REPORT

WAIMEA WATER AUGMENTATION COMMITTEE/TASMAN DISTRICT COUNCIL

Assessment of Water Storage Options - Waimea Catchment

Report prepared for:
WAIMEA WATER AUGMENTATION COMMITTEE/
TASMAN DISTRICT COUNCIL

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1 Introduction

In November 2004, Tonkin and Taylor was commissioned by the Waimea Water Augmentation Committee (WWAC) and Tasman District Council (TDC) to undertake 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 project is multi-disciplinary and covers a three year period. It has four main components:

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

Tonkin and Taylor is undertaking 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 Waimea Catchment
- assess broad-scale physical, engineering, and environmental constraints to refine 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
- work with ESR for them to assess community response to (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
- develop overall solution (or scenario) including distribution and allocation.

This report outlines the work undertaken to April 2005, leading to the first milestone for the overall project – facilitating a Workshop with WWAC to determine up to three possible storage options.

The work undertaken to date is based on a desk-top study only, using publicly available information, the project team's own databases or knowledge, and preliminary site visits (from public land). No specific fieldwork or investigations or modelling have been undertaken, and all work has been undertaken on a confidential basis. The information contained in this report therefore reflects the limitations imposed by the preliminary stage of the project and its confidentiality.

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 **down**stream. 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 Preliminary Work

In December 2004 Tonkin and Taylor completed a preliminary scan of possible storage (and infill) options in and adjacent to the study area, but excluding those below about 5 Mm^3 size. 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. The identified sites are shown on Figure 1.1 in Appendix A. We identified 18 possibilities and provided these 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 seven sites. The remaining sites were:

- Sites 1A and 1B – Pigeon Valley South
- Site 2 – Pigeon Valley North
- Site 3 – Unnamed tributary of the Wai-iti River
- Site 4 – Teapot Valley
- Site 10A – Lower Lee
- Site 10A – Middle Lee
- Site 11 – Upper Lee
- Site 13 – Wairoa Forks
- Site 14 – Right Branch Wairoa (western)
- Site 15 – Left Branch Wairoa (eastern)

Tonkin and Taylor's technical team undertook a ranking exercise of the above 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

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

This result was conveyed to WWAC's project manager and was generally endorsed. It is these five sites that are now the subject of this report, leading to the Workshop with WWAC to determine up to three sites or options for further investigation.

The following sections of this report address each Site. They are preceded by a section that indicatively discusses the water demand in the Waimea Basin and which gives a preliminary estimate of the volume of the storage(s) required.

We comment that full assessment of demand has not been made as yet and the present comparison adopts an arbitrary value only.

3 Water Demand

3.1 Introduction

No detailed assessment or modelling has yet been undertaken of likely water demand. However, the potential dam storage for initial site comparison was discussed and agreed between Tonkin and Taylor team members (Sally Marx and John Bealing) and WWAC representatives (Chairman Murray King, Richard Kempthorne, and Project Manager Joseph Thomas). The agreed preliminary assumptions are:

- irrigation water demand includes the area of Richmond, Stoke, Waimea Plains, and that part of the Wai-iti catchment that was considered not to be covered by a possible future dam, but highly likely to be planted in intensive horticulture
- 50 year planning horizon
- other demands include an additional equivalent demand of 380ha of full irrigation for other consumptive uses (urban/industrial)
- an interim minimum river flow of 0.500 m^3/s at Appleby Bridge, although until the surface water and groundwater interaction in the lower reaches has been modelled and understood, this minimum flow cannot be used meaningfully in the storage demand analysis.
- irrigated pasture to be largely/completely replaced by intensive horticulture.
- soil types having an influence on the yearly water volumes to be taken into account, even if peak weekly rates between varying soil types are similar.
- areas not likely to be available for irrigation were excluded (river and road berms, reserves, etc.).
- a 1:10 year drought security standard(currently stands at 1: 3 years), although an option of taking this to a 1:15 year drought security standard needs to be costed. Note that the 10 year drought storage (to meet the 10 year drought security standard) is defined as the amount of live storage which would be depleted completely once every ten years on long-term average based on full unrestricted supply.
- maximum release period of 15 weeks.
- assume all allocated water is used and available with no allowance for system losses

It should be noted that the storage to meet these requirements cannot be confirmed until various components of the Study have been assessed in detail (e.g. environmental flows, groundwater-surface water interaction, seasonal irrigation usage patterns, etc.), and cost-benefit considerations may influence final choices. The storage adopted for initial site comparison is therefore an approximate estimate.

3.2 Waimea Plains

The irrigable area has been assessed at 5,300 hectares (excluding non-irrigable areas as noted above).

The areas of each soil type (making up the irrigable area) have been divided into three broad groups, according to their relative soil moisture holding capacities. This gives the following:

- 1600 ha of light soils water with water allocated at 35 mm/week
- 2100 ha of medium soils with water allocated at 30 mm/week "
- 1600 ha of heavy soils with water allocated at 25 mm/week

To keep the concept simple, the above figures were converted into "full irrigation (pasture) equivalents", on the basis of 35 mm/ha/week, where a 100% plant ground cover was involved (which is the same as allocating 350 m^3/ha/week).

Therefore:

1600 ha x 35 mm = 56,000/35 = 1,600 ha full irrigation.

2100 ha x 30 mm = 63,000/35 = 1,800 ha full irrigation

1600 ha x 25 mm = 40,000/35 = 1,150 ha full irrigation

Total = 4,550 ha full irrigation

Since we have assumed that most irrigation will be for intensive horticulture, and by far the majority of this will be in rows, then the inter-row area does not require irrigating. In practice, more like 70% only of the area requires water at the above rates. By multiplying by a factor of 0.75 (allowing for some crops that occupy 100% of the ground, such as Kiwifruit, and a small allowance for those irrigable areas that never will get irrigated at all), the peak water demand reduces to 3,410 ha of "full irrigation equivalents" (4550 x 0.75).

It is worth noting, that grape irrigation allowance in the new Marlborough Southern Valleys' Irrigation Scheme, allows water at a little more than one third of the figure used here, as our "full irrigation equivalent" (126 m^3/week for the grapes, vs. 350 m^3/week used here for pasture).

3.3 Wai-iti Valley

WWAC representatives advised us that an additional allowance of 300 ha should be made for the lower end of the Wai-iti Valley. This was in addition to that already allowed for from the Wai-iti dam (under construction). The whole of the Wai-iti catchment is considered to have 4,000+ ha of irrigable land. About 800 ha currently has an allocation (albeit very risky). The Wai-iti dam will reduce the risk to a proportion of the currently irrigated area, and allow for a further 300 ha of newly irrigated land. If we allowed for an additional 300 ha from the Waimea project storage dam, the allocation for the Wai-iti Valley area would rise to a total of 1400 ha. This was considered acceptable by WWAC representatives, given that it will probably be uneconomic to pump water very far up this valley. If more water is needed, then other Wai-iti side valleys are available for further dams in the future, if and when there is a demand.

Given the soil types in this area, together with our 0.75 coverage factor used above, a further 260 ha of "full irrigation equivalents" is allowed for, for the Wai-iti Valley.

This brings the total area for irrigation from the current project to 3675 hectares.

3.4 Urban and Industrial Demand

The WWAC representatives considered the present Richmond allocation to be sufficient to cover additional urban/commercial/industrial requirements in the Richmond/Stoke/Hope areas. This was assessed at the equivalent of 380 irrigable hectares at the full allocation. This brings the total area for irrigation from the current project to 4055 hectares. [currently being revised by WWAC and may increase total demand]

3.5 Total Extractive Weekly Requirements for Irrigation and Urban

The total extractive weekly requirements are therefore assessed as being:

> 4550ha x 350m^3/ha/week = 1,420,000 m^3/week. Over 15 weeks, the total volume is therefore 21,300,000 m^3.

3.6 In-Stream Requirements

The other major water requirement that needs to be allowed for is an in-stream, minimum flow. This work is underway by Cawthron, and will be available to refine ongoing water demand assessment. However WWAC representatives have advised us that we should at this stage assume a minimum flow of 500 l/s in the Waimea River at the Appleby Bridge. This flow (500 l/s) is the equivalent of 300,000m^3/week, or a little over 20% of the extractive volume. The flow release from the storage dam required to sustain the minimum flow is expected to vary with groundwater conditions, the irrigation regime and flow contributed from sub-catchments below the dam. At this stage of the analysis, the additional demand imposed on the dam storage from minimum flow maintenance is not known and has not been explicitly allowed for.

3.7 Total Water Demand

The storage volume will be very dependent on the flows available from the various catchments that contribute to the dam, and to other tributaries which contribute to minimum river flows.

If the storage system provides for 15 weeks of peak irrigation water, then approximately 21 million m^3 of water storage would be required (about 5 times the volume stored by the Maitai Dam). In a particularly dry year, flow enhancement and provision for losses could add to this 21 Mm^3.

Note: - the above does not take into account any added storage flowing into the dam over the irrigation season from summertime freshes. The minimum flow ever recorded at the Wairoa Gorge outlet is above 1200 l/s. This flow could supply the minimum in-stream flow of 500 l/s, provided the remaining 700 l/s is sufficient to meet irrigation demands and maintain the groundwater flow regime. The duration of these low flows is also usually measured in days (or maybe a week or two), but is unlikely to ever be anywhere close to the 15 week periodicity that we have used in the above estimate. Further hydrological optimisation will be undertaken during later stages of this project. We expect that this will reduce the water storage figure of 21 x 10^6 m^3 , shown above.

At this stage we have therefore assumed a storage system needs to have capacity of between 15 to 20 million m^3.

4 Site 2 – Pigeon Valley North

4.1 Location/ Site Topography

This site is within the northern branch of Pigeon Creek, a tributary of the Wai-iti River near Wakefield. The site is approximately 2km upstream from the corner of Pigeon Valley Road and Pigeon Valley South Branch Road (see Figure 1.1 in Appendix A).

At the potential storage dam site, the valley floor is flat and approximately 200 metres wide. Approximately 200m upstream from the dam site, two main tributaries of the north branch of Pigeon Creek join.

The storage dam would be an instream dam on Pigeon Creek (north branch). Because of the limited size of the catchment above the dam, achievement of appreciable of safe storage would require transfer infill from other adjacent sources. The most likely options are:

- water pumped from the Wai-iti River, from a location approximately 700m upstream from Baigents Road.
- water from the southern branch of Pigeon Creek

Distribution to the area of demand would likely comprise a combination of stream release to the Wai-iti for direct stream abstraction or groundwater recharge, and a race connection to the Wairoa below gorge.

4.2 Engineering

Appendix A summarises the engineering approach adopted. Key results are as follows (15 Mm^3 storage).

1. dam normal top water level about RL 150 m (dam some 38.5 m high)
2. land area involved to crest level, some 100 hectares
3. dam type, earthfill
4. supplementary infill transfer 1000 l/s intake on Wai-iti
5. hydro potential not assessed as unlikely to be cost effective
6. indicative base cost including capitalised pumping, $22.4 M
7. area served for 15 Mm^3 storage, 86% of other sites

4.3 Land Ownership & Landuse

4.3.1 Pigeon Creek Storage area

TDC records show:

- most of the directly affected land is privately owned
- some slopes on the northern side of the valley are "Carter Holt Harvey Payee" (occupier and/or owner).

The valley floors comprise pastoral farmland. Side slopes comprise commercial forestry (exotic species) owned by Carter Holt Harvey.

A preliminary site assessment from public roads shows that there are likely to be two private residences and associated groups of farm buildings within the area directly affected by the reservoir. Another two residences look to be in close proximity to the dam and reservoir footprint (depending on actual location of dam)..

4.3.2 Infill Transfers

The pipeline route from the Wai-iti River to the storage area in Pigeon Valley would cross private land, including a golf course. A transfer route from the southern branch of Pigeon Creek, if employed, would cross forestry and private land.

There would be considerable disruption in the short-term while construction was underway, including substantial land acquisition/easement negotiations required on the part of TDC, although the land area affected is small.

4.3.3 Conveyance from storage area to use area

Depending on delivery systems of the stored water, there may also be a need for a pipeline to the Wai-iti Valley/Wairoa River mouth. This route would be likely to cross numerous parcels of private land.

4.4 Potential Effects on Existing Infrastructure

The following existing infrastructure would potentially be affected by the proposed storage:

- Pigeon Valley Road – approximately 1.2 km of this road runs along the bottom of the valley formed by the southern tributary. This road provides access to forestry land, and is the through road to Dovedale.
- Sharp Road and forestry roads - approximately 1 km of public road and 2km of forestry roads run mainly within the valley formed by the northern tributary. The roads provide access to forestry land, as well as to existing farmland on the valley floor – however, some of the latter would need to be acquired as part of the project.

There may also be additional effects on infrastructure arising from the pipeline and/or race connection route.

4.5 Hazard Potential

Given the size and height of the dam it would be classed as having High Potential Impact (hazard). Preliminary dambreak assessment is to be undertaken for the shortlisted options and more rigorously for the preferred option. At this stage we can observe that a dambreak could result in a flood wave which would spread out in the lower part of Pigeon Valley as it widens and spread further in the Wai-iti Valley, perhaps being the order of 3 m deep in the upper part of the Wai-iti Valley. There may be some low lying buildings in the floodpath.

4.6 Potential Environmental Issues

The following information (and that included for the other sites) is preliminary and general. Specific environmental effects will need to be assessed for the short-listed options.

Note also that the Wairoa-Wai-iti Rivers have been put forward by DOC as potentially meeting the national criteria as a "Type 1 Water of National Importance"(WONI) under the Government's national programme for water. This classification means that the majority of the catchment is considered nationally important for biodiversity (this appears to include the entire Wairoa and Wai-iti catchments (including the Lee and the Roding, and the lower Waimea River)). The implications of this, and the degree to which the classification should apply to the entire catchment would need to be investigated further.

4.6.1 Terrestrial Ecology

Existing land use is pastoral farming and exotic forestry. It is not expected that there will be any significant terrestrial ecosystems that would be affected by the storage reservoir and associated activities.

There appear to be no specific areas of significance on the potential pipeline routes from the Wai-iti or Pigeon Creek South Branch. Any local areas could potentially be avoided in route rationalisation at later stages of the investigation.

Any race between the storage site and the Wairoa would need to avoid Faulkners Bush and Baigents Bush near the Pigeon Creek/Wai-iti Valley confluence.

4.6.2 Water Quality & Aquatic Ecology

No specific studies have been undertaken of water quality in Pigeon Creek.

Fish and Game (Neil Deans pers. comm.) has undertaken some limited investigations in Pigeon Creek (although not specific to the northern tributary), and recorded the presence of:

- longfin eels
- common bullies
- upland bullies
- koura (freshwater crayfish)

This fauna is not particularly diverse or exceptional, although longfin eels are classified as chronically threatened. Further sampling higher in the catchment where there is good riparian cover (especially if any native vegetation persists) may reveal some migratory galaxiids such as koaro or banded kokopu. Such species are known to exist in neighbouring waterways (Eves Valley, where the stream flows through a DOC reserve). (M Rutledge, DOC, pers. comm.)

The lower reaches of Pigeon Creek may be used for trout spawning over winter (Neil Deans, Fish and Game, pers. comm.)

However due to its size, and the modified nature of its catchment (farming and exotic forestry), Pigeon Creek is not expected to be a particularly significant aquatic habitat. It is known to routinely dry up in a dry summer ((Neil Deans, Fish and Game, pers. comm.)

A review of work done to date shows that water quality in the Wai-iti River is variable (Cawthron Institute's report). The Wai-iti River has a history of elevated levels of nitrate and phosphorus compared with the Wairoa and Waimea Rivers. Faecal indicators, generally associated with flood flows, were also reported to be higher in the Wai-iti River, occasionally exceeding the "alert" and "action" levels. Guideline values for dissolved

inorganic nitrogen, water clarity and turbidity have also been exceeded. Overall water quality in the Wai-iti River is described as being in the "intermediate' range.

There is a paucity of information regarding algae in the overall Waimea Catchment. However, work undertaken in the late 1980s by Cawthron indicated that given the relatively low conductivity of waters in the Waimea Catchment (indicating low nutrient enrichment), development of algal communities to nuisance levels was unlikely, except under conditions of prolonged summer low flows in localised areas of nutrient enrichment.

Densities of invertebrates recorded in the Wai-iti River were significantly higher than those found at other sites in the overall catchment. This was possibly related to higher algal production in the relatively nutrient enriched waters of the Wai-iti River. Species richness is only "satisfactory" in the Wai-iti River.

Invertebrate communities through much of the Waimea Catchment are generally indicative of reasonably high water quality over time.

The Wai-iti River has been reported as having the poorest fish communities of the rivers in the Waimea Catchment. Cawthron has suggested that this might be due to summer drying of the river. The Wai-iti and its tributary 88 Valley Stream hold some trout early in the fishing season but angling opportunities are reduced once flows decline (Grant Irvine, local angler, pers. comm. reported by Cawthron).

4.6.3 Archaeology/Heritage Values

- TDC records show no specific sites in the affected area.
- 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 (Geological Society of New Zealand Miscellaneous Publication 104; 1999).

4.6.4 Potential Effects on Recreation

- the recreational values at Site 2 are likely to be minor, due to the size of Pigeon Creek at the dam site, and the fact that surrounding land is privately owned.
- potential minor effect on recreational driving across to Dovedale.
- the pipeline route is likely to cross the golf course at the downstream end of Pigeon Valley.
- the Wai-iti River and its tributary 88 Valley Stream hold some trout early in the fishing season but angling opportunities are reduced once flows decline (Grant Irvine, local angles, pers. comm. reported by Cawthron).

4.6.5 Community Issues

- no specific issues relating to the Pigeon Valley and Wai-iti Valley area have been raised through ESR's community survey work to date.
- the most significant community issues will arise as a result of the dambreak potential (see comments above re habitation of the valley), including position above Wakefield Village.

4.7 Potential Cultural Issues

TDC and DOC records show no specific sites of significance in the affected area.

Initial discussions have been held with iwi (at Motueka Iwi Resource Management Act Komiti meeting on 19 January 2005 and Nelson Iwi Resource Management Act Komiti meeting on 7 February 2005). Due to the stage at which the project was at, those discussions did not focus on any specific sites. Issues discussed at those meetings enable us to offer the following comments:

- a specific cultural impact assessment will need to be undertaken in relation to options selected for further investigation
- a dam at Site 2 would result in the intermingling of water from two tributaries of Pigeon Creek. This is unlikely to be a major issue, but would need to be assessed on a site-specific basis.
- infilling of the reservoir using water from the Wai-iti River would result in the mixing of water from two waterways in a location substantially separate from where they would naturally mix (at Wakefield). Transfer of water to the Wairoa River would result in the mixing of water from two waterways in a location substantially separate from where they would naturally mix (at Wairoa/Wai-iti confluence). This may be a significant issue, and would need to be assessed on a site-specific basis. Initial feedback from the iwi's representative on WWAC would assist the project team and WWAC.
- there is likely to be a need to provide for native fish passage past the dam structure, as well as fish passage past any intake structure on any waterway used for infilling.

4.8 Planning Issues

- the storage site is zoned Rural 2
- there are no denotations marked on the TRMP Area Maps for Site 2
- there appear to be no obvious inconsistencies with the objectives and policies for the Zone
- Site 2 is within the Wai-iti Water Management Zone
- range of consents will be required, mainly for discretionary activities, with exception as below.
- if infill water used from Wai-iti River, restrictions on consents apply. 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 515 l/s (assuming Wai-iti Dam is operating. The calculation of allowable take also must provide for the reservation of specified quantities of water for Maori Perpetual Lease Land and Community Water Supplies. Takes above these limits are non-complying (ie the resource consent process will need to pass a higher threshold test).
- water management objectives for Wai-iti River (TRMP Schedule 30.1):
  - protect trout spawning values
  - maintain contribution to Waimea River flows and groundwater levels
  - maintain or improve existing users' security of supply to acceptable level

4.9 Potential for Mitigation of Effects

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

- provision of replacement road to Dovedale
- provision of alternative road access to forestry land
- provision of system to allow native fish passage
- retention of residual volume in reservoir for native fish species refuge
- dambreak warning system

4.10 Potential Opportunities for Enhancement

The following potential opportunities exist for enhancement (in addition to those arising from augmenting flows in the lower catchment for water supply, protection of instream values, and enhancement of the values of the Waimea Estuary):

- Self-sustaining trout fishery within reservoir (assuming residual water volume maintained)
- Recreational use of 'lake' (reservoir) environment (picnic areas, swimming, boating, fishing)
- Creation of wetland habitat at reservoir margins
- Development of walkway system around reservoir (utilising land in public ownership (marginal strip).

5 Site 10B – Middle Lee River

5.1 Location/ Site Topography

This site is within the main stem of the Lee River, approximately 2.5km upstream from the confluence with the Roding River, and immediately upstream of the Long Gully (refer figure 1.1 in Appendix A). At the potential storage dam site, the river is incised within the valley with a base width of some 80 m. At two locations upstream the valley widens at meander loops.

The storage dam would be an instream dam. The head of the reservoir would extend upstream to approximately the cement works.

Delivery from the dam to the area of use would most likely involve release into the river and recharge/abstraction downstream and this has been assumed.

5.2 Engineering

Appendix A summarises engineering evaluations. Apart from approximate assessments of flood sizes for dam cost estimating and reference to Lee river flow duration for indicative hydro potential, no hydrological analysis has been undertaken. It is evident that the Lee has adequate flow to achieve a safe storage of 15 Mm^3.

Key results are as follows:

- dam normal top water level about RL 117 m (dam some 53.5 m high)
- land area involved to crest level, some 70 hectares
- dam type, concrete faced rockfill
- indicative hydro potential 1.56 MW and 8.85 GWh/annum
- indicative base cost (no hydro), $27.1 M

5.3 Land Ownership & Landuse

Due to the incised nature of the river through this stretch, the area of land potentially affected by the reservoir is narrow. TDC records show:

- the valley floor itself particularly at the meander loops is privately owned
- side slopes above the road on the western side of the valley and on the eastern side to approximately midway up the reservoir, are "Carter Holt Harvey Payee" (occupier and/or owner)
- the remainder of the eastern side slopes are privately owned

The two valley floor/meander loops contain one residence and one caravan/shed (presumably a "weekender"). Land use is pastoral – presumably lifestyle/grazing. The valley sides are used for commercial forestry (exotic species) by Carter Holt Harvey.

Lee Valley Cements Limited is located at the top of the reservoir. It is unlikely that the reservoir height would affect this property significantly (see next section for comment on access).

5.4 Potential Effects on Existing Infrastructure

The following existing infrastructure would potentially be affected by the proposed storage:

- Lee Valley Road – approximately 2 km of this road which runs along the western side of the Lee River could be potentially affected by the reservoir
- access to forestry land and roads, as provided by the above public road
- access to Lee Valley Cements Limited, as provided by the above public road
- access to Richmond Forest Park as provided by the above public road
- access to Lucy Creek Road and associated forestry roads (from just upstream of Long Gully)

5.5 Hazard Potential

This dam would be in the High Potential Impact category.

We can observe that because of the downstream topography the flood wave from a dambreak would be high and it would not be until some distance downstream of the end of the Wairoa gorge that the flood wave from a dambreak would have dissipated to a modest level. There are buildings in the lower valley, including a guide camp, and relatively low lying buildings at the head of the plains, which would be in the path of a flood wave.

5.6 Potential Environmental Issues

5.6.1 Terrestrial Ecology

Existing land use comprises a small area of pastoral/lifestyle farming and exotic forestry. It is not expected that there will be any significant terrestrial ecosystems that would be directly affected by the storage reservoir and associated activities. Overall, the vegetation in the Lee Catchment is more compromised that that in the Wairoa Catchment due to pine forestry (S Courtenay, DOC, pers. comm.). However in any areas where ultramafic geology exists, there may be flora of significance.

5.6.2 Water Quality and Aquatic Ecology

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 requiring access to and from the sea to complete their life cycles.

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.

Several records of blue duck (whio) exist in the lower and middle Lee, including sightings within the reach potentially affected by the storage system (Cawthron report). Both the Lee and the Wairoa Catchments appear to contain good habitat for blue duck and could potentially maintain breeding populations if predators were controlled (M Rutledge DOC pers. comm. reported by Cawthron).

5.6.3 Archaeology/Heritage Values

Two archaeological sites are recorded in the potentially affected area (N28/8 and N28/9). Both are listed as Maori workings of argillite. N28/8 is midway in the storage area. N28/9 is at the top end of the storage area. Their exact location in relation to the reservoir extent would need to be determined as part of further 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

5.6.4 Potential Effects on Recreation

The Lee valley is a popular recreational resource. Specific comments are as follows:

- there appear to be no formal picnic sites within the stretch of river that would be directly affected by the storage reservoir.
- there are several picnic areas downstream from the potential storage site. Activities at these sites include swimming, rafting and kayaking.
- the Regional Girl Guide Lodge is situated in the lower Lee Valley. This is a 38 bed lodge, that is booked every weekend (and some weekdays) from early spring – late autumn) (ESR report).
- the stretch of river that would be directly affected by the storage reservoir (from the Cement Works downstream) is of medium value for kayaking (white water and scenic value). This value continues down the length of the Lee River (ie from the Cement Works down to Max's Bush (below Wairoa confluence). The stretch above the potential reservoir is of low value. (Ron Wastney, pers. comm.)
- 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. Access through private property tends to restrict angling opportunities (Grant Irvine, local angler, pers. comm. as reported by Cawthron).
- Lee Valley Road provides some access to Richmond Forest Park.
- the reservoir may provide some recreational potential.

5.6.5 Community Issues

ESR's community survey work to date has provided feedback on the values of the Lee River Valley. These are summarised below. However many of these comments were made generally about the Lee and/or Wairoa Rivers and may not necessarily be specific to Site 10B.

- 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

Other significant community issues can be expected to arise as a result of the dambreak potential (see comments above re habitation and use of the valley). 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).

5.7 Potential Cultural Issues

Comment has been made above (section 5.6.3) on two specific sites of significance in the affected area.

Initial discussions have been held with iwi (as noted in previous sections) enabling us to offer the following comments:

- a specific cultural impact assessment will need to be undertaken in relation to options selected for further investigation
- a dam at Site 10B would not result in the mixing of water from tributaries
- based on the Lee River's habitat value for native fish, it can be expected that there will be a need to provide for fish passage past the dam structure.

5.8 Planning Issues

- the storage site is mainly zoned Rural 2, apart from top end of reservoir which is zoned Industrial Heavy (surrounding Cement Works)
- area surrounding the site is denoted as Residential Activity Restriction Area – gives protection to quarrying from potential residential expansion
- TRMP Area Maps show fault line passing close to site
- 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 10B is within the Upper Catchments Water Management Zone
- range of consents will be required, mainly for discretionary activities, with exception as 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):
  - 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

5.9 Potential for Mitigation of Effects

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

- provision of replacement road to upper Lee Valley and Richmond Forest Park, including alternative road access to forestry land and to Cement Works
- dambreak warning system
- provision of system to allow native fish passage
- provision of additional recreational areas and access to storage reservoir
- controlled flow releases to provide whitewater for specific events
- blue duck predator control programme in areas of habitat not affected by scheme

5.10 Potential Opportunities for Enhancement

The following potential opportunities exist for enhancement (in addition to those arising from augmenting flows in the lower catchment for water supply, protection of instream values, and enhancement of the values of the Waimea Estuary):

- Generation of electricity
- Self-sustaining trout fishery above dam, improving current fishery in Lee
- Recreational use of 'lake' (reservoir) environment (picnic areas, swimming, boating, fishing)
- Creation of wetland habitat at reservoir margins
- Development of walkway system around reservoir (utilising land in public ownership (marginal strip), including linkage to and improvement of legal access to Richmond Forest Park.

Several of these opportunities at Site 10B would be at their maximum potential (in comparison with other sites) due to the relative proximity of this site to population centres.

6 Site 11 – Upper Lee River

6.1 Location/ Site Topography

This site is within the main stem of the Lee River, approximately 700m downstream from the confluence with Anslow Creek (refer Figure 1.1 of Appendix A). We have not been able to view this site on the ground.

The storage dam would be an instream dam. The head of the reservoir would extend upstream for approximately 2km, and would incorporate the lower reaches of Anslow Creek and Waterfall Creek. Initial delivery would again be by release into the river.

6.2 Engineering

Appendix A summarises the engineering approach adopted. Key results are as follows (15 Mm^3 storage).

1. dam normal top water level about RL 187 m (dam some 53.5 m high)
2. land area involved to crest level, some 95 hectares
3. dam type, concrete faced rockfill
4. hydro potential 1.37 MW and 7.70 GWh/annum
5. indicative base cost (no hydro) $27.0 M

6.3 Land Ownership & Landuse

Due to the incised nature of the river through this stretch, the area of land potentially affected by the reservoir is narrow. TDC records show:

- the areas immediately adjacent to the valley floor are privately owned
- side slopes above this are "Crown Forest Manager"

The valley sides are used for commercial forestry (exotic species).

There appear to be no residences in the affected area.

6.4 Potential Effects on Existing Infrastructure

The following existing infrastructure would potentially be affected by the proposed storage:

- 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.
- the NZMS 260 topographic map also shows a track on the eastern side of the river and "Waterfall Creek Hut" (although we have been advised that the latter may no longer exist).
- access to Lucy Creek Road and associated forestry roads (from just upstream of Long Gully)

6.5 Hazard Potential

Because the valley is narrow, the effects of a dambreak would be closely similar to those for the Mid Lee site downstream. Although the cement works infrastructure is mainly well above the valley floor, there could be some damage here as well.

6.6 Potential Environmental Issues

6.6.1 Terrestrial Ecology

We expect that existing land use on the side slopes comprises exotic forestry. There may be native forest remnants immediately adjacent to the river. This would need to be assessed as part of further investigations.

Overall, the vegetation in the Lee Catchment is more compromised that that in the Wairoa Catchment due to pine forestry (S Courtenay, DOC, pers. comm.). However, in any areas where ultramafic geology exists, there may be flora of significance.

6.6.2 Water Quality and Aquatic Ecology

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.

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 (Cawthron report).

There are no recorded sightings of blue duck within the area potentially affected by the storage system. However, both the Lee and the Wairoa Catchments appear to contain good habitat for blue duck and could potentially maintain breeding populations if predators were controlled (M Rutledge DOC pers. comm. reported by Cawthron).

6.6.3 Archaeology/Heritage Values

- TDC records show no specific sites of significance in the potentially affected area.
- 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

6.6.4 Potential Effects on Recreation

The lower Lee Valley is a popular recreational resource as noted in previous sections. 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:

- it is unlikely that there are any picnic sites within the stretch of river that would be directly affected by the storage reservoir.
- 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 (white water and scenic value). This stretch begins approximately 2 km downstream from the potential storage site. This value continues down the length of the Lee River (ie from the Cement Works down to Max's Bush (below Wairoa confluence). (Ron Wastney, pers. comm.)
- 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.).
- 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.
- there are several picnic areas in the lower Lee Valley as noted in previous sections, as well as the Regional Girl Guide Lodge.

6.6.5 Community Issues

ESR's community survey work to date has provided feedback on the values of the Lee River Valley. These are summarised below. However many of these 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.

- 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

Other significant community issues can be expected to arise as a result of the dambreak potential. However this may be less than for Site 10B given the distance and a perception of "out of sight out of mind". 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).

6.7 Potential Cultural Issues

Initial discussions have been held with iwi (as described in previous sections) enabling us to offer the following comments:

- a specific cultural impact assessment will need to be undertaken in relation to options selected for further investigation
- a dam at Site 11 would result in the intermingling of water from the Lee and its tributaries. This is unlikely to be a major issue, but would need to be assessed on a site-specific basis.
- based on the Lee River's habitat value for native fish, it can be expected that there may be a need to provide for native fish passage past the dam structure.

6.8 Planning Issues

- the storage site is mainly zoned Rural 2, apart from 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
- range of consents will be required, mainly for discretionary activities, with exception as 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):
  - 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

6.9 Potential for Mitigation of Effects

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
- dambreak warning system
- provision of system to allow native fish passage
- controlled flow releases to provide whitewater for specific events
- blue duck predator control programme in areas of habitat not affected by scheme

6.10 Potential Opportunities for Enhancement

The following potential opportunities exist for enhancement (in addition to those arising from augmenting flows in the lower catchment for water supply, protection of instream values, and enhancement of the values of the Waimea Estuary):

- 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
- Development of walkway system around reservoir (utilising land in public ownership (marginal strip)
- Improved access to Richmond Forest Park, and development of linking tracks to main track system.

7 Site 13 – Wairoa Forks

7.1 Location/ Site Topography

This site is within the main stem of the Wairoa River, approximately 400m downstream from the confluence of the Right and Left Branches of the Wairoa River (see Figure 1.1 of Appendix A). This site is that identified by MWH in earlier studies for TDC.

At the potential storage dam site, the river is well incised within the overall valley with a narrow valley base.

The storage dam would be an instream dam. The head of the reservoir would extend upstream for approximately 2km, and would incorporate the lower approximately 1.5km of both the Right and Left Branches.

7.2 Engineering

Appendix A summarises the engineering approach adopted. Key results are as follows (15 Mm^3 storage).

1 dam normal top water level about RL 170.5 m (dam some 44 m high)

2. land area involved to crest level, some 105 hectares

3. dam type, concrete faced rockfill

4. hydro potential 2.63 MW and 15.0 GWh/annum

5. indicative base cost (no hydro) $25.6 M

7.3 Land Ownership & Landuse

Due to the incised nature of the river through this stretch, the area of land potentially affected by the reservoir is narrow. TDC records show:

- an area of privately owned land just above the dam site on the true right (eastern) bank, extending up the Left (eastern) Branch
- three Recreation Reserves (Department of Conservation); one immediately upstream of the potential dam site, and one in each of the lower reaches of the Left (eastern) Branch and the Right (western) Branch
- there appear to be some other small areas of land administered by the Department of Conservation adjacent to the river margins
- side slopes above this are "Crown Forest Manager"

The valley sides are used for commercial forestry (exotic species).

There appear to be no residences in the affected area. However there is a Scout Den (under concession from DOC) in the Right (western) Branch, near the Bull Creek confluence.

7.4 Potential Effects on Existing Infrastructure

The following existing infrastructure would potentially be affected by the proposed storage:

- Wairoa Gorge Road - approximately 2km of this road would be potentially affected by the reservoir, extending up the Right (western) Branch valley. This road provides access to forestry land and to Richmond Forest Park.
- Old Mill Road – this road branches off Wairoa Gorge at the Forks extending up the Left (eastern) Branch valley. Approximately 1.5km of this road would be potentially affected by the reservoir. This road provides access to forestry land and to Richmond Forest Park.
- Scout Den

7.5 Hazard Potential

The dambreak wave at this site would be generally similar to that outlined for dams on the Lee but the initial wave height would be lower because the dam height is lower. The small group of dwellings down the valley may be on a high enough terrace to escape the flood wave but they may be vulnerable.

7.6 Potential Environmental Issues

7.6.1 Terrestrial Ecology

Existing land use on the side slopes above the road comprises exotic forestry.

There are native forest remnants immediately adjacent to the river (comprising matai and totara), including areas of important native riparian vegetation (between the road and the river). Native vegetation within the flood zone comprises a distinctive combination of flood tolerant shrubs and herbs suited to hard rock sub-strata. These communities are endemic to Nelson. The Wairoa River differs from other Nelson rivers in the region in regard to its relatively unmodified riparian vegetation.

The lower to mid Wairoa valley supports nationally threatened species. It is expected to be of higher value than the upper catchment, although less work has been undertaken in the upper catchment (S Courtenay, DOC, pers. comm.).

The extent and significance of any vegetation potentially affected would need to be assessed as part of further investigations.

7.6.2 Water Quality and Aquatic Ecology

Consistently good water quality appears to occur in the Wairoa Gorge area, indicated by an invertebrate community typical of clean water. Species richness is very good in the Wairoa River (Cawthron report).

The fish community of the Wairoa River is described by DOC as a "diverse fauna of regional importance" (M Rutledge, DOC pers. comm. reported by Cawthron). Native fish species recorded in the Wairoa River are:

- koaro (both Branches)
- upland bully - in the Left (eastern) Branch

- longfin eel - in the Left (eastern) Branch and Right (western) Branch
- common smelt (Wairoa Gorge)

All of the fish species recorded, except upland bullies, are diadromous.

Brown trout are present in the Wairoa River. Recent drift diving by Fish and Game recorded 23.6 and 11.5 medium and large trout per kilometre in the Left (eastern) Branch and in the Wairoa River upstream of Pig Valley.

Blue duck (whio) have been recorded in the stretch of the Wairoa River just below the Forks. Both the Lee and the Wairoa Catchments appear to contain good habitat for blue duck and could potentially maintain breeding populations if predators were controlled (M Rutledge DOC pers. comm. reported by Cawthron).

7.6.3 Archaeology/Heritage Values

- TDC records show no specific sites of significance in the potentially affected area.
- 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.

7.6.4 Potential Effects on Recreation

The Wairoa River and Valley are a popular recreational resource.

Specific comments are as follows:

- there are presently three formal picnic sites within the stretch of river that would be directly affected by the storage reservoir. In addition the Forks area itself at the bridge is popular (off the rock formation).
- we note that in relation to the three DOC recreation areas, the "Nelson/Marlborough Conservancy Recreation Opportunities Review" (October 2004) has reviewed the status of each as follows:
  - Mid Wairoa Gorge Amenity Area: maintain
  - Wairoa (Left Branch) Amenity Area – cease to maintain
  - Wairoa (Right Branch) Amenity Area – cease to maintain

  If these recommendations are accepted, this will mean that only the site immediately upstream of the potential dam site (mid Wairoa Gorge Amenity Area) would have been maintained and be likely to have significant ongoing use.
- the river contains good swimming areas.
- the stretch of river that would be directly affected by the storage reservoir is of value for kayaking. The Left (eastern) Branch is of high value for both white water and its scenic value. The Right (western) Branch is of low value for white water – it is technically very difficult, and is only run once or twice a year when flows are higher. The stretch downstream from the Forks to Stillwells Bridge (mid Gorge) contains high value white water and has high scenic value. This would need to be taken into account when considering flow harvesting, and downstream releases. Below this (from Stillwells Bridge to the Lee confluence) is of low value for white water but does have high scenic value). (Ron Wastney, pers. comm.). Information obtained by ESR notes that members of the Nelson Canoe Club consider the

Wairoa River, when in flood, to be one of the premium rivers. It may be used by up to 100 kayakers when the river is high.

- the Wairoa is a good trout fishing river. Grant Irvine (a local angler) rates the Wairoa River highly and lists its proximity to Nelson and Richmond as a major attraction. However the river is not heavily fished and as a result the trout are relatively easy to catch. The aesthetic values of the river are also valued. (Grant Irvine, pers. comm. reported by Cawthron).
- Wairoa Gorge Road and Old Mill Road provide access to Richmond Forest Park.
- information provided by ESR notes that access to the top of the valley is important for hunters
- the presence of the Scout Den in the Right (western) Branch implies some use of this area for outdoor activities. However it is unclear whether this Den is still used. This would need to be investigated as part of further investigations.

7.6.5 Community Issues

ESR's community survey work to date has provided feedback on the values of the Wairoa River and Valley. These are summarised below. However many of these comments were made generally about the Lee and/or Wairoa Rivers and may not necessarily be specific to Site 13.

- 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

Comments specific to the Wairoa River included:

- clear water
- scenic beauty
- prefer a storage dam(s) out of the river

Other significant community issues may arise as a result of the dambreak potential.

The most important stretch of the river for residents (expressed to ESR via the Wairoa Valley Residents Focus Group) is the stretch up as far as the last habitation (adjacent to Pig Valley Road intersection).

7.7 Potential Cultural Issues

Initial discussions have been held with iwi (as explained in previous section)enabling us to offer the following comments:

- a specific cultural impact assessment will need to be undertaken in relation to options selected for further investigation
- a dam at Site 13 would result in the intermingling of water from the two tributaries of the Wairoa River. This may not be a major issue, but would need to be assessed on a site-specific basis.
- based on the Wairoa River's habitat value for native fish, it can be expected that there will be a need to provide for fish passage past the dam structure to provide access into both branches.

7.8 Planning Issues

- the storage site is mainly zoned Rural 2, apart from four small areas zoned Recreation
- 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 13 is within the Upper Catchments Water Management Zone
- range of consents will be required, mainly for discretionary activities, with exception as 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 Wairoa River (TRMP Schedule 30.1):
  - provide for protection of instream values including fisheries and natural values
  - maintain contribution to Waimea River flows
  - protect landscape, cultural and spiritual values
  - maintain or improve existing users' security of supply to acceptable level

7.9 Potential for Mitigation of Effects

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

- provision of replacement road to upper Wairoa Valley and Richmond Forest Park (via Right (western) Branch)
- provision of alternative road access to forestry land
- dambreak warning system
- provision of system to allow native fish passage
- provision of replacement recreational areas in river, including Scout Den
- provision of access to storage reservoir
- flow harvesting such that high flows suitable for kayaking are retained for some times
- controlled flow releases to provide whitewater for specific events
- blue duck predator control programme in areas of habitat not affected by scheme

7.10 Potential Opportunities for Enhancement

The following potential opportunities exist for enhancement (in addition to those arising from augmenting flows in the lower catchment for water supply, protection of instream values, and enhancement of the values of the Waimea Estuary):

- Generation of electricity
- Improved road system to mid catchment
- Self-sustaining/improved trout fishery above dam
- Recreational use of 'lake' (reservoir) environment (picnic areas, swimming, boating, fishing)
- Creation of wetland habitat at reservoir margins
- Development of walkway system around reservoir (utilising land in public ownership (marginal strip)
- Improved access to Richmond Forest Park.

8 Site 15 – Upper Wairoa River – Left Branch (Eastern)

8.1 Location/ Site Topography

This site is within the Left (eastern) Branch of the Wairoa River, approximately 3km upstream from the confluence of the Right and Left Branches (see Figure 1.1 in Appendix A)

The storage dam would be an instream dam. The head of the reservoir would extend upstream for approximately 3km. Controlled releases would again be directly into the river.

8.2 Engineering

Appendix A summarises the engineering approach adopted. Key results are as follows (15 m^3 storage).

1. dam normal top water level about RL 240 m (dam some 64.5 m high)
2. land area involved to crest level, some 75 hectares
3. dam type, concrete faced rockfill
4. hydro potential 1.9 MW and 10.8 GWh/annum
5. indicative base cost (no hydro) $28.3 M

8.3 Land Ownership & Landuse

Due to the incised nature of the river through this stretch, the area of land potentially affected by the reservoir is narrow. TDC records show:

- the true right bank immediately adjacent to and upstream of the potential dam site is Department of Conservation estate. Above this (in upstream direction) is private land
- the true left bank comprises partly "Crown Forest Manager", and partly private land

Land cover comprises a mixture of indigenous vegetation and exotic forest.

There are no residences in the affected area.

8.4 Potential Effects on Existing Infrastructure

Old Mill Road extends as a gravel track adjacent to the river (true left bank). It is used as access to forestry land and roads, and access to Richmond Forest Park. ,.

8.5 Hazard Potential

The flood wave from a dambreak at this site would be more severe than others because the dam height is greater. There would not be a lot of attenuation of the flood wave down the narrow Wairoa gorge.

8.6 Potential Environmental Issues

8.6.1 Terrestrial Ecology

Existing land use on the side slopes is expected to comprise either native forest or exotic forestry.

There may be native forest remnants immediately adjacent to the river, including areas of important native riparian vegetation similar to the lower parts of the catchment (see section 7.6.1). The lower to mid Wairoa valley supports nationally threatened species. It is expected to be of higher value than the upper catchment, although less work has been undertaken in the upper catchment. In areas where the geology comprises ultrmafics, there may be significant vegetation associations (S Courtenay, DOC, pers. comm.).

This would need to be assessed as part of further investigations.

8.6.2 Water Quality and Aquatic Ecology

Consistently good water quality appears to occur in the Wairoa Gorge area, indicated by an invertebrate community typical of clean water. Species richness is very good in the Wairoa River.

The fish community of the Wairoa River is described by DOC as a "diverse fauna of regional importance" (M Rutledge, DOC pers. comm. reported by Cawthron). Native fish species recorded in the Wairoa River are:

- koaro (both Branches)
- upland bully - in the Left (eastern) Branch
- longfin eel - in the Left (eastern) Branch and Right (western) Branch
- common smelt (Wairoa Gorge)

All of the fish species recorded, except upland bullies, 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 Wairoa River. Recent drift diving by Fish and Game recorded 23.6 and 11.5 medium and large trout per kilometre in the Left (eastern) Branch and in the Wairoa upstream of Pig Valley.

Several records of blue duck (whio) exist in the Left (eastern) Branch, above the potential storage site (Cawthron report). Both the Lee and the Wairoa Catchments appear to contain good habitat for blue duck and could potentially maintain breeding populations if predators were controlled (M Rutledge DOC pers. comm. reported by Cawthron).

8.6.3 Archaeology/Heritage Values

- TDC records show no specific sites of significance in the potentially affected area.
- 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

8.6.4 Potential Effects on Recreation

The mid and lower Wairoa River and Valley are a popular recreational resource.

Specific comments are as follows:

- Old Mill Road extends as a gravel road to the area that would be directly affected by the dam and reservoir footprint.. The road provides a significant access point to Richmond Forest Park via a track system to Ben Nevis.
- there are presently two formal picnic sites within the downstream stretch of river near the Forks area, as well as the Forks area itself at the bridge (off the rock formation).
- we note that in relation to the three DOC recreation areas, the "Nelson/Marlborough Conservancy Recreation Opportunities Review" (October 2004) has reviewed the status of each of the formal picnic areas downstream as follows:
  - Mid Wairoa Gorge Amenity Area: maintain
  - Wairoa Left (eastern) Branch Amenity Area – cease to maintain

  If these recommendations are accepted, this will mean that only the site downstream of the Forks (mid Wairoa Gorge Amenity Area) would have been maintained and be likely to have significant ongoing use.
- the downstream river contains good swimming areas.
- Ron Wastney has stated that the stretch of river that would be directly affected by the storage reservoir is of high value for both white water and its scenic value. However we are unsure of access to this area. This value extends downstream to Stillwells Bridge (mid Gorge) This would need to be taken into account when considering flow harvesting, and downstream releases. Below this (from Stillwells Bridge to the Lee confluence) is of low value for white water but does have high scenic value). (Ron Wastney, pers. comm.).
- information obtained by ESR notes that members of the Nelson Canoe Club consider the Wairoa River, when in flood, to be one of the premium rivers. It may be used by up to 100 kayakers when the river is high.
- the Wairoa is a good trout fishing river. Grant Irvine (a local angler) rates the Wairoa River highly and lists its proximity to Nelson and Richmond as a major attraction. However the river is not heavily fished and as a result the trout are relatively easy to catch. The aesthetic values of the river are also valued. (Grant Irvine, pers. comm. reported by Cawthron). It is not clear whether these comments apply to the upper Wairoa (Left Branch), especially given its difficult access. This aspect would need to be explored as part of further investigation.

8.6.5 Community Issues

ESR's community survey work to date has provided feedback on the values of the Wairoa River and Valley. These are summarised below. However many of these comments were made generally about the Lee and/or Wairoa Rivers and may not necessarily be specific to Site 15.

- 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

Comments specific to the Wairoa River included:

- clear water
- scenic beauty
- prefer a storage dam(s) out of the river

Other community issues may arise as a result of the dambreak potential. However this is likely to less significant given the distance between the dam site and the nearest residential areas.

8.7 Potential Cultural Issues

Initial discussions have been held with iwi (as noted in previous sections) enabling us to offer the following comments:

- a specific cultural impact assessment will need to be undertaken in relation to options selected for further investigation
- a dam at Site 15 would not result in the intermingling of water from tributaries.
- based on the Wairoa River's habitat value for native fish, it can be expected that there will be a need to provide for native fish passage past the dam structure to provide access to the top of the catchment.

8.8 Planning Issues

- the storage site is mainly zoned Rural 2, apart from two areas zoned Recreation (lower true right, and small area upper true right)
- 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 15 is within the Upper Catchments Water Management Zone
- range of consents will be required, mainly for discretionary activities, with exception as 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 Wairoa River (TRMP Schedule 30.1):
  - provide for protection of instream values including fisheries and natural values
  - maintain contribution to Waimea River flows
  - protect landscape, cultural and spiritual values
  - maintain or improve existing users' security of supply to acceptable level

8.9 Potential for Mitigation of Effects

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

- replacement of forestry roads and access to Richmond Forest Park
- dambreak warning system
- provision of system to allow native fish passage
- flow harvesting such that high flows suitable for kayaking are retained for some times
- controlled flow releases to provide whitewater for specific events
- blue duck predator control programme in areas of habitat not affected by scheme

8.10 Potential Opportunities for Enhancement

The following potential opportunities exist for enhancement (in addition to those arising from augmenting flows in the lower catchment for water supply, protection of instream values, and enhancement of the values of the Waimea Estuary):

- Generation of electricity
- Improved road system to mid catchment , including public access to upper catchment and Richmond Forest Park 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
- Development of walkway system around reservoir (utilising land in public ownership (marginal strip)
- Improved access to Richmond Forest Park, and development of linking tracks to main track system.

9 Ranking and Selection of Sites for Further Investigation

On 5 April 2005, a draft of this report was discussed during two workshop sessions, firstly with a Technical Group of the Waimea Water Augmentation Committee, and secondly with the formal Committee that evening. Comments made by the participants have been incorporated where appropriate into this final report. Additional pertinent points were made as follows:

- Need to ensure that delivery of water from Site 2 reservoir is able to be to a point in the system where the water is needed to augment existing water resources.
- It was agreed that all four sites in the Wairoa and Lee had sufficient water available to meet the required demand scenarios, so they 'level-pegged' in that sense.
- All sites are approximately comparable, cost-wise.
- The potential for power generation at the four Wairoa/Lee sites is a minor possible benefit of those options.
- Community involvement in assessing the options from here on is an important part of the process

A broad ranking exercise was undertaken by the Technical Group and was subsequently endorsed by the Committee. The ranking process 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 Branch) eastern) Wairoa
- 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 for ongoing investigation.

10 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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Appendix A: Engineering Assessment of Potential Storages

APPENDIX A
ENGINEERING ASSESSMENT
OF POTENTIAL STORAGES

1. Storage Identification

1.1 Identification of Possible Sites

The preliminary storage site identification aimed to find all storages able to be connected into the demand area and appearing to achieve practicably, in excess of 5 Mm^3 capacity. The objective was to be comprehensive and cover storages on smaller streams requiring supplementary infill from adjacent catchments, as well as storage dams on the larger rivers. Storages on smaller streams, particularly in situations where the storage is called upon mainly in droughts, sometimes enable a more cost effective solution despite the cost of transfer infill. Smaller capacity storages were included to enable consideration of possible staged development involving more than one storage.

Fifteen possibilities with variants (18 all up) as shown on Figure 1.1 overleaf, were identified from 1:50,000 base maps and inspection insofar as practicable from public roads. Land ownership and landuse were not taken as an overriding constraint for this exercise, except that where more than a few dwellings would be affected, the damsite was located to minimise the need to acquire existing properties. Local geological conditions as understood from published data, including geologically active faults, were taken into consideration, for example the Waimea and Mt Heslington faults along the northern side of the Dobson Range which would be at the upstream limit of storages 5 to 8.

Storages identified as possibilities form three generic types as follows:

- substantially "off river" storages west of the Wai-iti valley in subcatchments, involving with transfer infill, primarily from the Wai-iti and delivery downstream via the Wai-iti and/or a separate race/pipeline (storages 1 to 4)
- again substantially off-river storages, between the Wai-iti and Wairoa, requiring infill transfer from the Wairoa and delivery as for the prior group (storages 5 to 8)
- storages on the larger rivers (Wairoa, Lee and Lower Roding) able to be filled directly by river flow (storages 11 to 15) - the lower Roding site is located downstream of the Nelson City intake and below possible future damsites previously identified by the City, but its potential would be reduced if expansion of City supply involved a storage dam on the Upper Roding and the City had first call on the resource

1.2 Initial Shortlist

A shortlist of possible sites was required to take to a workshop, that workshop then selecting three storages for comparative evaluation, in turn leading to a preferred option. In the first instance, the WWAC Committee determined which of the possibilities should be excluded from consideration. The consultant team then undertook a broad based ranking of the remaining possibilities and discussed the findings with WWAC representatives. Stemming from this process, the following five sites were selected for workshop evaluation:

- Site 2 (Pigeon Valley)
- Site 10B (Mid Lee)
- Site 11 (Upper Lee)
- Site 13 (Wairoa Forks)
- Site 15 (Upper Wairoa)

2 Preliminary Arrangements

2.1 General

All of the five sites have been assessed on an even handed basis so that a balanced assessment can be made of relevant issues, including indicative comparative costs. Precedents available to the consultant team have been drawn upon as well as the knowledge and experience of team specialists. While hydroelectric potential is included in the brief, focus at this preliminary stage has been on storage and layouts do not include a hydro component and costing. However, hydro potential has been assessed in broad terms.

In the first instance, all sites have been assessed on the basis of 15 Mm^3 of safe storage.

2.2 Storage level and dam height

The only contour data available at this stage is 20 m contours from LINZ mapping. Elevation-storage characteristics have been developed from the 20 m contours. Indicative normal or pre flood top storage levels and dam heights have been based on the following:

- estimating the dam base level from 20 m contours by interpolation
- allowing 1 Mm^3 of base storage for future sediment accumulation
- making no additional allowance for storage to achieve a minimum reservoir level for aesthetic or environmental reasons
- assessing the storage level from the elevation/storage data to give 16 Mm^3 of storage
- adding flood/wave freeboard allowances of 2.5 m for Site 2 and 3.5 m for other sites

The resulting data are as follows:

Data for 16 Mm³ Total Storage

Site	2	10B	11	13	15
Dam Height (m)	38.5	53.5	53.5	44.0	64.5
Normal top Water Level (RL)	150	117	187	170.5	240
Reservoir Area to Crest Level (ha)	100	70	95	105	75

It should be noted that actual elevations and heights based on more reliable contour data, may be a little different from the above.

2.3 Geology

Site 2 is located in Moutere clay bound gravel formations. Based on prior TDC borehole data in the valley (reinterpreted) plus an in-place Moutere exposure close to the valley floor, valley floor infill deposits are shallow and not significant to dam arrangements and costs.

The other sites are located in basement rock terrain consisting of strong, indurated sandstone and siltstone formations. Because the Lee and Wairoa valleys are relatively deeply incised and have steep slopes, there is little weathering and almost no alluvial fans. Thus earthfill type materials as were available for the Maitai dam, are not available or available only in limited quantities. Dun Mountain ultramafics are present in the area and are associated with several areas of mapped slope instability. No dam sites are located on Dun Mountain ultramafic rocks although a small section of the Lee Valley underlain by Dun Mountain ultramafics will be inundated at the upstream extent of the reservoir behind Site 10B.

The Alpine Fault, which separated the Australian and Pacific crustal Plates is situated approximately 25 to 35 km to the southeast. The potentially active Waimea, Mt Heslington and Eighty Eight and Whangamoa Faults are located in the area. All damsites are clear of known faults line traces although Sites 10B and 13 are in close proximity to the Whangamoa Fault. The most significant seismic risk is likely to be from ground shaking associated with either rupture of the Wairau segment of the Alpine Fault or rupture of the Waimea Fault. Seismic loading will be broadly similar for all dams and the expected level of shaking for design (in the range .25 to .7g) is recognised in preliminary arrangements.

2.4 Hydrology

Hydrological assessment for present purposes has mainly been limited to calculation of flood peaks for preliminary sizing of diversions and spillways and derivation of flow duration characteristics on the Lee and Wairoa sites for appreciation of hydro potential. However, for the Pigeon Valley site, a preliminary modelling exercise has been undertaken to assess transfer requirements using data

available from the Upper Wai-iti study. The winter flows for the Lee and Wairoa rivers should amply assure capture of 15 Mm^3 without contravening flow allocation rules and capture of high flows in the irrigation season may also be achievable. Flood peaks have been assessed using the McKercher and Pearson (1989) method which is approximate, but puts flood issues realistically into perspective.

Setting aside any extra required for Wairoa minimum flow purposes and system losses, and assuming 3 l/s residual flow at the dam (supplemented by South branch flow a short distance downstream), the North Branch Pigeon Valley could service around 1200 hectares of irrigation from its own catchment. Assuming transfer from adjacent catchments is restricted to winter months, then potential infill contributions up to the estimated ultimate hydrological yield potential (viz: ignoring practical transfer sizes and costs) are roughly:

- 300 hectare irrigation equivalents from the adjacent south branch
- 3,500 hectare irrigation equivalents from the Wai-iti with an intake above Baigent Road

To achieve 15 Mm^3 of live storage, the most practical or effective infill system would involve an intake on the Wai-iti which requires a 1.0 m^3/s capacity intake. Because of the limited resource in the Wai-iti valley, Pigeon Valley storage will serve a lesser demand area than storages on the Lee or Wairoa. For comparative purposes, the 15 Mm^3 base case adopted would serve approximately 86% of the area served by other storages.

By damming both branches (north branch presently excluded) most or perhaps all of the demand may be satisfied, or in principle adequate infill could be provided from the Wairoa. However, the latter would be more costly and involve more environmental issues. Therefore a Wairoa transfer has been excluded from consideration at this stage.

Flood and transfer data resulting from the assessments are as follows:

Site	**2**	**10B**	**11**	**13**	**15**
10 year AEP flood peak (m^3/s)	30	150	130	220	140
200 AEP flood peak (m^3/s)	56	280	240	400	260
Transfer capacity (m^3/s)	1.0	NA	NA	NA	NA

2.5 Hydro Potential

Site 2 requires lift pumping for infill so is negative in terms of energy potential. The peak pumping requirement would be about 1000 kW and the average annual energy requirement, some 1600 kW hr.

The only hydrological record available is on the Wairoa at gorge. At this stage, the Lee is assumed to have similar flow duration characteristics to the combined subcatchment flows measured at gorge. These are:

Exceedance Percentile	**Flow as % of Mean**
10	190
20	107
30	74
40	56
50	44
60	*36*
70	28.5
80	22.5
90	17.0

Mean flow estimates are based on Wairoa flow duration with adjustments for catchment rainfall distribution. Results are as follows:

10B	4.1 m^3/s
11	3.6 m^3/s
13	6.5 m^3/s
15	4.0 m^3/s

Based on flow duration shape and prior detailed work for combined irrigation-hydro schemes where the release is at the base of the dam, and factoring in differences between regulated storage at these and prior reference sites, our preliminary judgement based assessment of the most economic hydro potential is as follows:

Site	**10B**	**11**	**13**	**15**
Peak generation Flow (m^3/s)	4.1	3.6	6.5	4.0
Peak Output (MW)	1.56	1.37	2.63	1.90
Average Annual Gross Output (GWh)	8.85	7.70	15.0	10.8

It should be recognised that while the dams provide the head and flow regulation which makes hydro attractive, the generation flows are significantly higher than the $\pm$ 2.0m^3/s release for irrigation and Wairoa low flow enhancement, thus adding significantly to intake system and release conduit costs. Apart from the power station costs, another significant cost (and environmental issue) arises in transmitting the power into the local network. Cost effectiveness will be an output for the three finally shortlisted sites, but in broad terms, similar results are expected for all but the Wairoa at Forks (site 13) where the available flow is about twice that for other sites.

2.6 Dam Types and Features

2.6.1 General

For 15 Mm^3 available storage under the assumptions made, the dams range in height from 38.5 to 64.5 m. Heights would decrease in the case of the volume being split between two storages, but not appreciably, because most of the storage volume is at higher elevations.

For these heights and given modern focus on water quality, notwithstanding the aeration achieved through release to rivers, it is likely that multiple level drawoffs will be required to enable selection of highest quality water. Such a requirement is assumed, although aeration by submerged pipes can be considered. The peak managed release for the maximum demand will be the order of 2.0 m^3/s. Thus reasonably large pipework will be required and for the present exercise a dry intake tower of about 4.0 m internal diameter is assumed for all sites with valved intakes at around 10 m vertical spacing.

Diversions will need to take at least a 10 year flood and this flood size is assumed for the base diversion structure, with supplementary flood capacity as described for the different dam types.

The spillway system is assumed sized to take up to a 200 AEP flood through a permanent spillway, with auxiliary spill via an unlined path occurring for larger floods. It is likely that fuse plugs would be employed for auxiliary spill. Under expected standards, floods up to 10,000 AEP size will need to be passed.

All sites would drown public or forestry roads and replacement roading to areas above the reservoir need to be allowed for. Reservoirs would have to be cleared of all vegetation down to stump level. Some exotic forest is mature (e.g. Pigeon Valley currently or recently logged) and other younger forest may have recovery value.

2.6.2 Pigeon Valley (Site 2)

The Pigeon Valley site clearly is suited to an earthfill type dam. Many dams have been built in the Moutere formations.

A dam type generally similar to the Maitai valley dam is expected except for requiring a different intake tower because of the larger drawoff. Figure 1.2 shows a schematic layout on which indicative costing is based.

Additional diversion capacity could be achieved first by building the dam to the order of 10-15 m height to provide storage and extra head on the diversion

structure, while leaving a gap at one abutment until the "last minute" , then one or more temporary overland flow paths at higher levels.

The transfer system from the Wai-iti assumes the following:

- 1.0 m^3/s river intake involving rebuildable low level bank weir and settling pond a short distance downstream at RL 90 m approx.
- transfer to about RL 86 m close to the confluence of the South – North Branch Pigeon Valley Streams principally involving a contour race but with 1 km which fringes hillslopes in pipe or flume
- pumpstation of about 1 MW capacity about 1 to 1.5 km downstream of the dam and rising main connected into the dam release flow conduit.

If the Site 2 option were considered further, a buffer pondage behind a low embankment could be considered in the stream confluence area, enabling capture of both South Branch and Wai-iti transfer flow, leading to an increase in capture potential or some overall transfer system cost savings.

2.6.3 Lee and Wairoa Sites (10B, 11, 13, 15)

These sites appear best suited to concrete faced rockfill or concrete dams.

Durable rock is expected to be obtainable at or in the close vicinity of each site after the order of 2 to 3 m of overburden stripping. Given the locations and nature of access roading, and perhaps excepting the Mid Lee site (10B), aggregates for a concrete dam would best be obtained by on-site quarrying and crushing. That could also be appropriate for concrete involved in a concrete faced rockfill dam, not only from a cost viewpoint, but to reduce construction (traffic) effects.

For present purposes and for consistency between sites, a concrete faced rockfill type dam has been assumed at each site for indicative costing. Figure 1. 3 shows a typical dam arrangement schematically, in this case site 11. Principal differences from the earthfill type dam outlined for Pigeon Valley are:

- rockfill rather than earthfill
- steeper dam slopes
- seepage control by upstream concrete facing
- steeper spillway chute and likely a stepped type spillway as employed at Opuha dam
- supplementary spill capacity by reinforcing the base 15 m or so of the downstream rockfill slope and allowing overflow without unravelling (Australian precedents)

3. Indicative costs

Indicative cost estimates have been prepared for all five options for 15 Mm^3 of useable storage on a consistent basis. It is stressed that the dollar values are indicative and approximate, given the present level of study. However, the estimates serve to put costs into perspective and illustrate the relative costs of different options. In the case of Pigeon Valley, the capital cost of the infill transfer system has been included and the cost of energy for pumping taken as 10 times the average energy at an assumed rate of 10 cents/unit. The latter is simplistic, but enables a rough comparison of equivalent capital cost with other dams not involving pumping. Pumping costs would fluctuate and would be subject to real cost rises relative to inflation.

Cost estimating has been based on the following:

- quantifying earthfill, rockfill, filters, wave armour and associated principal embankment dam items using typical proportions in relation to dam size/type (assumed 5:1 overall upstream/downstream slopes for Site 2 and 1.4:1 upstream/1.3 downstream for rockfill dams at the other four sites – allowance for elver pass included but no more elaborate fish pass)
- proportioning diversion/delivery conduits and spillways relative to preliminary design flows with reference to precedents for quantities
- similarly proportioning the intake tower and outlet pipework
- forestry and metalled public roads are assumed at between $70,000 and $100,000/km
- estimating costs-to-build using current rates and lump sums for certain items
- for dams adding 50% to the above to cover contractor establishment, engineering and a contingency/uncertainty allowance of around 20%
- for the Site 2 transfer which involves less uncertainty, adding 40%
- adding an estimate for land acquisition based on $10,000 per hectare nett after any purchase and resale and timber recovery

The resulting indicative costs, exclusive of construction financing, preliminary studies and consenting, legal and developer administration, are as follows, all for 15 Mm^3 of storage:

Site	**Comparative Cost ($M)**	**Comparative Cost/m^3 of storage ($)**
2	22.4 (17.7 dam 4.7 transfer)	1.74
10B	27.1	1.81
11	27.0	1.81
13	25.6	1.71
15	28.3	1.89

(* adjusted by "area served factor" in section 2.4 to be comparable)

Note that for this comparative exercise, no allowance has been made for delivery systems. While simple release back into the Wai-iti may be adequate for the Pigeon Valley site, there may be a need to transfer some flow to the Wairoa. Thus the comparative Site 2 cost may be higher than tabled.

The simplistically capitalised pumping cost for Site 2 is 7% of the total cost. Land costs at the assumed rate of $10,000/ha are around 4 to 5% of total cost.

4 Comments on Comparative Merits

The following issues are arguably the most significant in comparing options from the engineering perspective (viz: setting aside environmental issues, hazard potential, and land acquisition):

- cost
- potential for hydro add-on
- construction risks
- integration with delivery
- operation and maintenance
- potential for staging to meet staged demand growth

From the capital cost perspective, albeit recognising the preliminary nature of the desk study estimates which include assumptions about geology/foundations, indications are that Sites 2 and 13 are at the lower end of the cost range and closely comparable, with Sites 10B, and 11 costing the same and in the middle of the range. Site 15 shows the highest cost/m^3 of storage.

Site 13 on the Wairoa main stem has the greatest hydro potential. Sites 10B, 11 and 15 are broadly similar. Site 2 has no real hydro potential.

The Lee and Wairoa sites all essentially equal in terms of integration with delivery. Site 2 may end up similar depending on the centre of gravity of demand and potential to use the groundwater system as part of the delivery system, but may require an additional transfer to the end of the Wairoa gorge.

Operation and maintenance of all dams will be closely similar, but Site 2 would involve additional work and costs because of the transfer system, primarily in the area of pumping. However, although exposed to energy cost rises exceeding the inflation rate, the energy cost component of any scheme involving pumping (in this case around $47/ha/annum) is difficult to compare with offset capital cost without undertaking full financial analysis.

In principle, any dam can be arranged for staged development but not without a lot of difficulty and cost which becomes redundant, as well as extra environmental issues. Site 2 is essentially the only one offering practical staged development, mainly by deferring infill transfer until demand growth requires it.