Enhancing Water Distribution from the Waimea Water Augmentation Project

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1. Background

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

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

In 2007 WWAC initiated Phase 2 of the study, to take the Lee investigation programme to a feasibility level. The Phase 2 feasibility study is based on a potential dam on the Lee River, at a site approximately 300 metres upstream of the confluence of Anslow Creek and the Lee River. The required storage capacity of the reservoir has been determined to be approximately 13 million m^3, with a normal top water level to RL 197m, and dam height of approximately 52 m. The reservoir would extend about 4 km upstream from the dam, and at top water level would cover an area of approximately 65 hectares.

Two major distribution system options were identified in Phase 1 to deliver stored water from the reservoir to the areas where it was to be used. The first option was to deliver the released water via a pipeline to the mouth of the Wairoa Gorge, and then use an extensive pipe system to deliver it around all areas on the Waimea Plains. In Phase 1, the estimated cost to pipe water to the mouth of the Gorge, without any reticulation around the plains, was $6.5million or an additional capital cost per irrigated hectare equivalent of $750/ha (Tonkin & Taylor 2007). Because this option appeared so expensive, and would potentially have additional adverse environmental effects, it has not been investigated further.

The conclusion reached in Phase 1, and upon which Phase 2 investigations have been based, is that the most economic and environmentally acceptable system of water distribution would be to release and allow stored dam water to flow down to the Plains in the existing river bed. From here some of the extra flow will infiltrate into the three river-connected aquifers to replenish depleted aquifer storage (one original reason for its release). However, whether for irrigation or other uses of the water, parts of the Plains will not benefit directly from flow releases without additional reticulation.

This report – completed as part of the Phase 2 feasibility study – presents the results of a scoping investigation of water distribution infrastructure that may be needed to make the augmented river flows and groundwater resources available to all potential water users within and adjacent to the Waimea Water Augmentation Service Area.

2. Rationale for Water Distribution Assessment

It was recognised in the Phase 1 pre-feasibility study that a run-of-river scheme would require water users on the Waimea Plains to be able to access water released from the Lee Dam and into the Wairoa and Waimea rivers. Without reticulation, water users would need to access the additional river flows either via groundwater bores (where the groundwater yields were enhanced or maintained by flow release from the reservoir) or direct river takes (for example, via the Waimea East Irrigation Company or TDC reticulation).

This issue was framed as follows in the review of water allocation options for the Phase 1 study (Fenemor, 2006, p. 18 in Tonkin & Taylor 2007):
How can water paid for actually be made available, particularly for users distant from the river, such as from the Hope aquifers?...
Reliance must be placed on the groundwater model to estimate the recharge effects of increased river flows, so that water available after augmentation in each zone is assessed for allocation. It may be necessary to consider building weirs in the Wairoa-Waimea rivers to enhance groundwater recharge, and/or build wellfields to reticulate water towards the eastern hills. Options open to investigation include expanding the Waimea wellfield upstream of the Appleby Bridge, expanding this wellfield to supply Nelson City, expanding the Waimea East Irrigation Company reticulation, and constructing recharge wells for the Lower Confined Aquifer.

Resolution of the variable availability of augmented water within the Waimea Water Augmentation (WWA) Service Area[#] (Fig. 1) will affect the charging and governance options for the scheme. The brief for Phase 2 of the water augmentation project includes a scoping review to determine the effectiveness of run-of-river delivery through the groundwater system (i.e. determination of the 'zone of effect'). It is also to cover consideration of other options for delivery of water, including distribution of water beyond the zone of effect.

Note that because water distribution infrastructure is not seen as a component of the core water augmentation project, this review of distribution options is simply a pre-feasibility gauge of options and indicative costs to aid WWAC decisions on funding for the scheme. We understand the costs of any water distribution options are not intended to be included in the costings for the primary augmentation scheme. If any of the water distribution options raised here were to be pursued, detailed design and costing would be needed.

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

Waimea Water Augmentation Service Area is taken from the project brief, and follows boundaries of TDC's Waimea water management zones where flow releases from the dam are expected to benefit water availability. However not all land within this boundary is irrigable, with or without the scheme. Also, some of the Distribution Areas evaluated in this report are within and some are outside this Service Area.

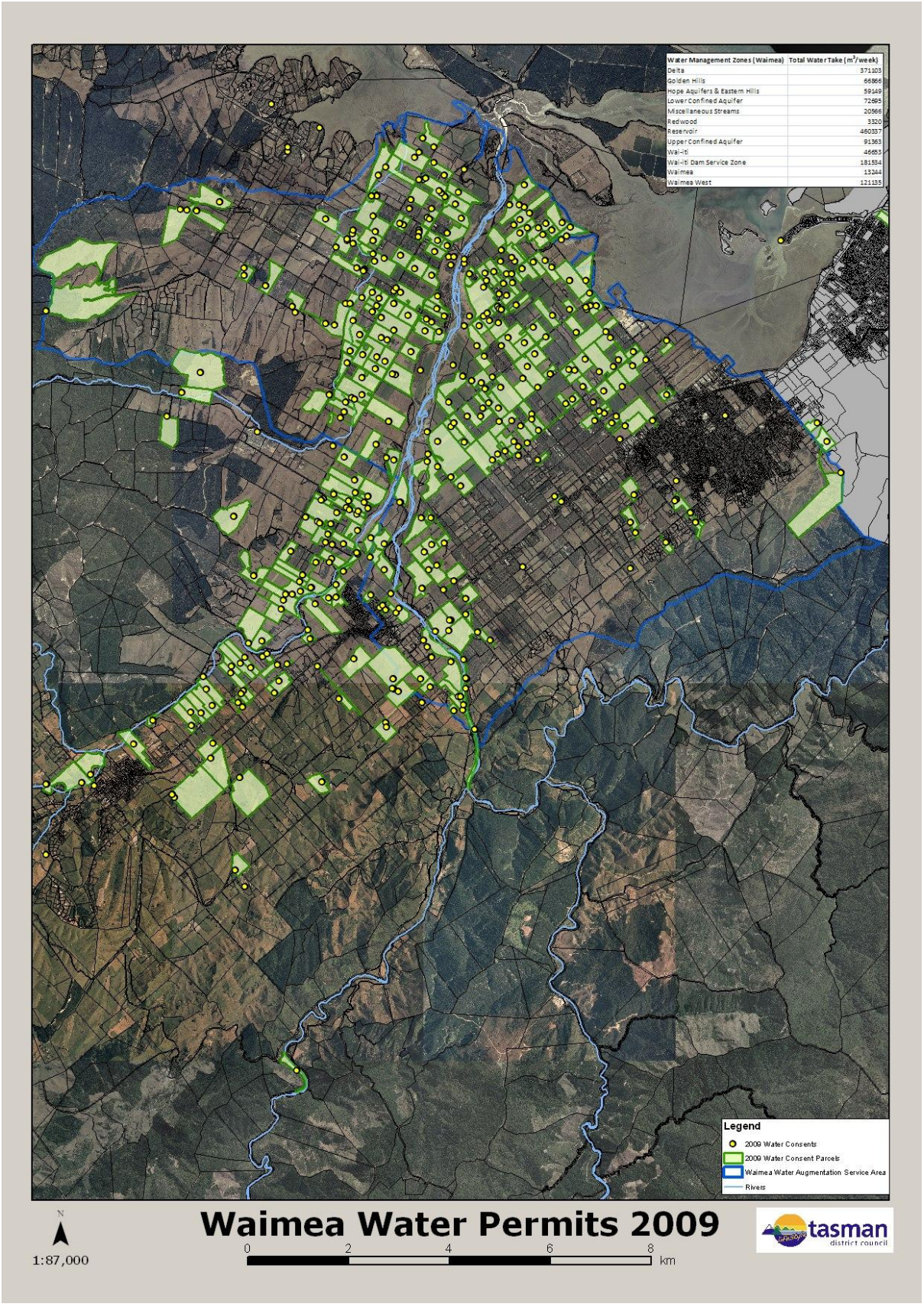


Figure. 1 Land titles showing all water permits as at August 2009 for the Waimea Water Augmentation Service Area (heavy blue boundary) and Wai-iti Valley. Refer Appendix 3 for total allocations by water management zone listed in top right corner of this figure.

3. Zone of Effect' for Released Water

To determine which areas of the WWA Service Area may require water reticulation, we need to map the parts of the aquifers where increased river flow is predicted to raise the water table or piezometric levels of the aquifers during a design drought year, as a means of determining the so-called 'zone of effect'.

A judgement is also required to include in the 'zone of effect' those areas that already have adequate well yields, even if the water table has not risen, or which have adequate reticulation to meet part of the projected water demand, for example, the Waimea East and Redwoods Valley irrigation schemes. Beyond the resulting 'zone of effect', irrigable land will likely require piping and pumping of water – the so-called water distribution zones.

Using their Waimea groundwater model, GNS Science simulated flow releases from the Lee Valley dam which would maintain at least 1100 l/sec minimum flow in the Waimea River (see accompanying technical report 'Water Resources Investigation'). Comparing the augmented and non-augmented piezometric surfaces during the driest part of an irrigation season would identify which parts of the Waimea aquifers are most affected by the increased river flows.

GNS presents the following figure, for the Appleby Gravel Unconfined Aquifer and the Hope aquifers combined, showing average rises in the water table – where they exceed 10 cm – for the summer period January–March 2001 inclusive. The first cut 'zone of effect' is the area within the 10-cm contour. The responses of the Upper Confined Aquifer and Lower Confined Aquifer have not been plotted, but are assumed to benefit from the flow releases and therefore fall within the 'zone of effect'..

As expected, the largest rise in water table is predicted to occur in the Appleby Gravel aquifer between about Clover Road and the Appleby Bridge. This is expected because this is the reach where parts of the Waimea River dried up during January–March 2001. The rise in water table beyond the Appleby Gravel aquifer in the minor Hope aquifers underlying and west and north of the Waimea East Irrigation Company boundary is likely to be an artifact of the design of this model, and has been ignored. This is because the Hope aquifers are recharged by rainfall and hillslope runoff from the Barnicoat Range, not by the river (Dicker et al. 1992; Fenemor 1988). We would expect the 'zone of effect' to extend in the east only to Burkes Bank (the eastern side of the 30-cm contour) then NNE to Queen Street.

The 10-cm water table rise extends almost to the western boundary of the model and this delineates the higher yielding western margin of the Appleby Gravel aquifer. We have also included the Appleby Gravel aquifer from the Wairoa Gorge to the Wai-iti confluence in the 'zone of effect' because well yields here are high despite the modelled rise in water table not being shown as exceeding 10 cm. The Waimea East Irrigation Company area of 1100 ha is also within the 'zone of effect' because it is supplied by river pumping; the Hope aquifers underlying it are unreliable and, as discussed above, not recharged by river flows.

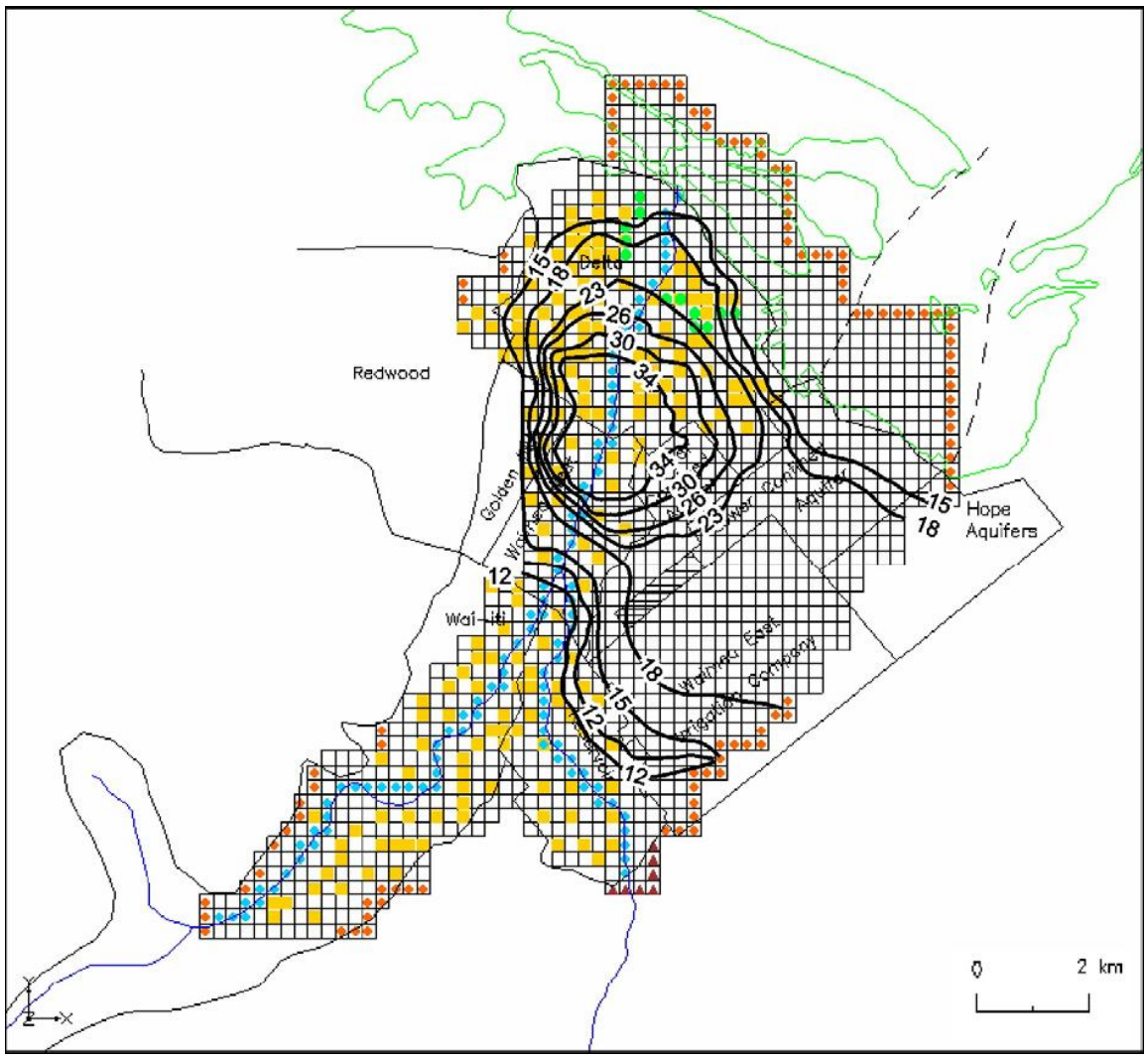


Figure. 2 Modelled 'zone of effect' of river recharge to the upper level aquifers of the Waimea Plains. Map shows contours of the average groundwater level (cm) increase comparing the augmented river flow at Irvines–Wairoa Gorge to maintain a minimum 1100 l/s at Nursery–Appleby Bridge over the period Jan–March 2001 (24 year drought) with average groundwater level for non-augmented river flow at Irvines–Wairoa Gorge (Fig. 44 from GNS in accompanying report 'Water Resources Investigation').

4. Water Distribution Zones

Water users within the ‘zone of effect’ described above are expected to be able to access water through existing or new bores, or through existing or new river pumping. Outside the ‘zone of effect’ further water distribution infrastructure is likely to comprise wells or wellfields to supply communal, pressurised water to property boundaries in each area. These areas, which were also modelled in the GNS river-aquifer model simulations (Fig. 27 in the GNS report), have been identified as:

1. 300 ha of additional irrigation in the lower Wai-iti Valley supplied from a wellfield west of the Wai-iti/Wairoa confluence. Two sub-options for these 300 ha are costed. The Mid-Lower Wai-iti Distribution Area is for 300 ha irrigated from Aldourie Rd south to Wakefield. Alternatively, the Lower Wai-iti Distribution Area has the 300 ha spread evenly between Aldourie Rd and Teapot Valley, without crossing the Wai-iti River.
2. 625 ha in the Redwood Valley/Waimea West area (total includes the present Redwood Valley Irrigation Scheme that services 70 ha), to be supplied from a wellfield in the southern River Road area.
3. 250 ha on Rabbit Island, to be supplied from a wellfield a short way down Cotterell Road just north of State Highway 60.
4. A smaller area (about 120 ha not currently irrigated) west of the proposed Richmond West town extension. This area lies from McShane Road to just west of Swamp Road. Water would be sourced from either spare capacity within the Waimea East Irrigation Company boundaries, or from wells further west in the Delta Zone.
5. A small 50-ha area that lies at the southern end of Haycock Rd, and is situated on either side of the Waimea East Irrigation Company (WEIC) mainline, between the Wairoa River pumped intake site and the main scheme reservoir.
6. Potential regional water demand for use beyond the proposed service area. This water could come from a wellfield where State Highway 6 crosses the Wairoa River near Brightwater.

In most cases where existing well yields are adequate, the new distribution areas have been assumed to supply water only to currently unirrigated blocks. To assess the spatial layout of land titles with water permits, a map of all current water permits has been compiled from TDC records. This is available - with consent details - as an A0 sized plan and is summarised in Figure 3 below. Note that the areas shown in Figure 3 as having water permits are the land titles to which the permit is attached, and the actual irrigated area may differ from the area of the title (usually smaller).

Table 1 summarises the land areas either currently irrigated, or yet to be irrigated via the possible distribution systems shown in Figure 3.

Table 1. Existing Irrigation and Proposed New Water Distribution Systems

Irrigation Area Classification	Area ha	Assigned Flowrate l/s	Percent of Total %	Comments
Existing Irrigation	3800	1,885	65	Includes the existing Redwood Valley Scheme. Mostly serviced using irrigators own bores/river takes
Mid-Lower Wai-iti or Lower Wai-iti	300	149	5	Pumps water up the Wai-iti Valley from a site west of the Wairoa/Wai-iti confluence. Possible supply to part of Waimea West
Redwood Valley & Waimea West	555 (625–670)	275	9	Pumped from a wellfield alongside the Waimea River, just SE of the southern end of River Rd. Existing scheme area has already been allowed for
Rabbit Island	250	124	4	Water supply is just piped onto the main island. No further distribution has been allowed for
Swamp Road Area	120	60	2	Water piped from a wellfield west of Lansdowne Road, with some possibly from extensions to the WEIC (subject to their approval)
Haycocks Rd South	50	25	1	Surrounding the WEIC delivery pipe. No distribution system necessary if allowed to connect into this main
Remaining "New" areas	775	390	14	Will be serviced by landowners using their own wells, or drilling new wells on their own land, or extension of WEIC reticulation (subject to their approval)
Total	5850	2908	100	
Future Regional Demand		255		Volume allowed for is 22 000 m^3/day, probably from a wellfield near the Brightwater bridge over the Wairoa

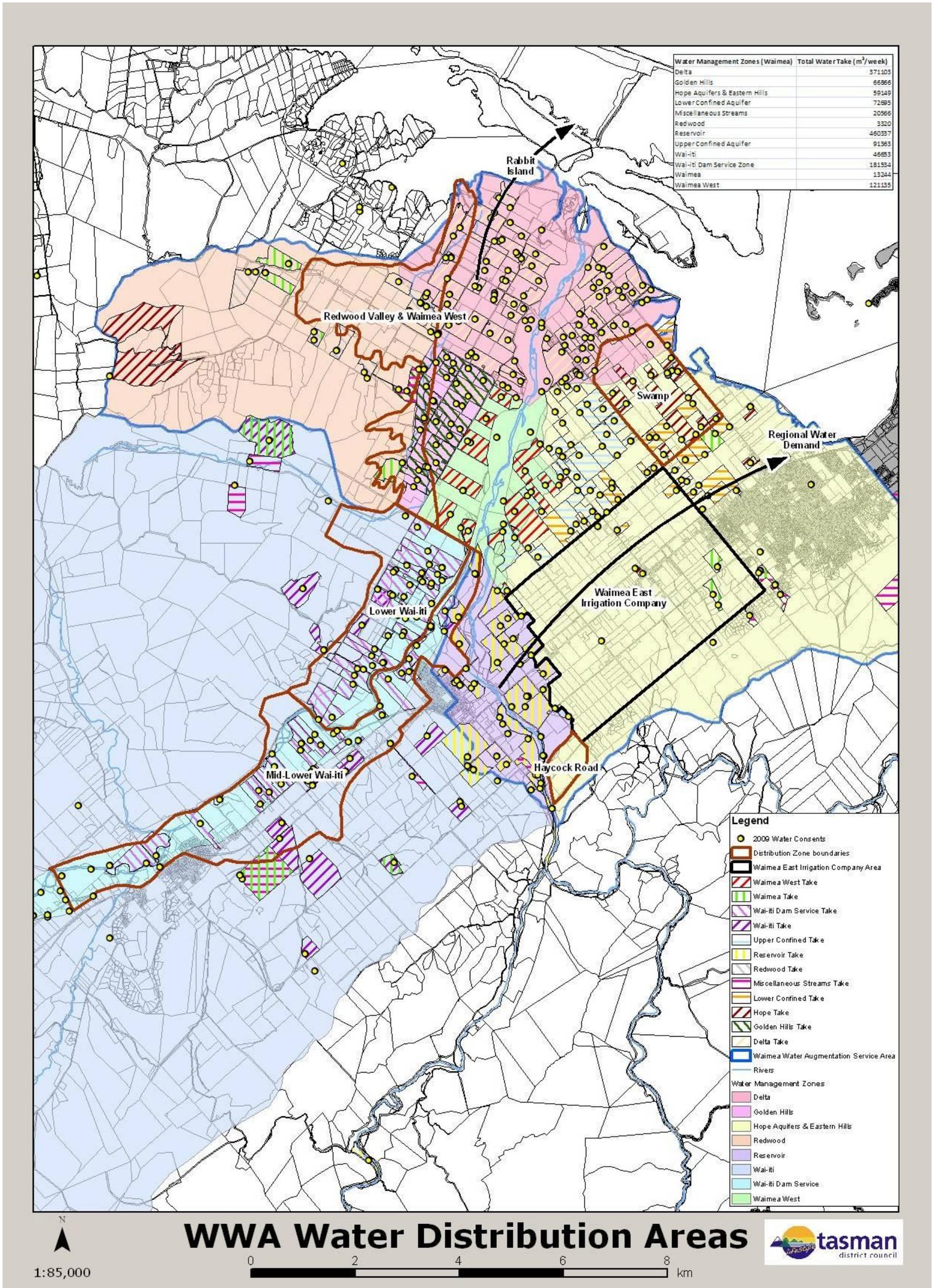


Figure. 3 Schematic map of water distribution zones, with existing water permits overlaid on TDC water management zones

The next step was to develop a conceptual mainline layout in order to assess the off-farm costs for providing pressurised water to the farm gate. The following assumptions have been made:

- One well will irrigate between 60 and 100 ha (30–50 l/s), with the higher yielding bores near the lower sections of the river
- Communal well yields are each rated at about 30–35 l/s near the confluence of the Wai-iti with the Wairoa, and up to 50 l/s nearer the coast (e.g., in Cotterell Rd).
- Pipelines to be run down roadways where possible
- Submersible pumps with variable speed drives (VSD)
- Water is unfiltered
- An adequate power supply is available nearby
- Water is delivered to property boundary at a pressure of about 30 m head
- Allotted water is delivered over 24 hours/day. If higher flows are required, then on farm storage at the landowner's expense would be necessary
- Water demand has been assessed at the rate of 30 mm/week (300 m^3/ha/week). Actual water demand will vary, as the Ranzau and Motupiko soils may need up to 35 mm/week (30% of total area), Waimea soil 30 mm/week (40% of area), Dovedale soil 25 mm and any Mapua soil only 19 mm/week (for a combined 30% of the area)
- Areas shown in Table 1 are net hectares (i.e. the actual area irrigated)
- No on-farm costs, such as pipelines and irrigation equipment, are included.

Table 2 summarises the main design features, mainline pipe sizes and layout for each distribution system.

Table 2 Description of Distribution System Design Requirements

Irrigation Distribution System	Area ha	No & Location of Wells Needed	Mainline Sizes & Approx Length m	Comments
Mid-Lower Wai-iti	300	4 wells near confluence of Wairoa & Wai-iti Rivers	375 mm pipes & smaller with mainline about 9 km	Booster pumping needed from about the Wai-iti River crossing south
or Lower Wai-iti	300	4 wells near confluence of Wairoa & Wai-iti Rivers	375 mm pipes & smaller with mainline about 6 km	Booster pumping probably not needed
Redwood Valley & Waimea West	555	Allow for 6 or 7 wells near the Waimea River, 1.5 km upstream of the Appleby Bridge	Up to 400–450 mm mainline, with a total length of around 9 km	The higher distant areas may require booster pumps if the delivery pressure is to be maintained to 30 m
Rabbit Island	250	3 wells (near Fire Stn, Cotterell Rd)	300 mm × 4.2 km	Only delivered 1 km on to the island
Swamp Road Area	120	Possibly serviced from both the Delta Zone and from WEIC. Allow for 2 wells	Mostly 225 and 150 mm mainline over 5 km	The size of the demand at the ends of the lines will dictate pipe sizes
Haycocks Rd South	50	Use Waimea East delivery main	Individual property pipes only required	System requires approval from WEIC
Future Regional Demand		Probably 6 or 7 wells	If not using any existing pipes, then a ~400 mm line to meet existing pipes near Queen St/ Gladstone Rd corner	Not expected to be installed for several decades

The off-farm distribution costs (i.e. the communal part) for the above newly irrigated areas are estimated from the costs of other community irrigation schemes updated where necessary to 2009 figures. Adjustments of those costs are also made depending on the relative complexity of the new scheme (when compared with the known costs of the existing schemes), and an extra allowance made if the new scheme requires booster pumping. Costs of existing schemes are provided in Appendix 1 for reference. Costs of individual components are given in Appendix 2.

Table 3 summarises the cost estimates for each distribution system. In summary, the average per hectare capital costs – to add to the overall per hectare capital cost of the scheme for those users outside the 'zone of effect' – range from $4700 to $5030/ha, depending which Wai-iti option is chosen. Actual per hectare costs range from $1500/ha for Haycocks Road South to $5900/ha for Mid-Lower Wai-iti.

Table 3 Cost Estimates for Irrigation Distribution Systems

Irrigation Distribution System	Irrigated Area ha	Budget Off-Farm Distribution Costs$	Comments
Mid-Lower Wai-iti	300	1,770,000	Scheme would need booster pumping around Wai-iti River crossing
or Lower Wai-iti	300	1,350,000	Probably possible without booster pumps
Redwood Valley & Waimea West	555	3,165,000	Distant and higher areas may require booster pumping
Rabbit Island	250	750,000	Pumps and delivery mainline about 1 km onto the main island only. No further distribution
Swamp Road Area	120	650,000	Mixed scheme from wells and WEIC
Haycocks Road South	50	75,000	Utilizing existing WEIC mainline
Totals	**1275 ha**	**$5,990,000 or $6,410,000**	**Per ha Distribution Cost $4,700 or $5,030/ha**

5. Other Works to Enhance Water Availability

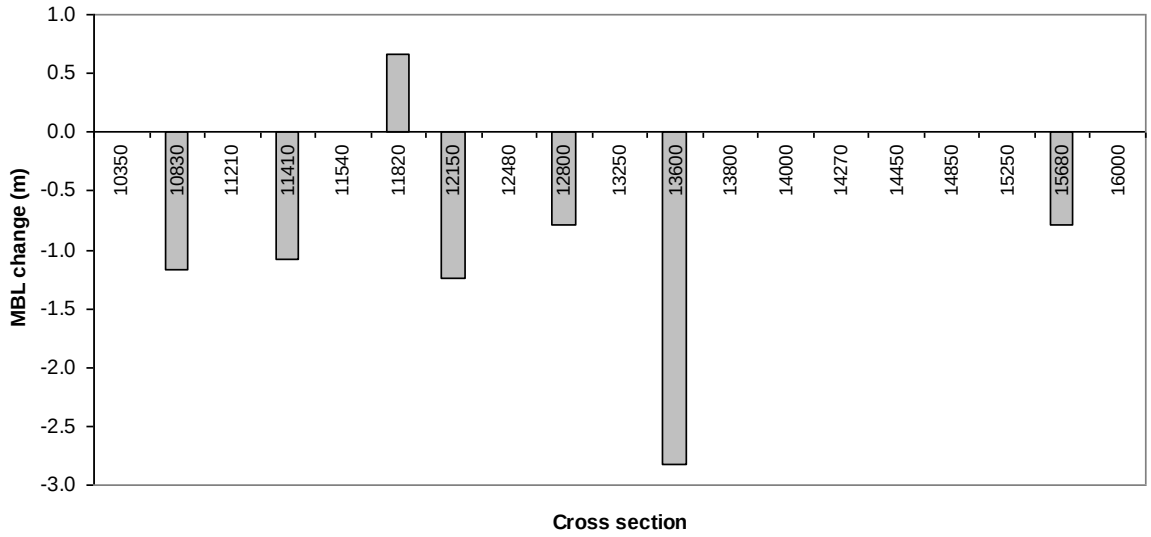
As well as the options for reticulation scoped above, there are measures that could be undertaken to improve groundwater recharge with augmented river flows on the Waimea Plains. These would improve groundwater yields within the 'zone of effect' and potentially extend the 'zone of effect' locally. Primary among these are methods to raise the water levels down the Wairoa-Waimea river system, and artificial recharge of the Appleby Gravel Unconfined Aquifer.

Artificial recharge could be investigated using pumped recharge wells or gravelled infiltration beds receiving diverted river water, but neither is discussed further here.

In addition, it may be possible to relocate existing wellfields such as the Richmond water supply wells in lower Queen Street to allow increased abstraction from the Lower Confined Aquifer further inland from the coast, away from the risk of seawater intrusion.

Besides maintaining limits on river gravel extraction to maintain or increase riverbed levels in the Wairoa–Waimea rivers, local rises in the water table can be achieved by building weirs. This has been successful in the nearby Wai-iti water augmentation scheme (Fenemor et al., 2003), where river flow is augmented by flow releases from the Kainui dam at the head of 88 Valley, and where three rock weirs have now been built in the lower Wai-iti River between Teapot Valley and just above the Wairoa/Wai-iti confluence.

Table 4 lists some potential locations and indicative costs for such weirs. They should ideally be considered in locations where significant aquifer recharge already occurs, and where there is low risk of exacerbating flood overflows. Weirs would need be designed to accommodate migrating fish and in the lower river potentially jet-boat passage, so there would be public interest in their location and design. They should preferably be at stable and narrower parts of the river system to minimise maintenance and construction width. Rosser and Basher (2009) show in their figures 18 and 22 where the more stable cross-sections are in the Wairoa and Waimea rivers (Fig. 4).



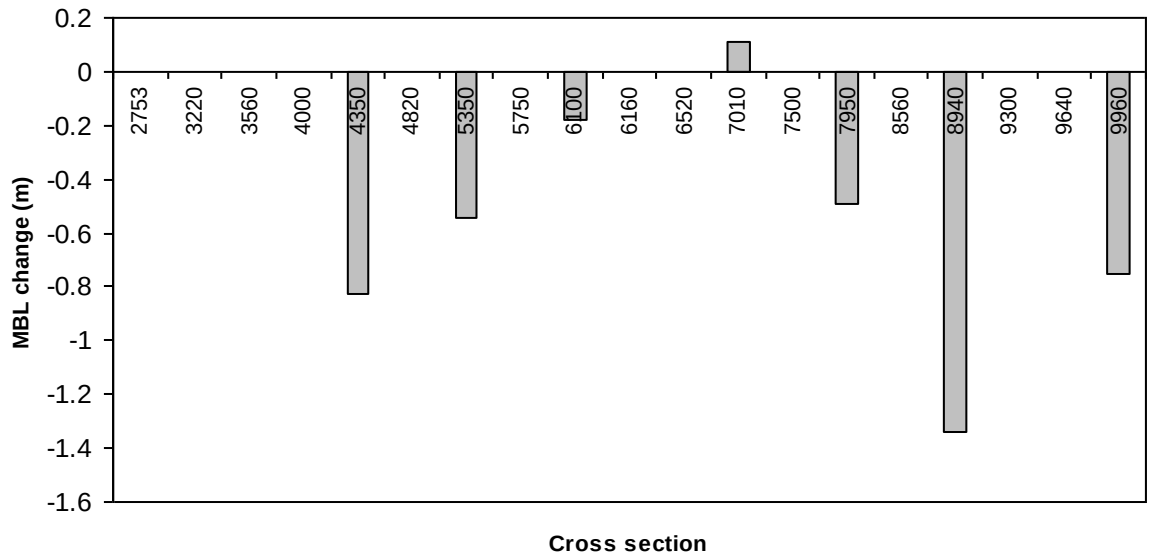


Figure 4. Net mean bed level change for the Wairoa River between 1971 and 2005 (upper plot) and the Waimea River between 1968 and 2005 (lower plot). Cross section number represents distance in metres from the coast near Rabbit Island. From Rosser and Basher (2009)

At cross-sections with an armoured beach, and on river bends, it may be cost-effective to construct a weir across only the active part of the channel (however, we note that the weir recently built on the Wai-iti below the Brightwater bridge was outflanked in a flood and has required extending).

The concept of weir construction in the Wairoa–Waimea rivers has been discussed with TDC Rivers Engineer Philip Drummond and MWH Rivers and Roading Engineer Rick Lowe. Cost estimates in Table 4 are based on weirs 3 metres high with an apron at 5:1 slope, heavy rock weighing 2.7 tonne/m^3 and costing $35/tonne in place, plus 20% for design, supervision and consents. These estimates compare with an approximate cost of $15,000–20,000 for the three weirs in the narrower Wai-iti River. Weirs in the larger rivers would require larger rock. River distance (RD) in Table 4 refers to the TDC river cross-section network numbering used in Fig 4 and is the approximate distance in metres from the Waimea river mouth near Rabbit Island

Table 4 Cost Estimates and Locations for Waimea-Wairoa Recharge Weirs

Weir Location	Estimated Width, m	Estimated Cost, $	Comments
Extension of Paton Road at river distance RD14850	40 (part width of channel)	$100,000	Within main recharge area for confined aquifers, from Gorge to Bryants Lane
300m below Brightwater Bridge at RD13600	30 (part)	$75,000	To stabilise large drop in riverbed 200 m below bridge, and maintain bed levels under SH6 road bridge
About 700m downstream of Bryants Lane, Brightwater at RD12300	50 (part)	$125,000	Lower end of primary recharge area for Appleby Gravel aquifer
Below Wai-iti/Waimea confluence at RD9900	70 (part)	$175,000	Upper area of Challies Island section of Appleby Gravel aquifer
Below Appleby Bridge at RD6000	100 (full width)	$250,000	Adjacent Waimea wellfield

6. Conclusions and Recommendations

This project scoped the locations and possible costs for water distribution systems – mainly wellfields and pressurised water delivered to farm boundaries – for areas of the Waimea Plains unlikely to have direct access to water released from the Lee dam as part of the Waimea Water Augmentation scheme.

A 'zone of effect' was determined based on river-aquifer modelling carried out by GNS Science, together with knowledge of hydrogeology, relative well yields and existing irrigation schemes. The 'zone of effect' comprises mainly the Appleby Gravel Unconfined Aquifer plus the Waimea East Irrigation Company irrigation area.

Outside this 'zone of effect', six potential irrigation Distribution Areas have been defined (Fig. 3), plus the potential future regional water demand (TDC/NCC). The total irrigable area within these Distribution Areas is 1275 hectares, which is 22% of the 5850ha area assessed as irrigable from the scheme (Table 1). Costs for irrigation distribution within these six Distribution Areas range from $1,500/ha to $5,900/ha, and average $4,700/ha. These costs have implications for the charging regime and governance options for the scheme, as water users outside the 'zone of effect' would face additional capital costs to receive water from the scheme. One option could be a tiered charging structure based on accessibility to the augmented water (a differential rate).

The project also evaluated potential locations and costs of rock weirs which would enhance groundwater recharge in the Wairoa and Waimea rivers. Costs were about $2,500 per lineal metre of weir and ranged between $75,000 for a 30-m weir below Brightwater Bridge to $250,000 for a weir the full width of the Waimea River below the Appleby Bridge.

7. Acknowledgements

We acknowledge the considerable effort by Pete Frew (TDC) to compile the GIS map of current water allocations (Fig. 1), and the diagrammatic map of possible water distribution areas (Fig. 3).

Thanks to Philip Drummond (TDC) and Rick Lowe (MWH) for discussions and advice on rock weir engineering.

Thanks also to Sally Marx (Tonkin & Taylor), Anne Austin (Landcare Research) and Joseph Thomas (TDC) for editorial reviews of this report.

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Appendix 1 – Updated Costings for Comparable Schemes

Basis for Per Hectare Costs for Communal Off-Farm Irrigation Distribution Network

The following schemes were those considered when arriving at the per hectare cost for determining the likely costs for the new irrigation distribution networks. This additional cost is needed so that the whole of the WWA Service Area can gain access to the additional dam water released into the Lee River. Generally, land near the river has the aquifers replenished when the river levels are raised, which allows those land owners to draw water from under the blocks they wish to irrigate. Other areas (outlined in Table 1) do not have access to water using this method, and have to rely on the water being pumped from the nearest "water-rich" areas and delivered to their properties in a pipeline.

Irrigation Scheme	Original Cost $/ha	Year	Design Basis mm/ha	Inflation Factor	Today's Cost $/ha
WEIC	2,455	1984	28–38	2.16	5,200
SVIS	3,800	2003/04	18	1.135	4,300
Scheme in Awatere (B Class Water)	1,800	2004/5	18	1.135	2,000
Another Scheme in Awatere (C Class Water)	3,200	2008/09	18	1.006	3,200
Mid-Lower Wai-iti (Agfirst Budget Price)	5,900 (Est.)	2009	30	1	5,900
Lower Wai-iti (Agfirst Budget Price)	5,900 (Est.)	2009	30	1	4,500

Appendix 2 - Other Budget Prices used to Estimate Distribution System Costs

Item	Size mm	Unit Cost $/m
Pipeline Purchase and Installation (incl. Contingency Allowance)	400 375 300 225 & 200 150	400 272 173 90 51
Well Drilling, Pumps & Shed, Power & Headworks	250 or 300 With wedge-wire screen	50,000 ea.

Note that the above costs do not include any allowance for cost of any easements or the purchase of any land.

Appendix 3 – Current Waimea Basin Water Allocations

Total current water permits by water management zone from the TDC consents database, August 2009 (see Fig. 1)

Water Management Zone	Total Water Allocation (m^3/week)
Delta	371 103
Golden Hills	668 66
Hope Aquifers & Eastern Hills	59 149
Lower Confined Aquifer	72 695
Miscellaneous Streams	20 566
Redwood	3320
Reservoir	460 337
Upper Confined Aquifer	91 363
Wai-iti	46 653
Wai-iti Dam Service Zone	181 534
Waimea	13 244
Waimea West	121 135
TOTAL ALLOCATIONS	**1 507 965 m^3/week**