIA supports the moves to increase water flows as long as it is beneficial to the river and other problems are not created
- Iwi consider that the scheme may result in further intensification of landuse with potential for worsening water quality
- Concern expressed about the potential for toxic sediment from the catchments to accumulate in the reservoir and affect water quality in the reservoir and downstream river
- Potential increase in biosecurity risks
- Potential reduction in water quality in the Waimea Estuary as result of landuse intensification
- Loss of native vegetation
- Loss of wetlands
- Loss of native birdlife
- Effect of exotic forestry on water yields
- Effect of vegetation in reservoir (methane production) if not cleared prior to reservoir filling
- Effects of climate change on water yield and drought frequency
- Increase in pesticide etc use as a result of landuse intensification
- Tino rangitiratanga
- Kaitiakitanga
- Manaakitanga
- Potential effect on people's health from landuse intensification
- There needs to be equitable and fair water allocation
- Consideration needs to be given to alternatives and water conservation measures

- Potential loss of mahinga kai and rongoa – design of scheme needs to consider opportunities for mahinga kai
- Potential loss of commercial opportunities
- Need to look at crop suitability for the area and the various crops' water demand.

Fifteen recommendations were made by Tangata Whenua in the CIA. WWAC's response at this stage of the project is also noted below.

1. Recommendation 6.0 – A clause was requested to be inserted in any future resource consent that future outcomes under the Treaty of Waitangi will be recognised.

   Response: The appropriateness of this will be assessed at the time of any consent process.

2. Recommendation 6.1 – Carry out a risk assessment of ultramafic sediments to determine potential for effect on water quality.

   Response: An initial assessment has been completed. The catchment above the preferred site (Site 11 Upper Lee) does not contain ultramafic sediments.

3. Recommendation 6.2 – Develop wetlands in dam bounds, for the mitigation of biodiversity losses as well as protect the dam from siltation.

   Response: WWAC is happy to consider this possibility. The potential for this will be addressed in later stages of the project.

4. Recommendation 6.3 – Develop fish and waterfowl passage.

   Response: This issue has been preliminarily addressed in the current study. Further consideration will be given in later stages of the project.

5. Recommendation 6.4 - Develop a biodiversity and rongoa restoration plan

   Response: WWAC supported this proposal. The potential for this will be addressed in later stages of the project.

6. Recommendation 6.5 - Develop a native bird recovery plan

   Response: The potential for this will be addressed in later stages of the project. To be considered in conjunction with DOC initiatives.

7. Recommendation 6.6 - Develop a mahinga kai harvest and maintenance plan

   Response: WWAC supported this proposal. To be considered at later stages of the project, in conjunction with other plans.

8. Recommendation 6.7 - Develop set of iwi environmental indicators

   Response: WWAC happy for iwi to consider developing environmental indicators alongside scientific indicators for monitoring.

9. Recommendation 6.8– Carry out 'taonga survey' once final site chosen.

   Response: To be included in second phase of investigations as part of specific effects assessment. There is the potential for identification of taonga to influence design aspects in later stages. The map in the CIA report to date shows no specific taonga in the areas that would be directly affected by the dam or reservoir.

10. Recommendation 6.9– Promote or require the protection of native vegetation.

Response: WWAC has neither the ability nor the responsibility to promote native vegetation protection on private land. However, minimising the effect of the dam and reservoir footprints on native vegetation is being considered.

11. Recommendation 6.10 - Promote or require the development of treatment wetlands

    Response: WWAC agreed that the creation of wetland systems to treat farm runoff was a positive idea. However, it is not the responsibility of WWAC to seek creation of wetlands on private land. However the creation of wetlands within the reservoir can be considered.

12. Recommendation 6.11 - Develop plantations for supply of non-toxic posts.

    Response: WWAC acknowledged that the use of large numbers of treated posts for horticulture is an issue in parts of New Zealand. However it is not WWAC's responsibility or role to address this issue.

13. Recommendation 6.12 - Provide for Waimea catchment mitigation fund.

    Response: WWAC considered that if the proposal were well designed, that it would provide a form of mitigation in itself.

14. Recommendation 6.13 - Involve tangata whenua in implementation of recommendations.

    Response: WWAC endorsed iwi involvement in the implementation of the recommendations (in particular), and the continuing process (in general).

15. Recommendation 6.14 - Provide for tangata whenua as shareholder in scheme.

    Response: WWAC expressed its intrigue at the recommendation. Ways this might be able to be achieved will be considered through further dialogue.

10 Aquatic Ecology

10.1 Introduction

Cawthron has prepared three reports for this phase of the investigations. Each of these is presented in the accompanying **Component 3 Report: Environmental and Economic Assessment**.

Cawthron's three reports are:

- Review of biological data relating to the Waimea River Catchment.
- Instream Habitat Flow Analysis for the Waimea River and Provisional Minimum Flows for the Proposed Dam Sites in the Upper Wairoa and Lee Catchments.
- Issues and Mitigation Options Associated with Storage in the Lee River.

The main points are summarised in the following sections.

10.2 Review of Available Data

This review was undertaken at the commencement of the overall project to collate all known information on the rivers of the Waimea Catchment, and to identify information gaps and potential issues for follow-up work. The main conclusions of the report that are relevant to the present stage of investigations are as follows:

- The rivers of the Waimea Catchment generally are characterised by good water quality although there are some concerns with nutrient enrichment and faecal contamination in the Wai-iti River.
- Elevated water temperatures occur, especially during prolonged periods of low flow in summer.
- The Wairoa River's macro-invertebrate community does not appear to contain any rare or endangered species.
- The Wairoa River's fish community is considered to be of regional importance due to its diversity and includes dwarf galaxias and longfin eel, both classified as chronically threatened by the Department of Conservation.
- Unsightly accumulations of algae are common in the Waimea River, and in the lower reaches of the Roding, Wairoa, and Wai-iti rivers.
- There is a relatively large amount of information available on the Waimea River, Roding River and on the lower reaches of the Waimea and Wai-iti rivers.
- Little is known about the water quality, macroinvertebrates, or algae present ion the Left and Right Branches of the Wairoa River, the upper Lee River or the tributaries of the Wai-iti River.
- Records of fish distribution are reasonably well-spread.
- Native fish species recorded in the Lee River are:
    - Koura (freshwater crayfish) - in upper Lee River. Koura are listed by DOC as one of the aquatic values of this area.
    - Koaro

- ➢ bluegill bully
- ➢ redfin bully (upper and mid Lee)
- ➢ shortfin eel
- ➢ longfin eel.

All of the fish species recorded are diadromous (ie they spend part of their life cycle in the sea and part in freshwater). They therefore require access to the sea at some stage of their life cycle, and conversely must be able to negotiate any obstacle to their upstream passage if they are to reach habitat higher in the catchment.

- Brown trout are present in the Lee River. Recent drift diving by Fish and Game recorded 26.3 medium and large trout per kilometre of river.
- There is a lack of information on the distribution of blue duck in the catchment (see also Section 12 of this report).
- There is the potential for positive effects from water augmentation such as the ability to maintain higher minimum flows ion the lower river during dry periods.
- Potential negative effects include disruption to fish passage, changes to flow regimes, changes to water quality and temperature regime, and submersion of river and river margin habitats behind the storage dam.

10.3 Instream Habitat Flow Analysis

Cawthron assessed the minimum flows required to provide instream habitat in the Waimea River and at two potential alternative dam sites (Sites 11 and 15).

Three alternative minimum flows were derived 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.

Instream flow requirements for the section of the Waimea River upstream of the Appleby Bridge were assessed using physical habitat modelling within the Instream Flow Incremental Methodology (IFIM). The proposed minimum flows provided for this reach were based on maintenance of adult brown trout habitat. Providing adequate habitat for brown trout should also provide for the flow needs of other species, including most native fish species.

The following minimum flows were proposed for the Waimea River immediately upstream of the Appleby Bridge:

- Environmental benchmark: 1300 litres/sec
- Retention of 70% of adult brown trout habitat at the natural Mean Annual Low Flow (MALF): 500 litres/sec
- Retention of 80% of adult brown trout habitat at the natural Mean Annual Low Flow (MALF): 800 litres/sec.

Maintenance of the existing MALF was suggested as the environmental benchmark minimum flow immediately below the potential dam site(s). More conservative options would be adoption of the 1 in 10 year low flow, and the 1 in 5 year low flow.

WWAC's selection of minimum flows for the purposes of the hydrological modelling has been described in Section 3.3 of this report.

10.4 Issues and Mitigation Options for a Lee Storage

Cawthron's third report focussed solely on issues relating to the preferred site, Site 11 Lee River. It addressed the potential effects of the proposed storage on the flow regime downstream of the dam based on preliminary hydrological modelling, water quality in and downstream of the reservoir, and fish passage past the dam structure.

The main conclusions are:

Effect of changed river flow regime

- The effect of the dam on flows in the Wairoa River downstream of the confluence with the Lee, and in the Waimea River, is expected to be largely positive with higher minimum flows predicted during summer. This effect would be more pronounced in the Lee River with substantially higher minimum flows in summer than at present.
- These higher flows are expected to have positive ecological effects.
- Flows in the Lee River could be "flat-lined" for extended periods in summer and autumn with any small natural freshes during this period being captured within the reservoir.
- The likelihood of nuisance algal growths occurring after the augmentation scheme is put in place is relatively low. However if algal growth did become a problem, flushing flows equivalent to 6-8 times the base flow (ie 3-4 m^3/sec) may be necessary once or twice per year to remove accumulations of algae.
- The loss of natural freshes may also affect fish migrations which are often associated with high flows.
- Changes in the level of augmentation from the reservoir have the potential to result in sudden decreases in flow in the Lee River. The effect of these reductions depends on how suddenly they occur and their effects could be minimised by 'ramping' flow down over several hours.
- Sediment will be impounded behind the dam, reducing sediment supply below the dam. This could lead to bed armouring which may encourage periphyton proliferation and reduce availability of gravels for trout spawning. However the coarser substrate size and greater substrate stability may be beneficial for benthic invertebrate production, as long as they are not smothered by excessive periphyton growth.
- Sediment could be periodically dredged from behind the dam and placed downstream so that it is carried downstream with subsequent flood events.

Water Quality

- The Lee River currently has high water quality. Impacts of construction and operation of the proposed storage need to be minimised through good construction techniques and sediment control measures to avoid negative effects on ecological, cultural, recreational and abstractive values of the water in the reservoir and/or downstream. However effects are likely to be short-lived since any deposited sediment should flush out of the system reasonably rapidly once construction is completed.

- Generally the longer water is retained in a reservoir, the greater the potential effects on water quality. Based on preliminary hydrological modelling, the average residence time for water stored in the reservoir will be around six weeks which is more than sufficient for thermal stratification of the impounded water, deoxygenation of the bottom waters, and for phytoplankton blooms to develop.
- Mitigation measures can be put in place to minimise the effects on water quality, such as manipulating the level from which released water is sourced, and use of multiple release levels. Thorough removal of terrestrial vegetation and topsoil from the reservoir footprint prior to filling will reduce potential deoxygenation and nutrient release.
- The geology of the Lee catchment above the proposed reservoir does not include ultramafic rock so adverse effects related to geochemistry of the catchment are unlikely.

Reservoir levels

- Based on preliminary hydrological modelling it appears that the operation of the augmentation scheme will see fluctuations in the water level behind the dam. This will limit the development of a productive ecosystem within the reservoir and may result in some erosion along the shoreline. These variations are inevitable, given the function of the reservoir. However a drought management plan will help to mitigate the effects of lake level fluctuations.

Fish passage

- Five species of fish found in the vicinity of the proposed Lee dam site require access to and from the sea during part of their life-cycle. If upstream migration is blocked by the dam, the self-sustaining fish community in the reservoir and upstream would be restricted to brown trout, upland bullies and possibly land-locked koaro. Remnant populations of other species upstream of the dam would either die out or migrate downstream.
- At a structure as high as the proposed dam (49m) it is only practical to provide upstream access for the strongest of migrants such as elvers and young koaro.
- A fish pass could be developed as part of the spillway to provide an uninterrupted wet surface that leads from the downstream base of the dam to permanent water in the reservoir. During periods when the reservoir is not completely full and spilling, a small flow of water would need to be pumped across the crest to form a continuous wetted surface.
- An alternative trap and transfer system could also be developed to manually move fish over the dam crest. However a manual system would require continual effort and maintenance.
- Downstream migration of fish will probably only occur in periods in autumn when water is released through the spillway. However many natural autumn freshes may be captured within the reservoir as water levels recover following flow augmentation over the summer. Therefore spilling is likely to occur only in wet years. If successive dry years result in no spilling during autumn, the only feasible option for downstream migration would be to trap migrants and manually transfer them down over the dam wall.

11 Indigenous Vegetation

Refer to **Component 3 Report: Environmental and Economic Assessment** for detail.

An assessment of the indigenous vegetation values of the footprint of the potential dam and reservoir at Site 11 Upper Lee, and downstream values likely to be affected by changed flow regime was undertaken by Uruwhenua Botanicals.

The assessment was based on an assumed top water level of RL 195m (based on original assumed required storage volume of 15 million m^3). This level is slightly higher than that for the adopted storage volume of 13 million m^3. It therefore presents a 'worst-case' scenario, including conservatism for 'edge effects'.

The focus of the work at the stage it was undertaken was on a comparative assessment between the two sites then being considered (Site 11 Lee and Site 15 Wairoa). It is not a detailed botanical survey, and has made no attempt to put the significance of the vegetation into a regional context (ie whether eventual loss is likely overall to be a significant issue).

The survey involved identifying areas of natural vegetation within the catchments. Those that were of a reasonable size and significance were mapped. Many other smaller areas may also exist.

Findings relevant to Site 11 Lee River are summarised below (findings relevant to Site 15 Left (eastern) Branch Wairoa are summarised in the appendices to accompanying **Component 2 Report: Storages Assessment** and presented in full in **Component 3 Report: Environmental and Economic Assessment**.

The Lee Catchment has a generally lower altitude, more gentle, even slopes, and greater tendency to create river flats.

- The Lee may offer a more favourable environment for ecological diversity and vegetation development.
- Of the total Lee Catchment, only approximately 12% has been cleared.
- Natural areas in the Lee are scattered along the valley in small areas.
- The mineral belt band of ultramafic rocks crosses the catchment downstream from the proposed dam site. The vegetation associated with this band has largely been disturbed by fire.
- The catchment is very weedy in its lower reaches.

Significant sites:

- Immediately downstream of dam site: High quality native vegetation begins a few hundred metres below the proposed dam site and extends upriver; eg at confluence of Lucy Creek and Lee River. This area may not be influenced by the dam but could be damaged by construction activities.
- Site 1 – dam site and upstream: 3-4 ha. Overall significance = medium (including high rank for rarity). Extends from the dam site upstream for 1 km on both sides of river. Variety of original and secondary riparian flat forest and rocky gorge habitat. All would be inundated.

- Site 2: 3-4 ha. Overall significance = medium to high (including high representativeness). Is riparian as well as hill slope. All but the mid to upper part of the gully at the southern end would be inundated.
- Site 3: 4 ha – Waterfall Creek flat and riparian forest. Overall significance = high (including high representativeness, high rarity, high diversity and pattern, high distinctiveness/special ecological characteristics, and high sustainability). High ecological value – is a remnant of regenerating kahikatea forest with a unique understorey. All would be inundated.
- Site 4: 4 ha. Riparian forest zone of beech and kahikatea. Overall significance = medium to high (including high connectivity and sustainability). All but the upper left bank slope would be inundated.
- Site 5: Extensive area at head of reservoir, grading to continuous original forest. Overall significance = high (including high representativeness, high diversity and pattern, high size and shape, high connectivity, and high sustainability). The potential reservoir would form a narrow, shallow waterway that would inundate the immediate riparian zone for approximately 1km but will have little overall impact on the forest.
- Downstream impacts: At issue is whether a changed flow regime will alter the habitat of species which require regular flooding to keep the site open from colonisation by exotic weeds. Low flow periods may be extended but it is doubtful that the river flowing over bedrock will influence the water regime along its bank. Plants growing on rock in the flood zone are regularly exposed to dry conditions and are adapted to them. The reservoir may alter the flooding pattern and will halt downstream movement of rocks and logs. It is probable that the bed-rock nature of the river will minimise changes in the riverbed and adjacent riparian zone.

12 Blue duck (whio)

Refer to **Component 3 Report: Environmental and Economic Assessment** for detail.

A survey in the area of the Lee and Wairoa Catchments likely to be affected by the potential reservoir was undertaken in November 2005 by Dave Barker.

No blue duck or sign of blue duck was found in either catchment.

The Department of Conservation (Peter Gaze) has commented on the above survey findings as follows:

"The findings presented in this report should be considered in the light of what we know about blue duck in the Richmond Range over recent times. Twenty years ago blue duck were regularly encountered in all of the major catchments – Pelorus, Wakamarina, Timms, Goulter, Motueka and Wairoa as well as minor catchments such as the Brook, Maitai, Lee and Roding. Whether they bred in all these catchments is not known. Over this period sightings have become less widespread and less frequent. These observations are consistent with what is known of trends elsewhere in the country – breeding productivity is low because of egg predation and while adults may live to an old age, females are often killed on the nest.

During the last 20 years blue duck were occasionally recorded from the Lee and Wairoa, sometimes well downstream of the bush boundary (Hay & Young 2005). These were usually single birds and I am unaware of any breeding records.

Dam construction and loss of river habitat could only have an adverse effect on this relict population of blue duck in the Richmond Range. However the significance of this would be small given the continued decline of the population through predation. A predator control operation would not make these rivers safer for dispersing birds but would be beneficial if a pair chose to breed.

The expense of establishing and maintaining a predator control operation of sufficient size to benefit blue duck at this location could probably only be justified if it was supplemented by the introduction of captively raised young birds. Mitigation of this nature would be more effective if directed at supplementing blue duck conservation work currently undertaken elsewhere.

The Department of Conservation is focusing its work on eight sites throughout the country, each of which will be managed to support at least 50 pair of blue duck. The Wangapeka/Fyfe catchments is one of these sites and, although resources are only available to manage a small part at present, this work has seen numbers in the lower Wangapeka rise from three to almost thirty in less than four years.

The Wangapeka/Fyfe operation now has the infrastructure to ensure that any additional resources can immediately be used to extend the area of protected habitat and the size of this population."

13 Archaeology/Heritage Values

TDC records show no specific sites of significance in the potentially affected area. Iwi have recommended that a taonga survey be undertaken in the next phase of investigations.

The "Inventory and Maps of Important Geological Sites and Landforms in the Nelson and Marlborough Regions, including the Kaikoura District" shows no sites in the area potentially affected by the storage system.

14 Potential Effects on Recreation

Refer to **Component 3 Report: Environmental and Economic Assessment** for detail.

The lower Lee Valley is a popular recreational resource. However this part of the upper Lee Valley appears to be of lower value, largely due to its lack of access (a locked gate exists at the Cement Works).

Specific comments are as follows:

Informal recreation

- It is unlikely that there are any picnic sites within the stretch of river that would be directly affected by the storage reservoir.
- There are several picnic areas in the lower Lee Valley, as well as the Regional Girl Guide Lodge.

Kayaking (Ron Wastney, Training and Conservation Officer Nelson Canoe Club, pers. comm.)

- The stretch of river that would be directly affected by the storage reservoir is of low value for kayaking. The stretch from the Cement Works downstream is of medium value for kayaking (Class 2-3 rapids when the river is high).
- Parts of it are used by beginners, but it is not high value to serious kayakers.
- Above the Cement Works the river is mostly gorge and access is difficult. Even at relatively easy river flows it is dangerous (Class 4-5 rapids during a fresh – is a very technical paddle).
- Creation of a dam on the Lee River is unlikely to draw much (if any) opposition from kayakers.

Trout fishing

- The Lee is not as significant a trout fishing river as the Wairoa, due largely to difficult access. It is smaller than the Wairoa and is perceived to hold fewer fish, although the fish are of good size (Grant Irvine, local angler, pers. comm. as reported by Cawthron).
- It is expected that lack of access to the upper reaches restricts fishing in the reach potentially affected by the storage system. It is not known how far trout move up the system (Neil Deans, F&G pers. comm.).

Richmond Forest Park access

- Anslow Road and Bush Road provide some access to Richmond Forest Park. Legal access to the Park exists up the true right bank of the Lee River, although few people either know this or use the access. The valley provides an emergency exit point from the Park. (Neil Deans, F&G pers. comm.).
- The NZMS 260 topographic map also shows a track on the eastern side of the river and "Waterfall Creek Hut". The significance of this to trampers and hunters would need to be determined during further investigations, although we understand the hut may no longer exist.

15 Community Issues

15.1 Introduction

Assessment of community issues and values was not part of T&T's Phase I brief. However, WWAC undertook a preliminary assessment of these issues through separate contracts and processes. The results (provided by TDC/WWAC) are included in this report for completeness, and because they guided some of the Phase I investigations undertaken by T&T.

15.2 Values of Lee and Wairoa Valleys

Refer to **Component 3 Report: Environmental and Economic Assessment** for detail.

Under a separate contract with WWAC/TDC, ESR undertook a community survey on the values of the Lee and Wairoa River Valleys. Many of the comments were made generally about the Lee and/or Wairoa Rivers and may not necessarily be specific to Site 11. In general we expect it is fair to conclude that most comments would apply to the middle or lower Lee, rather than the upper, which is not generally accessible, and is unpopulated.

The main values of the river(s) were expressed as follows:

- intrinsic values of the river itself
- significant recreational asset
- habitat values (instream and terrestrial)
- sense of identity (for valley residents)
- easy access and proximity
- contrast to urban environment

ESR's work with Lee Valley residents showed a perception that any water storage system large enough for power generation would pose an additional risk to downstream residents.

The most important stretch of the river for Lee Valley residents was expressed as being the area up to the Cement Works (Ann Winstanley pers. comm.). ESR's work also showed that Lee Valley residents who did not want to see storage options detracting from their enjoyment of the area, also stated that they appreciated that water is needed on the Waimea Plains (ESR report).

The most important stretch of the river for other general residents (expressed to ESR via the family survey) is from the Mead Road bridge down to the Wairoa confluence (ie the lower Lee).

15.3 Community Views on Water Augmentation

Refer to **Component 3 Report: Environmental and Economic Assessment** for detail.

In October 2006 WWAC distributed a survey to all ratepayers in Richmond and the Waimea Plains. There were 434 responses received.

The results of the survey (as provided by TDC) that are particularly relevant to the Phase I investigations programme are summarised as follows:

- 97% of respondents were aware of water shortages
- 75.5% of respondents support a storage option (dam)
- There was a high level of knowledge about water shortage issues
- There was a high level of knowledge about the water storage option

Important concerns about dams were raised, specifically as follows:

- safety issues, including earthquake risk, potential dam failure/flooding, engineering and construction
- cost and funding, include cost-effectiveness
- minimising environmental effects, keeping rivers in good health, and the effect of a dam on fishing
- the dam needs to be in an appropriate location, and be big enough to cater for long-term requirements
- recreational opportunities need to be provided for around the dam (survival of fish, improvement of river health, public access, white water amenity).

15.4 Community Consultation

Community liaison was not part of the study team's current Phase I brief. However it is noted that WWAC and TDC have separately conducted consultation with parts of the local community over the potential for water augmentation. This has comprised public meetings, meetings of Wairoa and Lee Valley residents, and establishment of a Wairoa and Lee Valley Community Liaison Group.

Key stakeholder groups are also represented on WWAC (representatives of water user groups, Tasman District Councillors, Department of Conservation, a Tangata Whenua representative, Fish and Game, and Nelson City Council staff). These representatives have provided key feedback and input to the study.

16 Planning Issues

A preliminary assessment of the augmentation scheme has been undertaken with regard to planning issues. See also Section 18 of this report. These issues will need to be explored further in Phase II investigations, as the project develops.

Under the Tasman Resource Management Plan (TRMP), the storage site for Site 11 Upper Lee is mainly zoned Rural 2, apart from the top end of reservoir which is zoned Conservation (Mt Richmond Forest Park).

There are no denotations on the TRMP Area Maps.

There appear to be no obvious inconsistencies with the objectives and policies for the Zones. Special attention will however need to be paid to the following objectives:

- maintenance of public access to and along margins of rivers which are of recreational value (objective 8.1.0)
- protection and enhancement of biological diversity and integrity of terrestrial, freshwater and coastal ecosystems, communities and species (objective 10.1A.0)

Site 11 is within the Upper Catchments Water Management Zone. Development of the scheme will require a range of consents, mainly for discretionary activities, with the exception as noted below:

- to be a Discretionary Activity, the total amount of water taken (between November and April each year) either by the scheme or in combination with other takes, must not exceed 3 l/s. Takes above this limit are non-complying (ie the resource consent process will need to pass a higher threshold test).

Water management objectives for the Lee River (TRMP Schedule 30.1) include:

- provide for protection of instream values including fisheries and natural values
- provide for recreation in the Lee (and Roding) River
- maintain contribution to Waimea River flows
- protect landscape, cultural and spiritual values
- maintain or improve existing users' security of supply to acceptable level.

17 Economic Analysis – Site 11 Upper Lee

17.1 Introduction

Refer to **Component 3 Report: Environmental and Economic Assessment** for detail.

Crighton Anderson undertook a preliminary economic assessment of the storage option for Site 11 Upper Lee. The overall objective was to assess the high-level economic feasibility of the potential development on the basis of two factors:

- Capital cost of augmentation – on a per hectare basis
- Opportunity cost of non-augmentation – an assessment of the economic costs that would result if the scheme did not proceed and there was a reduction in the security of supply for existing water users.

17.2 Capital Cost of Augmentation

The assessment of the capital cost of augmentation assumed the following:

- Total capital cost of $23 million (including a nominal allowance for land purchase). This cost assumes water is transferred from the reservoir via the river system (ie excludes any costs associated with piped delivery), and excludes any costs associated with delivery infrastructure beyond the bottom of the Wairoa Gorge
- Two year construction period
- Funding method and cost – 8.7%
- Standard corporate taxation
- 70% of the total capital cost should be met by consumptive users, and 30% met by the wider community for environmental flows (through possibly a general rate struck by TDC)

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 four charging regimes:

- **Existing Irrigation Users:** Costs are assumed to be met by existing irrigators only. This is the equivalent of apportioning costs over an area of 3,265 hectares.
- **All Existing Users:** All costs are met by existing consumptive water users (existing irrigators (3,265 hectares) plus urban / industrial demand (420 hectares)). Total effective demand equals 3,685 hectares, when expressed on the basis of water demand equal to 35 mm/ha/wk.
- **Existing Irrigation Users Plus New Irrigation**: Costs are uniformly allocated between existing irrigators (3,265 hectares) and new irrigators (1,540 hectares). Total effective demand equals 4,805 hectares.
- **All Potential Users:** Annual charges are estimated assuming the capital cost is evenly allocated among all users. Total effective demand equals 6,065 hectares.

- Using the 70% allocation of total cost to consumptive users as a base case[1], the indicative capital costs are presented in Table 17.1.

Table 17.1: Indicative Costs for Base Case Cost Sharing Scenarios

	Existing Irrigation Users	All Existing Users	Existing Irrigation Users Plus New Irrigation	All Potential Users
Effective Hectares	3,265	3,685	4,805	6,065
Capital Cost per Hectare	$4,930	$4,370	$3,350	$2,655
Equivalent Annual Charge per Hectare	$565	$500	$380	$305

Some caution should be exercised when interpreting these results. Irrigation benefits can vary considerably from property to property on the basis of land use, soil type, and the intensity of the adopted farming system. It is also very difficult to fully incorporate into this analysis one of the main advantages of irrigation relating to the large reductions in year to year production variability. The economic feasibility of the scheme is ultimately a decision for each potential scheme participant based on their evaluation of the indicative scheme costs.

In addition the above base case excludes any delivery costs beyond the bottom of the Wairoa Gorge.

When the cost of delivering piped water from the proposed dam site to the Wairoa Gorge/Waimea East Irrigation intake is included (estimated at $6.5 million), the capital cost per hectare increases by $750, and the equivalent annual charge per hectare increases by $85. (Note: this excludes reticulation costs over the Waimea Plains.)

Table 17.1 gave the indicative costs assuming consumptive users pay for 70% of the scheme. Table 17.2 presents the indicative costs of the scheme under the assumption that 100% of the initial capital expenditure is paid for by consumptive users (i.e. there is no community contribution for the environmental flow proportion).

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[1] The capital cost allocated to the provision of the environmental flows is approximately $6.9 million. If this cost was financed on the same terms as assumed for consumptive users, the annual servicing charge would be approximately $685,000 over a 25 year repayment period.

Table 17.2: Indicative Scheme Costs – 100% Allocation to Consumptive Users

	Capital Cost Per Hectare	Equivalent Annual Charge per Hectare
Base Case (70% cost allocated to consumptive users)	$2,655	$305
100% Allocation to Consumptive Users	$3,790	$435
Incremental Cost to Consumptive Users	$1,135	$130

In summary, the likely costs of the scheme for each user are dependent on which groups of consumptive users are included in the charging base, and the extent to which the costs of meeting the enhanced environmental minimum flows are met by the community as a whole (via the TDC). Assuming that 70% of the capital costs are evenly allocated among all potential future users of the scheme (with the remaining 30% covered by the Tasman District community at large), the annual charge will be approximately $305 per hectare. It is important to emphasise that this indicative charge is based on a preliminary estimate of the total capital cost for the scheme ($23.0 million including land) and no delivery infrastructure. Any change in the estimated capital costs will result in about the same percentage change in the indicative annual charge.

However, based on the information available to date, the preliminary estimate of the annual charge for this scheme compares favourably to other schemes that have been initiated recently, and is relatively consistent with charges for existing irrigators using the Wai-iti augmentation scheme.

17.3 Opportunity Cost of Non-Augmentation

A high level assessment was undertaken of the potential economic loss that current irrigators may suffer if the augmentation scheme does not proceed. In this assessment it has also been assumed that at some time in the future the current minimum environmental flow is increased – a nominal figure of 800 l/s in the Waimea River at Appleby has been assumed for this purpose.

An assessment was made by Landcare Research of the likely water restrictions that would occur for seasons that are thought to represent both an average summer (2004/05) and a drought with a probability of occurrence of 1 in 25 years (the 1982/83 and 2000/01 years[2]). Assuming a minimum flow of 800 l/sec was imposed, the water records were then used to simulate the frequency and duration of water restrictions that would be imposed on irrigators under the assumed hydrological conditions. This information was then used by Agfirst Consultants to estimate the likely reduction in net farm surplus for the predominant land uses within the irrigable area. While the results of the relatively mild restrictions implied by an average season are expected to have a negligible impact on the profitability of all land uses, the impact of a 1 in 25-year drought is significant.

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[2] The definition of the drought return period depends on the timing, severity and duration of the water shortages. The 1982/83 year actually represents a 25-33 year drought and the 2000/01 season is described as a 27-85 year drought.

Summary results are presented in Table 17.3 for the two data sets derived from the 1 in 25-year drought scenario. These show that, with the exception of pasture, the impact of the water restrictions is dependent on the timing of the water restrictions.

Table 17.3: Incremental Losses for 1 in 25 Year Drought (Earnings Before Tax / ha)

	25 – 33 Year Drought (1982/83)		27 – 85 Year Drought (2000/01)	
Crop Type	**Light Soils**	**Heavy Soils**	**Light Soils**	**Heavy Soils**
Pasture	$1,250	$1,250	$1,250	$1,250
Apples	$7,670	$5,186	$15,917	$7,670
Kiwifruit	$5,846	$4,516	$7,736	$4,516
Grapes	$1,903	$1,062	$7,382	$1,903

The total economic impact of a 1 in 25-year drought is estimated by combining the per hectare losses presented in Table 17.3 with the crop area estimates. The results are set out in Table 17.4.

Table 17.4: Estimated Economic Losses (NZD 000's) of 1 in 25 Year Drought for Current Irrigable Area (3800 ha)

	25 – 33 Year Drought (1982/83 Data)			27 – 85 Year Drought (2000/01 Data)		
Crop Type	**Light Soils**	**Heavy Soils**	**Total**	**Light Soils**	**Heavy Soils**	**Total**
Pasture	$875	$1,125	**$2,000**	$875	$1,125	**$2,000**
Apples	$6,557	$4,201	**$10,759**	$13,609	$6,213	**$19,822**
Kiwifruit	$555	$407	**$962**	$735	$406	**$1,141**
Grapes	$419	$138	**$557**	$1,624	$247	**$1,871**
All Crops	$8,407	$5,870	**$14,277**	$16,843	$7,992	**$24,835**

In summary, a limited set of hydrological data has been used to determine the possible impact of non-augmentation on agricultural and horticultural production in the event that minimum flows in the Waimea River are increased. Based on current land use and return levels, the indicative cost of a 1 in 25 year drought is estimated between $14.3 million and $24.8 million, depending on the timing of the water shortages. This is an estimate of the aggregate value of lost production from the 3,265 hectare equivalents that are currently irrigated using water from the Waimea River. These estimated losses represent between 45% and 75% of aggregate net earnings from the irrigated land during an "average" year. Given the significance of this potential economic impact, non-augmentation may well lead to considerable changes to the existing balance of land use.

17.4 Ownership/Funding Options

The level of charges may be influenced to some degree by the chosen ownership structure for the scheme. Given the scale and nature of the proposed Waimea scheme, Council or private ownership structures are likely to be most appropriate in this case. Among the key characteristics that must be appropriately accounted for in the chosen structure are:

- **Public / Private Water Demand**: It is proposed that the water storage will be used to both enhance the security of supply for consumptive users as well as allow for a provision of greater minimum flows within the Waimea River. Consumptive users are also split between private land owners and the TDC on behalf of the community (both for community consumptive water use, and other community benefits). One of the most important requirements of the chosen structure will be to allow for a fair and transparent allocation of capital and operating costs between the scheme participants.

- **Existing / New Irrigators:** It is currently proposed that the scheme will not only improve security of supply for existing irrigators, but will also provide new supply to 2,380 area equivalents (1,540 hectares for irrigation, 400 hectares for future demand by urban and industrial uses, and 440 hectares for future regional supply). If a differential charging regime is deemed to be appropriate for the existing and new irrigators, then the ownership structure of the scheme must be capable of reflecting these differences.

18 Water Allocation Issues

Refer to **Component 4 Report: Water Allocation Issues** for detail.

Landcare Research undertook a review of issues relating to allocation of water from the proposed augmentation scheme.

The report specifically looked at four areas:

- Policies and rules in the Tasman Resource Management Plan (TRMP)
- Options for improving water use and flexibility
- Policy options for allocating newly available water
- Changes possibly required to the TRMP.

18.1 TRMP- Existing Provisions

It is considered that the management objectives identified for Waimea catchment rivers and aquifers under Issue 30.1 of the TRMP will be better achieved through provision of water augmentation than through not proceeding with it. Objectives such as maintaining minimum flows, preventing saltwater intrusion and maintaining an acceptable security of supply for water users will be most easily achieved through water augmentation. Achieving objectives for instream values in the lower part of the Waimea River affected by significant summer flow losses will be clearly demonstrable. However, achieving the objectives for instream values in other parts of the river system, is at this first stage of the investigations less clear. Water quality, recreational uses, fishery habitat, and cultural, spiritual and landscape values will all be affected to some extent by the modified flow regime and quality of water released below the dam, especially in the Lee River from the dam to the Wairoa confluence. Whether these changes will be beneficial or potentially adverse and to what extent, and over what timeframe, is yet to be confirmed, and should be addressed further during Phase II investigations.

Other policies relating to competition for water address equitable water allocation, security of supply and efficient water use. The policies can be addressed through design of the scheme water allocation framework. Water augmentation is encouraged under one policy as a way to improve security of supply, and another policy enhances the options for transfers of water permits when the supply has been augmented. The augmentation scheme can be set up to implement both of these policies.

Policies relating directly to water augmentation encourage and support development of water augmentation schemes. The proposed scheme is clearly consistent with this policy direction. One policy states the criteria under which the level of support for a water augmentation scheme is to be determined; these nine criteria are a useful guide for completion of any Assessment of Environmental Effects for the project and for design of questionnaires for evaluating the level of support for a scheme.

18.2 Water Use Efficiency

In terms of options for improving water use efficiency and flexibility, water metering data for the 2000-01 drought (a 23-year event based on 7-day river flows) before rationing was implemented showed that the highest zonal water usage reached 79% of full allocations in the Lower Confined Aquifer Zone and 75% in the Waimea West Zone. In the absence of active transfers of water permits, which are likely to result in increased usage of existing allocations, an assumption of 80% maximum usage against zonal allocation limits seems reasonable. However an assumption that 100% usage will occur at times provides a buffer for the uncertainties in the policy settings for allocation limits and security of supply.

Among the policy options that have been identified for improving water use efficiency are:

- Regulatory requirements, including:
  - prescribed efficiency standards
  - farm irrigation plans
- Financial options, including:
  - reduced annual water permit fees for users meeting efficiency standards
  - rates rebates or discounts on scheme charges for implementation of efficient water use measures
- Education and advocacy options, including:
  - providing soil moisture information for irrigators
  - information sheets on water use efficiency
  - presentations and data on the hydrology of the Waimea water resources.

18.3 Options for Allocation

As these water resources are currently fully allocated, provision should also be made to encourage re-allocation within the system. Providing for site-to-site transfers including temporary leases of water allocations, as implemented already in the Wai-iti water augmentation scheme, is recommended in conjunction with formal removal of conditions on permits allowing 'bona fide' adjustments of users' allocations.

Eight policy options for allocating newly available water have been identified. In general, the current policy settings are an appropriate balance between water allocated and administrative costs of the water allocation system. The main opportunities for changes appear to be in the areas of user-driven water management plans, and re-allocation of water through transfers, particularly through leasing of allocations. One policy and physical challenge for the scheme which needs investigation in Phase II investigations is how to ensure physical access to augmented water for users distant from the river.

If the scheme is built, the main changes needed to TRMP policies will be to formally recognise the status and ownership of the scheme, and to increase the security of supply under which water is allocated to users. Main changes to rules will involve setting a higher minimum flow regime for the Waimea River, re-setting and increasing water allocation limits for the water management zones across the Plains, and (depending on the funding option chosen) linking allocations to payments by scheme contributors.

It is recommended that drafting and consultation on the required changes to water allocation policies and rules be carried out as a part of the Phase II investigations.

19 Potential for Mitigation of Effects and Enhancement

The following **mitigation** measures could be considered (excluding land acquisition issues):

- provision of replacement road to upper Lee Valley and Richmond Forest Park
- provision of alternative road access to forestry land
- preparation of drought management plan setting out guidelines and procedures for releasing water from the reservoir in response to specified climatic and soil moisture triggers, including ramping rates to mitigate effects of reservoir level fluctuations
- dam breach warning system
- provision of system to allow native fish passage
- provision for flushing of algal growths if necessary
- consideration of ramping flows to avoid sudden changes in river flows
- consideration of periodic sediment removal and placement downstream to provide natural sediment to system
- requirement for good sediment control during construction
- removal of vegetation and topsoil from reservoir footprint prior to filling
- consideration of use of multiple level water release system to reduce effects on water quality.

Overall the project provides the following major **enhancement** opportunities:

- greater security of water supply
- positive economic impact
- improved habitat for protection of instream values
- enhancement of the values of the Waimea Estuary

Additional, more specific opportunities exist for **enhancement** as follows:

- generation of electricity
- public access to upper catchment by provision of road network
- self-sustaining (lake) trout fishery above dam
- recreational use of 'lake' (reservoir) environment (picnic areas, swimming, boating, fishing)
- creation of wetland habitat at reservoir margins for mitigation of biodiversity losses
- development of a biodiversity and rongoa restoration plan
- development of a mahinga kai harvest and maintenance plan

- development of walkway system around reservoir (utilising land in public ownership (marginal strip)
- ecological restoration: improvement to quality of indigenous vegetation and associated habitat through pest and weed control
- improved access to Richmond Forest Park, and development of linking tracks to main track system.

20 Applicability

This report has been prepared for the benefit of the Waimea Water Augmentation Committee/Tasman District Council 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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