Water Augmentation Options for Irrigation in the Motupiko Catchment

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Landcare Research Contract Report: LC0607/157

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DATE: June 2007

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This project funded by:

Sustainable Farming Fund
Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

TDC Tasman District Council

plus contributions from farmers in the Motupiko catchment

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Executive Summary

This pre-feasibility scale project provides the basis for landowners in the Motupiko catchment and Tasman District Council to proceed with design, consents and construction for one or more water augmentation dams for irrigation development of the Motupiko catchment.

The study has been carried out by Landcare Research and Tonkin & Taylor for the Motupiko Catchment Water Augmentation Committee (MCWAC) in conjunction with Tasman District Council (TDC). It comprises these components:

- Irrigable land use assessment, water availability and water needs analysis
- Selection and shortlisting of storage sites
- Description of effects of water augmentation
- Cost estimation for shortlisted sites
- Landowner discussion and formal community consultation.

The total irrigable land was calculated at 3228 hectares with 2024 hectares being on slopes less than 5 degrees. Most of the irrigable land (2407 ha) is below the confluence with the Rainy River, with a further 403ha irrigable in the Rainy subcatchment.

Climate factors such as frost and climate change are the main constraints on future irrigable crops. The lower Motupiko has greater versatility for a range of irrigated crops such as berries and vegetable crops, but landowners consider the most immediate opportunity for irrigation would be for pasture irrigation for dairy development.

The study identified two large scale storages (>3 million cubic metres (MCM)) but both with significant challenges. Eight medium sized storages (1-3 MCM) and 17 small scale storage sites (~0.6 MCM) were identified, and in discussion with the MCWAC cut to an initial shortlist of five:

- S1 labelled Rocky, a tributary in the eastern side of the Motupiko;
- S2 labelled Melville, a tributary on the west of the upper Rainy
- S site, labelled Chinaman's Gully, a tributary on the western Motupiko near Kikiwa
- M4 labelled Horopito in the South Branch of Big Gully, a tributary of the Rainy
- M2 labelled Kikiwa on the mainstem Motupiko River.

Irrigation demand modelling was carried out to determine storage requirements at these sites, using a catchment water balance model WATYIELD, and an irrigation scheduling model based on rainfall data since 1954. The agreed security of supply was for the storage to be sized to fill 9 years out of every 10.

Initial capital cost estimates for constructing the shortlisted dams were in the range $4900/ha -$9200/hectare for irrigable areas of 2100 down to 500 ha. Two sites were then chosen as a final shortlist:

- M4 Horopito, as above.
- M5 Ben&Alan, two Motupiko tributaries on the west below Big Gully near the Rainy confluence.

Final costings based on releasing dammed water into the Motupiko River to meet irrigation demand above that naturally provided by river flows, and while maintaining Motupiko River flow past Quinneys Bush, were:

Site Name	**Assumed area served (ha)**	**Cost including land and financing ($ million)**	**Comparative capital cost/ha ($/ha)**
Horopito M4	500	3.15M	6,300
Horopito M4*	1 000	4.8M	4,800
Horopito M4	1 350	6.17M	4,570
Ben/Alan M5* with diversion	1 000	5.20M	5,200

Dam heights range from 16-27 metres for these four options. *A preliminary economic analysis indicates that based on repaying the capital cost over a 20, 30 or 40 year period at 8% interest rate for a dam servicing 1000 ha the cost per hectare per year for the Horopito M4 would be $489, $426 and $403 respectively and for the Ben/Allen M5 option would be $530, $462 and $436. These costs are higher than the costs for the Wai-iti scheme recently commissioned ($380/ha/year equivalent for new users). As for the Wai-iti, landowners would also face the costs of on-farm capture and delivery of their share of water released via the river system.

Environmental effects were assessed qualitatively. Construction of dams on mainstem sites in the Motupiko (eg. Kikiwa) and Rainy is prevented by the Motueka Water Conservation Order. However, preliminary assessment of effects at the two shortlisted tributary sites showed no fatal flaws which would prevent these options proceeding to feasibility stage for design and consents.

A community survey of all landowners in the Motupiko was carried out together with two public meetings to discuss the results. Results suggest qualified support at the projected costs, but a need for further information and costings at feasibility level.

For a scheme to proceed, a preferred site needs to be chosen, the level of support (irrigable area) needs to be determined from potential water users, and a feasibility study carried out. These steps will provide the information needed for detailed design, resource consent applications, amendments to TDC water allocation rules and implementation of whatever system of charges is decided.

1. Rationale for Study

Growth in irrigated agriculture and horticulture in the Motupiko catchment is severely hampered by the current full allocation of available water resources. The allocation limit of 110 l/s has been met already through the 13 current water permits for an irrigated area of about 191 ha.

A combination of clay-bound geology (Moutere Gravel) and annual rainfall averaging 1250mm (see Figure 1) results in low flow yields in the critical summer months. The Motupiko River goes dry in the reaches above its confluence with the Motueka in even average dry years. The water source for irrigation in this catchment is principally the Motupiko River and the groundwater in the shallow alluvial gravel underlying the river flats. The shallow aquifer is fed by rainfall and river recharge and in dry summer months depends totally on river recharge.

The Council manages the water resource in the catchment as one integrated river-aquifer resource. There have been recent individual attempts to find alternative water sources and this included drilling to explore deep groundwater in the Moutere Gravels which underlie the shallow alluvial gravel. A private bore was drilled to 300 m and was not successful in encountering economic quantities of water. There is a significant potential for further irrigable land in the area.

The Tasman Regional Water Study completed in 2003 (Lincoln Environmental, 2003) identified a total of about 7200 ha of land suitable for irrigated agriculture in the catchment. This regional study also estimated, based on projected regional crop and irrigation growth and assuming irrigation water was available, that as much as 2600 ha could be in productive irrigated use by 2051 in the catchment. The catchment has a further 150 landowners without water permits who could potentially benefit if there were more water available. In December 2003, the Tasman District Council declined two large water permit applications for irrigation (Dillon; Simpson) due to the low availability of summer water flows; the catchment allocation limit was formally adopted in the TRMP in April 2004.

Both the lack of water and the threat of rationing during droughts is inhibiting further irrigated agricultural growth in the area and posing a risk to current water users. The Motupiko River is an important early season trout fishing and spawning river and abstraction is also limited May-October by clause (e)(ii) of the Motueka Water Conservation Order which sets a minimum flow in the lower Motupiko during trout spawning.

The brief for this study states its principal objective as 'a holistic study into a range of opportunities for water augmentation for enhancing water availability to both current users and potential new users as well as to further enhance flows in the Motupiko river for environmental/community and aesthetic benefits downstream'.

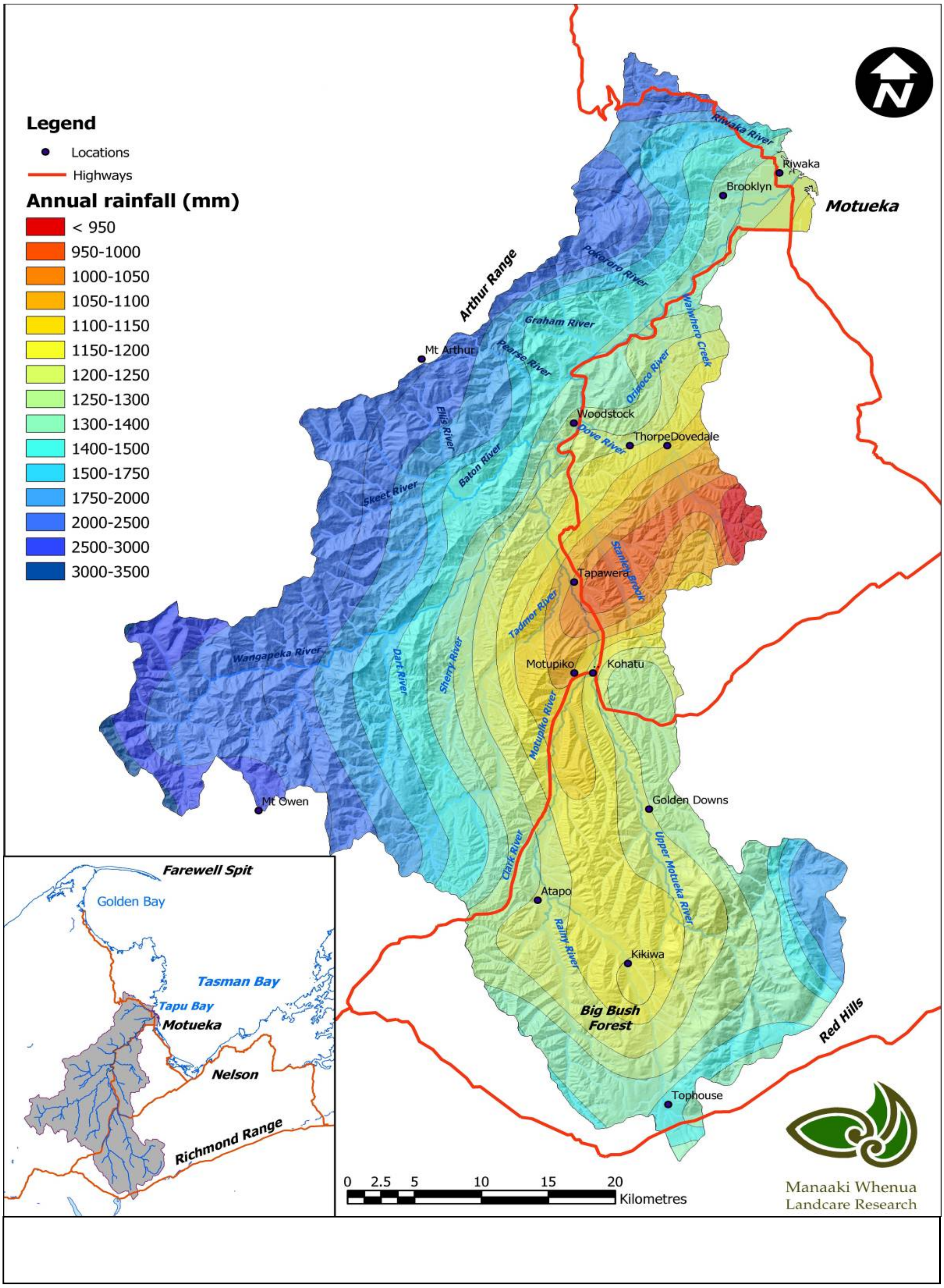

Figure 1 Motueka catchment annual rainfall isohyets (mm)

2. Scope of Study

This pre-feasibility study provides the Motupiko Catchment community with the necessary information to make informed decisions on future water storage options. The project affects about 160 landowners of which only 13 hold water permits.

The study has been commissioned by the Motupiko Catchment Water Augmentation Committee (MCWAC), comprising local farmers, representatives of conservation and iwi groups, and Tasman District Council. The project is managed for MCWAC by Joseph Thomas of TDC. Funding for the two-year study has come from the Sustainable Farming Fund, Tasman District Council, Motupiko landowners plus a small contribution from the FRST-funded Motueka Integrated Catchment Management research programme. The work has been carried out by Landcare Research and Tonkin & Taylor engineering consultants, with input from TDC, local iwi, DOC and Fish & Game.

The study area comprises the Motupiko Catchment from Old School Road near the confluence of the Motupiko River with the Motueka River above Tapawera, upstream to Tophouse, and including the Rainy River. The Motupiko catchment is a medium size sub-catchment of the larger Motueka catchment and covers an area of about 347 km^2 (Figure 2).

The study comprises three major components which are reported on below:

- Water availability analysis and detailed irrigation landuse assessment;
    - Irrigable land assessment (section 3 of this report)
    - Irrigation water needs assessment (section 5)

- Site/Storage - range of options and costing including delivery methods
    - Dam site scoping (sections 4, 6)

- Economic and Environmental benefit analysis for augmentation including funding options and sustainable and optimised water allocation from augmentation.
    - Qualitative effects assessment (section 7)
    - Cost estimates (section 8)
    - Community consultation (Appendix II)

The funding and information available have limited the scope of this study to a pre-feasibility study, without detailed geological and engineering investigations of individual sites.

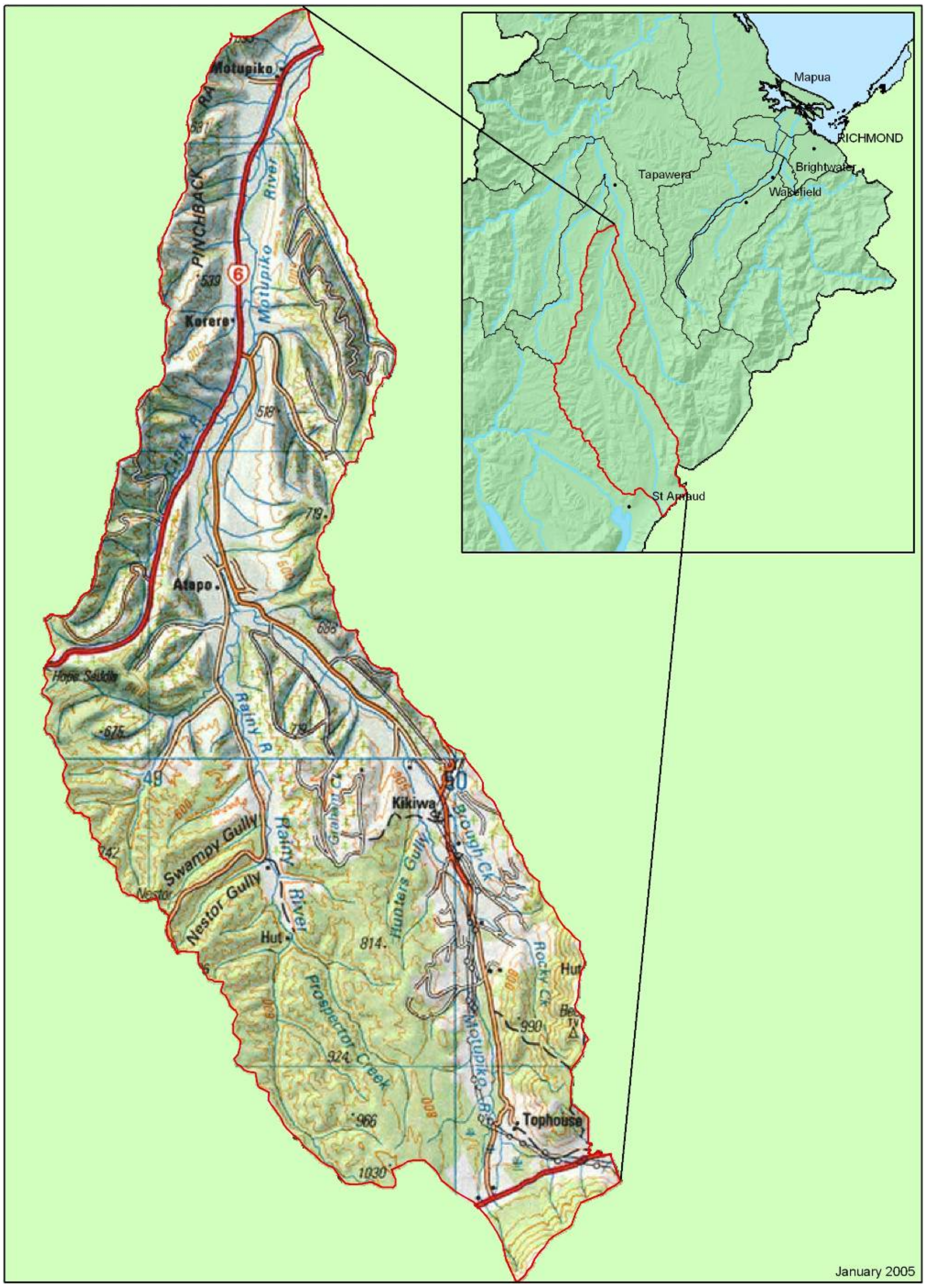

Figure 2 Topography and location of the Motupiko catchment in Tasman District

3. Irrigable Land Use Assessment

This part of the study aimed to refine the gross estimate of 7200 irrigable hectares reported for the Motupiko catchment in the Tasman Regional Water Study (2003). The objective was also to identify in conjunction with MCWAC the likely area of irrigation development in the valley in the medium term - the next 20+ years – if an affordable water source were available.

3.1 Method

Irrigation suitability was assessed following the procedure of Griffiths (1975). This rates irrigation suitability based on topography, drainage and soils. Suitability is grouped in classes from 1 (highly suitable) to 5 (unsuitable) and is determined from assessment of 8 primary factors: slope, overall drainage class, permeability of the soil profile, infiltration class of the soil, maximum depth to an impermeable layer, minimum available water in the root zone, minimum effective rooting depth, and maximum stone content (see Table 1 for data sources). Suitability was assessed for each factor, with the lowest suitability class determining overall suitability.

The soil information was derived from regional soil survey coverage (Chittenden et al. 1966) and is suitable for regional-scale evaluations of irrigation suitability. It should not be used for farm-scale evaluations of irrigation suitability without field checking. An attempt was made to use more detailed (1:15,840) Cawthron Institute soil maps compiled in the 1930s. However because of difficulties in registering these to a modern map base, and lack of a key to identify and characterise the map units portrayed on these maps they were unusable.

Table 1: Sources of data used in assessment of irrigable land

Primary factors	Source of data
Slope	Digital elevation model of region
Drainage class	Midpoint values for the DRAIN_CLASS, PERMEABILITY, DSLO, PAW, PRD, and GRAV parameters in Landcare Research's Fundamental Data Layers extension to the NZ Land Resource Inventory
Permeability	
Depth to impermeable layer	
Available water	
Rooting depth	
Stone content	
Infiltration class	Estimated from soil texture and structure

3.2 Soils

The distribution of soils is shown on Figure 3. The young river terraces are dominated by Motupiko loams, with minor areas of Dovedale and Atapo soils. Older dissected terraces have Kikiwa soils, with Kikiwa rolling phase on the more dissected terraces. Tophouse and Katrine soils occur on terraces, fans and moraines in the upper valley. A wide range of soils, unsuitable for irrigation, occur on the hilly and steep terrain.

Most of the soils of the flat terraces are rated as class 3 (moderately suitable) for irrigation (see Figure 3), while Kikiwa rolling phase is rated as class 4. The main limitations on land suitable for irrigation are soil properties (slow permeability in the subsoil for Motupiko, Kikiwa and Tophouse soils, soil depth for Dovedale soils, stoniness for Atapo soils) and slope (Kikiwa rolling phase). The total area suitable for irrigation is about 6600 hectares. If the area currently in tall vegetation (exotic forest, indigenous forest and scrub) is excluded, the area suitable for irrigation is about 4600 hectares. Of this, only 2830 hectares has slopes of less than 5 degrees.

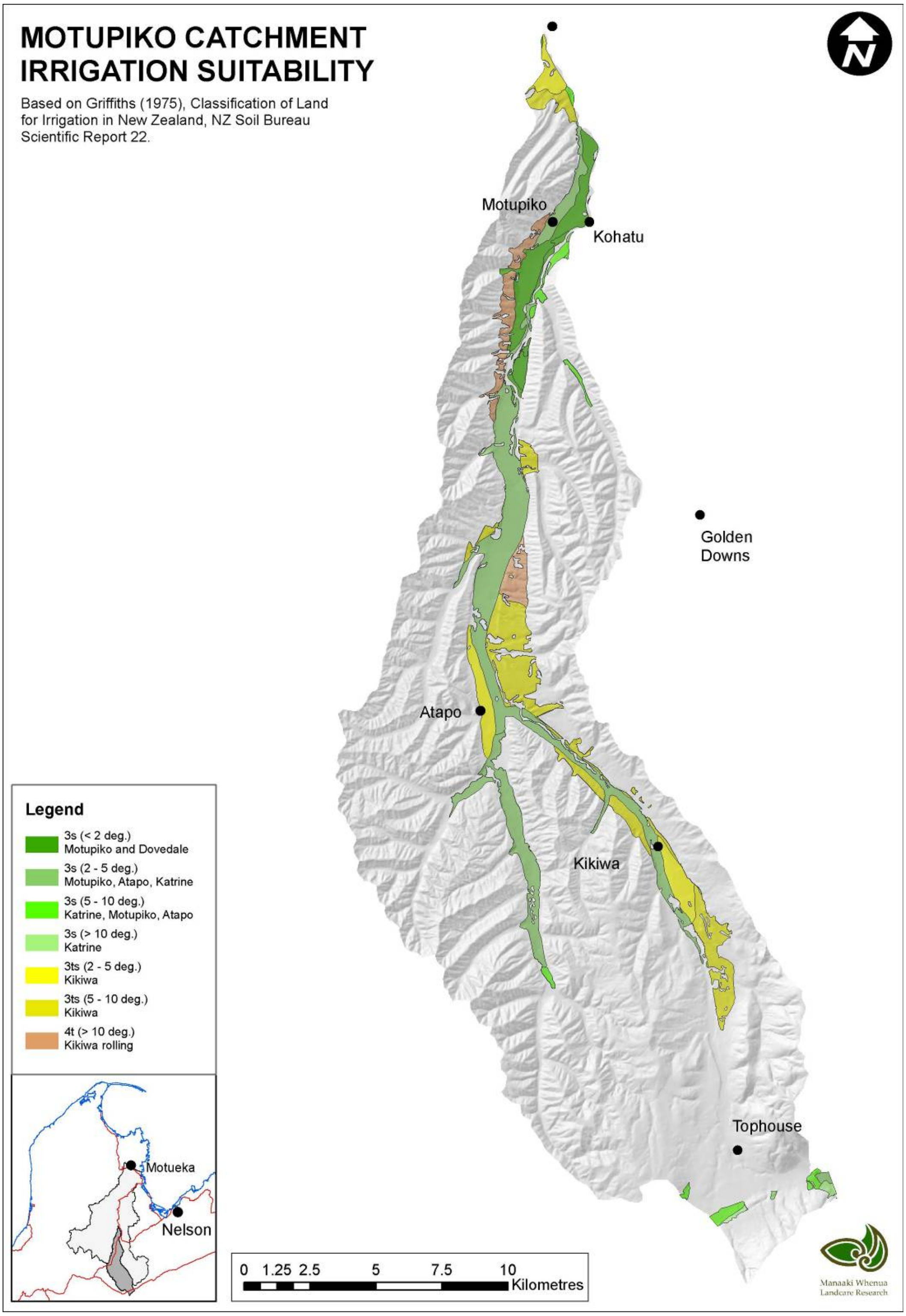

Figure 3 Motupiko catchment irrigable land assessment, excluding currently forested land. See below for explanation of key.

The key in Figure 3 is divided between irrigation class, limiting factor for irrigation and the slope. A notation of "*3s (5-10 deg)*" refers to a soil in irrigation class 3 where soil type is the limiting factor in the irrigation class. This has then been separately evaluated to show all areas with 3s classification where the slope derived from the digital elevation model (DEM) is between 5 and 10 degrees. The letter after the number (e.g. 4t) refers to whether the limiting factor for irrigation is likely to be either soil (s) or slope (t) or both (ts). In simple terms the key shows the land most suitable for irrigation at the top of the key (dark green) and moves through a gradation until the least suitable land is shown at the bottom of key (pink).

3.3 Vegetation cover

The land within the total catchment was classified into vegetation cover as defined by the Land Cover Data Base (LCDB II). This is a land cover database derived from classification of satellite imagery in 2002. The amount of land in each vegetation type is shown in Table 2. The majority of land is grassland with exotic and indigenous forest being the next largest classes.

Table 2: Irrigable area in the Motupiko valley by vegetation cover

Irrigability class	Area (ha)								
	Exotic forest	Indigenous Forest	Major Shelterbelts	Manuka and/or Kanuka	Mixed Exotic Shrubland	Orchard and Other Perennial Crops	Gorse and Broom	High Producing Exotic Grassland	Low Producing Grassland
3s (<2°)	22	25		1		94		472	
3s (2-5°)	122	267		130		79	12	1702	<1
3s (5-10°)	80	99		46				132	
3s (>10°)		197		15				27	
3ts (2-5°)		15	4	1			<1	470	<1
3ts (5-10°)	739	239		69	3		7	1218	
4t (5-10°)									
4t (>10°)	25	41		5		29	<1	386	4

3.4 Climatic Factors

Figure 4 is a way of presenting climate data to assist landowners in determining crop suitability across the catchment. Figure 4 utilises mean soil temperature previously mapped by Barringer (1997 and 2000) and a correlation between soil temperature and growing degree days (base 10°C) to derive a map of growing degree day classes for the Motupiko catchment. Although mean air and soil temperature are well correlated, air temperatures are subject to much more convective mixing as a result of wind and turbulence in the atmosphere. To account for this when using soil temperature as a base layer for calculating growing degree days (GDD), the GDD surface was averaged over areas of approximately 1.5 ha.

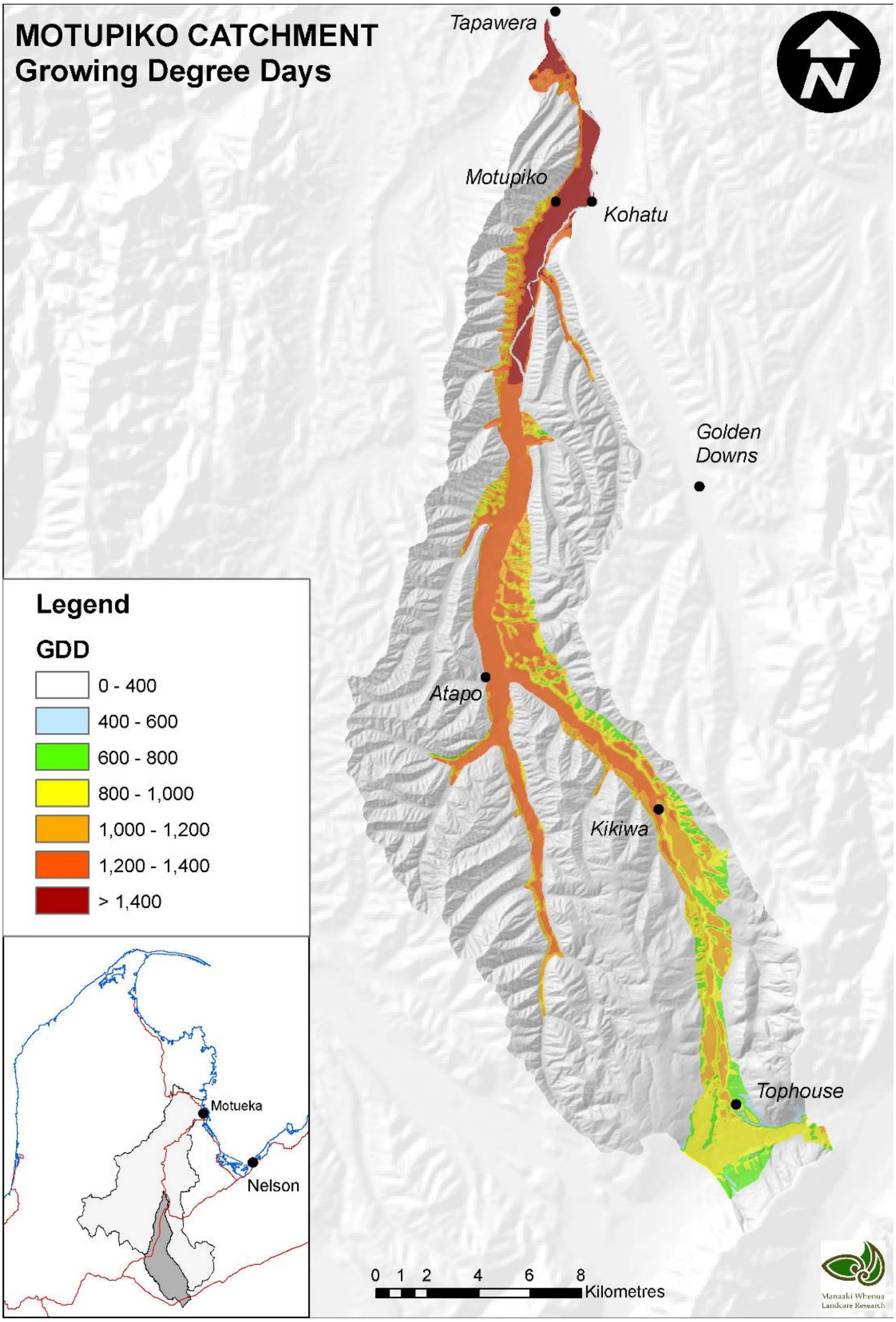

Figure 4 Growing Degree Days (GDD, base 10°C) for the Motupiko catchment

3.5 Summary of irrigable areas used in this study

Following consultation with the MCWAC it was decided that medium term irrigation development in the Motupiko is likely to be in the mid to lower valley, i.e. below Lachlan Taylor's property in the Motupiko and below Wayne Higgins' hay paddock in the Rainy. The land below Old School Road (near the confluence of the Motupiko and Motueka rivers) was also excluded as it has an adequate water supply sourced from the Motueka river and associated groundwater. These areas are shown in Figure 5 with the irrigation classification being distinguished purely in terms of greater or less than 5 degrees slope.

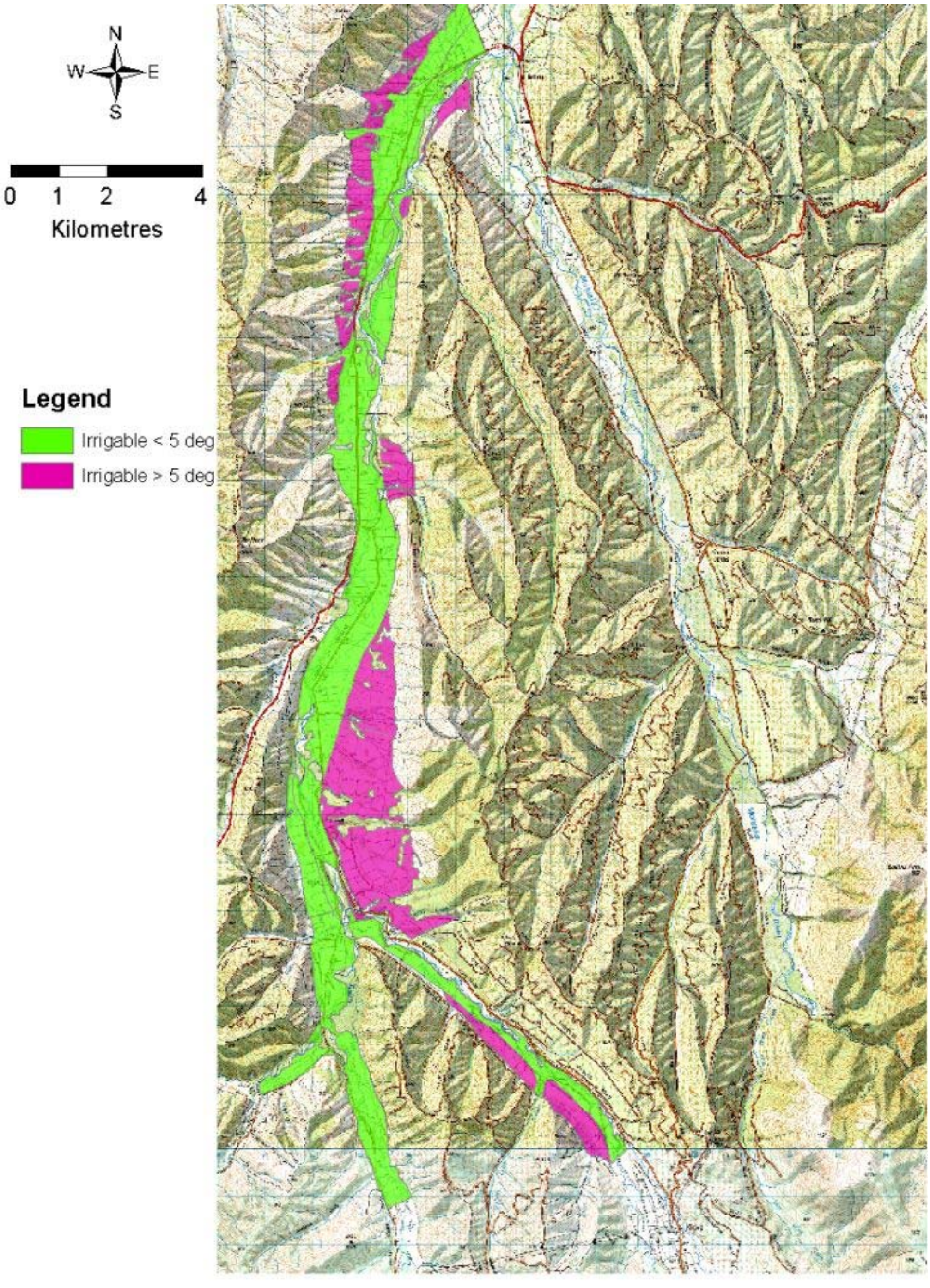

Figure 5 Irrigable land in Motupiko valley following consultation with MCWAC

The total irrigable land was calculated at 3228 hectares with 2024 hectares being on slopes less than 5 degrees. Most of the irrigable land (2407 ha) is below the confluence with the Rainy River. In the Rainy, 403ha - all less than 5 degrees slope – is irrigable. In the Motupiko above the Rainy confluence, 418ha is irrigable but only 207ha of this has slopes less than 5 degrees.

Table 3: Summary of discussion by MCWAC on potential irrigable crops within 20 years in the Motupiko catchment

- Suitable crops depend on the versatility of the particular land parcel
- Flat valley-bottom areas are most likely to be developed first but slopes >5° could still be irrigated dairy land, e.g. using K-line systems
- Most of the valley floors below Kikiwa have greater than 1100 GDD (Growing Degree Days), which could suit grapes. However spring and autumn frosts may limit grape production
- Maize is also affected by frosts
- Cherries grow well in some home gardens; in Otago they require irrigation at 1 mm/hr for every degree of frost, which would likely result in boggy ground here.
- Some vegetable crops could be grown: peas were grown up as far as the Rainy when Talleys operated, and potatoes used to be grown at Korere
- Above the Rainy confluence, pasture or brassicas are the most likely irrigated land uses
- The whole area shaded in Figure 5 is considered potentially irrigable
- Irrigated biofuel crops may become economic within 50 years
- Hemp could be grown over this whole area.
- For berries and currants, frost is limiting for most such as boysenberries and blackberries; the season is too short but raspberries could be and have been grown throughout the valley.
- Irrigation is not currently economic for sheep and beef farms – conversion of those land uses to dairying or cash crops is most likely if irrigation is to be used. Investors may finance land use change to dairy.
- The most likely current scenario for irrigation is to grow grass.

4. Initial Dam Site Scoping

4.1 Desk-Top Scoping and Site Inspection

Initial scoping of potential storage sites used the Tasman Regional Water Study (Lincoln Environmental, 2003) plus topographic maps of the catchment. Inspection of the study area was undertaken on 24 November 2005 by Landcare Research and Tonkin & Taylor staff with members of MCWAC, followed by a briefing meeting at the home of MCWAC chairman Edwin Newport.

Indications from farmers at the 24 November 2005 meeting were:

- Little irrigation anticipated above the Rainy-Motupiko confluence;
- Irrigation unlikely to exceed 4,000 hectares in the foreseeable future;

- The likely more affordable concept is to store winter flows for release downstream when needed for irrigation through the summer, rather than a reticulated scheme

Based on preliminary assessments of maximum irrigation potential and storage demand, a total of 12.8 million cubic metres (MCM) of storage was targeted to serve a possible 4,000 hectares of irrigated land.

Where access to possible dam sites had been obtained in advance they were visited, features noted and photographs taken, otherwise as much as was practicable was observed from public road access. Consistent with the brief, storage sites of different sizes were identified by initial desk study, observations from the area inspection and MCWAC discussion. Three categories of Large (L), Medium (M) and Small (S) storages were considered as described below. Figures 6 and 7 show the full suite of possibilities identified.

This information plus the irrigation demand mapping then contributed to a shortlisting of sites following a field visit on 9 June 2006 with MCWAC members and local farmers.

4.2 Single large (L) storage

The 2003 Tasman Regional Water Study proposed a 3 MCM storage dam at "The Forks" on the Rainy river but did not go into detail on other possibilities to service larger areas of irrigation. It was assessed at the time that 3 MCM was about the maximum sustainable size for a dam at this location.

Recognising the limits on river flows available for reservoir filling, only two potential single large (L) storage sites were identified within the study area, both involving transfers from adjacent catchments to achieve secure filling. These sites and the corresponding transfers are shown schematically on Figure 7 labelled L1 and L2.

Site L1 is located on the upper Motupiko where it substantially avoids existing infrastructure, but it would require rerouting about 2 to 3 km of the Korere-Tophouse road, would flood some farmland and would drown a large patch of native bush. The catchment above the dam is only about 20 km^2, and so has limited infill capacity. The only practical way in which this dam could be kept full would be to pump from the Buller River just below the Lake Rotoiti outlet from the 5% of Buller flow available under the Buller Water Conservation Order. A static lift of about 90 m would apply along with head losses in some 11km of rising main to the Tophouse saddle between the Buller and Motupiko catchments. Clearly there are significant cultural and environmental issues associated with a development of this kind as well as headworks pumping costs. Transfer of the invasive algae *Didymo*, already identified in the upper Buller and now in the lower Motueka, would be another barrier.

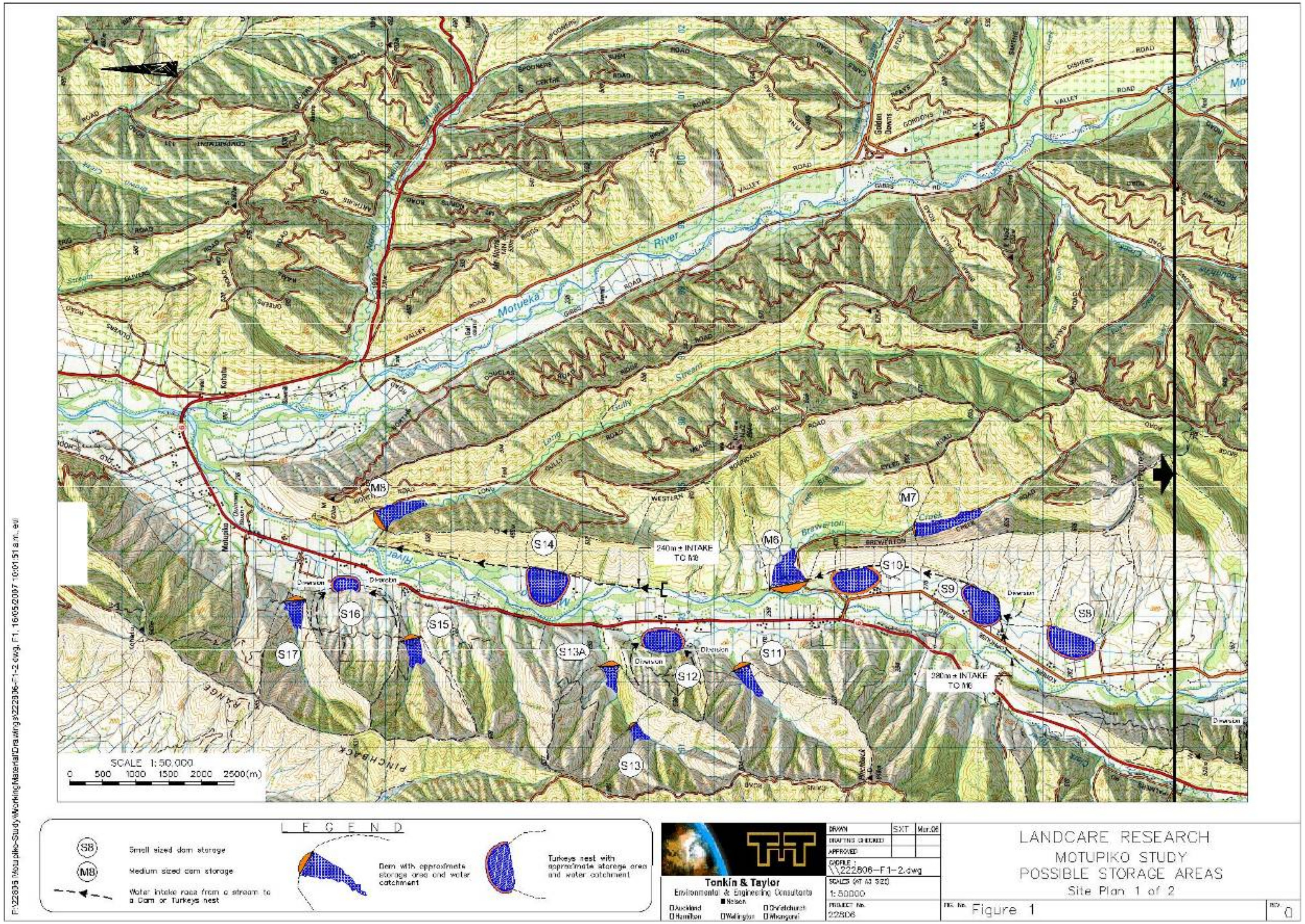

Figure 6 Desk-top screening selection of potential medium (M) and small (S) reservoir sites, lower Motupiko catchment

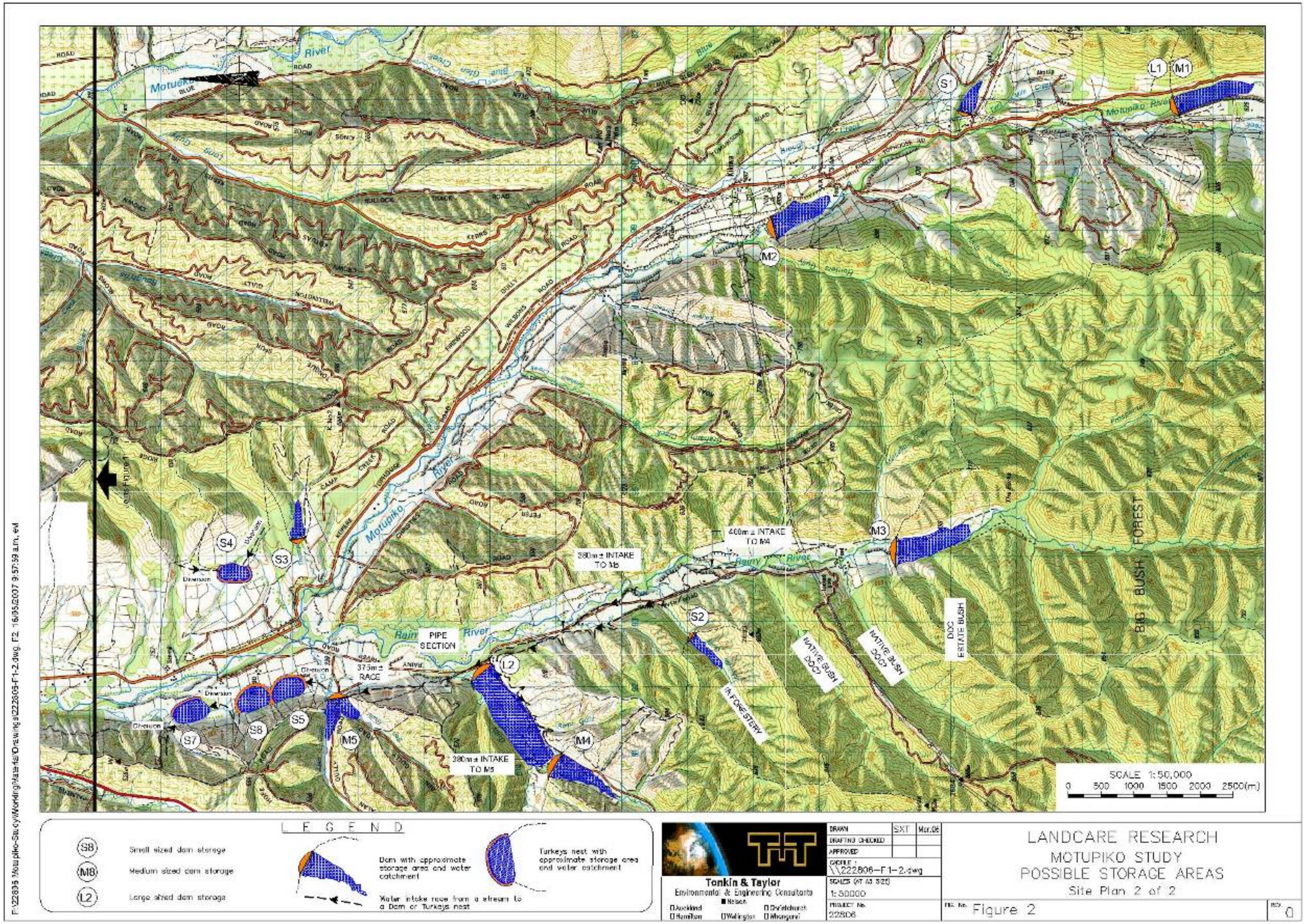

Figure 7 Desk-top selection of potential medium (M), small (S) and large (L) reservoir sites, upper Motupiko and Rainy tributary

Site L2 involves a dam across the base of Big Gully above the Rainy-Motupiko confluence. Here the combined Horopito and Rainy River catchments total close to 100 km^2 and with an oversized reservoir, infill security may be achievable. To fill the reservoir, it would be necessary to divert winter flow from the Rainy River and this looks to be achievable under gravity from an intake and race at about RL 400 (400 metre contour), as shown on Figure 7. The reservoir would flood dairy farmland and forestry in the south (Horopito) branch of Big Gully, and would also flood an area of native forest on the northern side of the reservoir. This site also has environmental issues such as fish passage.

While the above have been outlined for completeness, it is doubtful that either site would gain resource consent without onerous conditions and costs. In principle, a large storage could be built lower down the Motupiko but not without what is likely to be an unacceptable level of effect on farms and infrastructure.

4.3 Medium sized (M) storages

Medium sized storages are taken as those enabling upwards of about 1.0 MCM of storage. The eight sites identified on Figures 6 and 7 are summarised as follows, with storage potential based on first cut estimates of catchment yield:

- M1 in the area of the upper Motupiko L1 site, sized on the basis of inflow from the Motupiko catchment only, has an approximate potential 3 MCM;
- M2 at Kikiwa approximately 5km downstream of M1 on the Motupiko river also has potential storage greater than 3 MCM;
- M3 below the Rainy River "Forks" site previously identified would reduce the impact on DOC-administered native bush while still achieving much the same storage capacity of about 3 MCM;
- M4 at the mouth of the South Branch of Big Gully (Horopito) has an approximate potential of 2.5 MCM;
- M5 across either or both of Alan and Ben gullies has an approximate potential of 1.5 MCM but would require a diversion from the Rainy or Big Gully to achieve its maximum potential of about 4 MCM if neither M3 nor M4 is developed;
- M6 at the mouth of the Brewerton may possibly be stretched to 1.5 MCM of storage if limited to flooding only a small amount of the native bush and filled by own catchment inflow if M7 does not apply, otherwise a gravity transfer from the Motupiko appears possible as indicated in Figure 7;
- M7 on the Upper Brewerton above the extensive zone of native bush in the lower section of the valley has an approximate potential of 1 MCM based on own catchment inflows;
- M8 at the bottom end of Long Gully has some 2 MCM provided by own catchment flow.

4.4 Smaller scale (S) farm storages

Individual farm storages can be built in a side gully where there is one on the farm (more particularly on the western side of the Motupiko) or as "turkeys nest" storages on the flat, involving cut and fill and exploitation of any local broad gully or terrace edge landforms. Usually the latter type has a relatively shallow depth and at 5 m average depth, a 500,000 m^3 storage serving around 150 hectares, would cover 10 hectares. Apart from taking up what is almost certain to be productive land, the latter type involves the extra cost of sealing against leakage because of the more permeable soils on the flats, whereas gullies in the Moutere gravels, which are tight, need only a shallow cut-off through surficial gravels, depending on location. Moutere gravels are visible close to the surface in the upper catchment but may be too deep to reach cost effectively in the lower catchment.

Figures 6 and 7 also indicate potential smaller scale storages labelled S1 to S17 based on a target of around 600,000 m^3 safe storage and adopting as a preliminary “rule of thumb” that a gully dam should not exceed 20 m height. Without pumping from the river as backup, some 200 hectares of catchment is required for 600,000 m^3 of storage. The smaller gullies are generally regular with a longitudinal base slope of about 1 in 20 to 1 in 50, a narrow base about 100 to 150m wide and side slopes of around 20 to 30 degrees. Except where there is a local widening in the valley floor as occurs typically at forks in the valley, a 20 m high dam can only store around 500,000 m^3 to 750,000 m^3. Indicative or illustrative turkey’s nest possibilities are based on 5 m water depth. Clearly many configurations are possible, so those marked do not represent all possibilities. Similarly only what appear to be the more promising gully dam possibilities are shown and dams higher than 20 m, if affordable, would open up other sites.

A conceptual design for a farm-scale gully dam is shown in Figure 8.

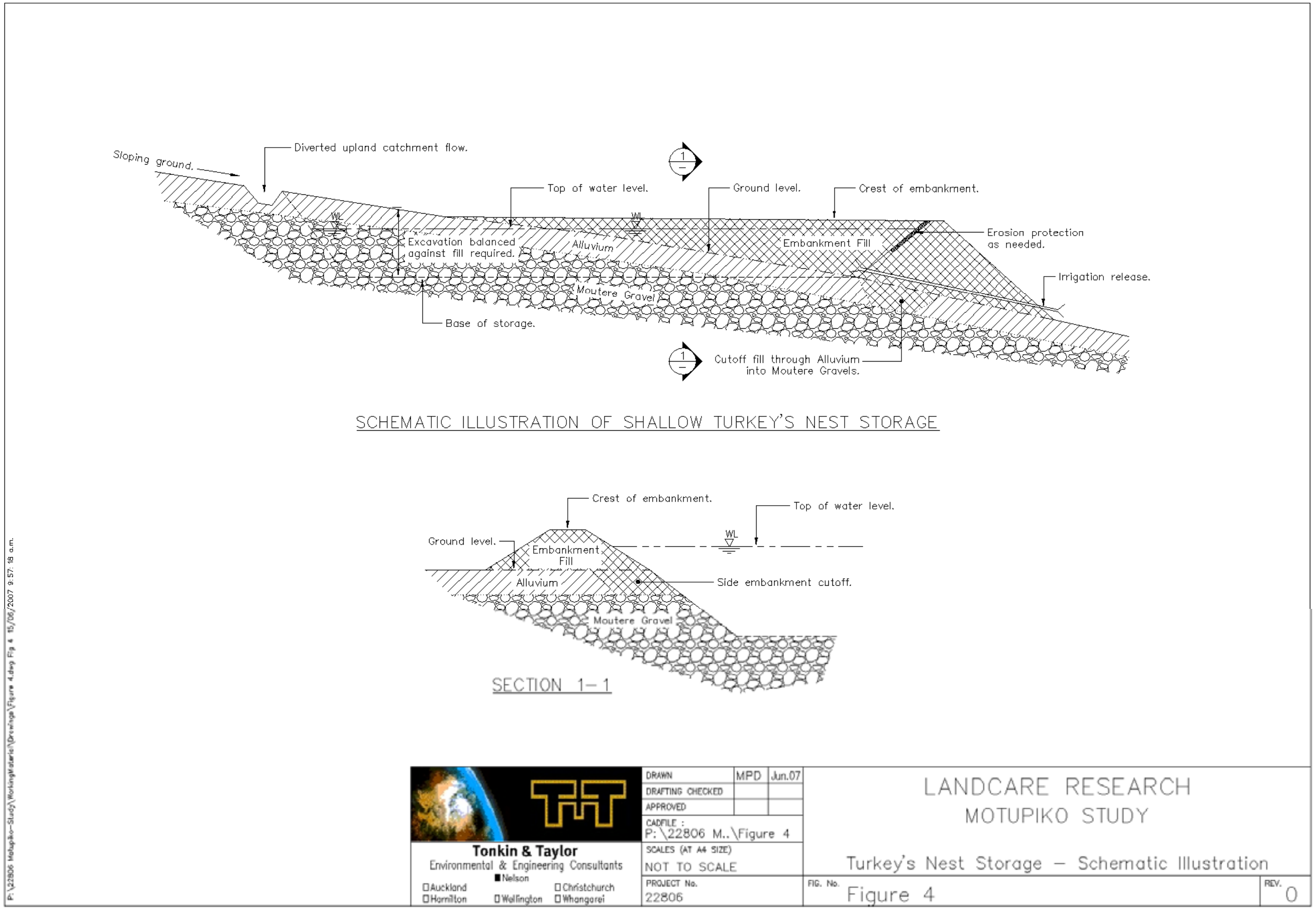

Figure 8: Turkey's Nest Storage – Schematic Illustration

5. Irrigation Water Needs Assessment

Having ascertained the maximum irrigable area and the scale of potential storages, detailed analysis of irrigation water needs was undertaken, based on both planning constraints for water allocation in the Motupiko, and hydrological analysis of available stream flows. This analysis is needed for sizing storage at shortlisted sites.

5.1 Allocation limits and current allocations

This section reviews the planning constraints imposed by either the Motueka Water Conservation Order (WCO) or the water management rules in the Council's Tasman Resource Management Plan (TRMP). The Motueka WCO was gazetted in 2004 and sets limits on damming and abstraction of water to protect nationally important values of the Motueka catchment. The Motupiko River is recognised in Schedule 3 of the WCO for fish passage and trout spawning in spawning tributaries during the months of May to October inclusive; it also contributes flow to the mainstem Motueka River which is recognised in Schedule 2 for its brown trout fishery.

Clause 8 of the WCO prohibits damming of the Motupiko and Rainy rivers, because of their contribution of flow to outstanding features in the Motueka below the Wangapeka confluence. This means that obtaining resource consent for any damsites identified for water augmentation in the mainstem Rainy or Motupiko rivers would require a change to the WCO, which is likely to be a lengthy process.

Clause 9 specifies high level limits on flow alteration in the Motueka River below the Wangapeka, and minimum residual flows in the Motupiko River during the winter trout spawning period May to October inclusive. Water allocation limits subsequently set in the TRMP apply to the non-augmented waters of the Motupiko catchment.

The relevant WCO rules are 9(1)(c) and (e)(ii):

9(1) No resource consent may be granted or rule included in a regional plan that—

c. will cause, either by itself or in combination with any other existing consents or rules, alteration of the flow of that part of the Motueka River specified in Schedule 2 by more than 12% as measured by the residual flow at Woodstock; or

d. will cause, either by itself or in combination with any other existing consents or rules, alteration of the flow of water in any part of the Wangapeka River by more than 6% as measured by the residual flow at Walter's Peak; or

e. That will cause, either by itself or in combination with any other existing consents or rules, including existing surface and groundwater takes, reduction of the naturally occurring instantaneous flow of that part of the rivers, identified in Schedule 3 below the following threshold minimum flows, during the months of May to October inclusive;

i. 1000 litres/second in the Motueka River immediately above its confluence with the Motupiko River (at N28:961 731)

ii. 500 litres/second in the Motupiko River immediately above its confluence with the Motueka River (at N28:961 731) *iii. 250 litres/second in the Tadmor River at the Mudstone recorder.*

In the TRMP the following allocation limits have subsequently been set for subcatchment water management zones:

Table 4: Allocation limits affecting irrigation in the Motupiko catchment (from TRMP Figs 31.1E and F)

WATER MANAGEMENT ZONE	ALLOCATION LIMIT (litres per second)
Upper Motueka Zone	**1000**
Wangapeka Motupiko Tadmor (total augmented flow) Tapawera Plains	265 110 56 515

The 13 water permits in the Motupiko catchment authorise irrigation of 191 ha. These permits total 110 l/s allocated, based on weekly water volumes allocated, and as this equals the allocation limit specified for the Motupiko catchment in the Tasman District Council's TRMP (Fig 31.1E, F), the catchment is currently fully allocated. Water allocations above the Woodstock river flow recorder totalled 689 l/s in 2004, i.e. around 70% allocated.

The 10 year low flow at Woodstock is 6486 l/s and the 50 year is 5132 l/s. In theory, dams could be required to release a residual flow when flows are below about a 5 year return period at Woodstock (1000/0.12=8333 l/s). However, this would probably only affect mainstem Motupiko dams and these would also have local residual flow requirements. These dams would be releasing water for irrigation supply during low flow periods anyway.

WCO clause (e)(ii) limits May-Oct flows to no less than 500 l/s in the lower Motupiko. There is no recorder but monthly winter low flows estimated by TDC from Christies flow monitoring site in the Motupiko above the Rainy confluence, and from Motueka Gorge records as at 1999 were as shown in Table 4.

Table 5: Estimated monthly river flows April-October in the Motupiko River

	Estimated flows for Motupiko at Quinneys Bush	
	Lowest recorded 7 day minimum flow (l/s)	Mean Annual Low Flow MALF (using only data from month shown in l/s)
April	292	1132
May	537	1595
June	543	2272
July	522	3477
August	1273	3610
September	1662	3483
October	699	2511

If dams were considered for the mainstem Motupiko or Rainy, their design would need to allow residual flow to maintain a proportional contribution to the 500 l/s minimum flow required from May to October. Tributary sites, because of their proportional size, may not have a significant impact on winter flows and therefore local residual flow needs would be the main consideration in a consent process.

Residual flow will need to be set taking into account TRMP policy 30.1.17 relating to adverse effects of dams, and policy 30.3.2 recognising beneficial effects of water augmentation. For an augmentation scheme releasing water into rivers for downstream abstraction, the augmented flow regime also needs to take into account the uses and values for the Motupiko River listed in TRMP Schedule 30.1; apart from the contribution to the nationally important values deriving from the WCO discussed above, Schedule 30.1 explicitly identifies the Motupiko as having regionally significant native fish habitat.

In summary, the WCO 12% Woodstock limit is unlikely to have a significant effect on residual flows required from Motupiko dams, nor in our opinion are the TRMP policy and rules likely to require a significant additional storage requirement to meet residual flow requirements. Because the WCO currently prohibits dams on the mainstem Motupiko or Rainy rivers, preference has been given to identifying sites on tributary catchments. The 500 l/s May-October minimum flow for the Motupiko is unlikely to significantly influence dam sizing but will need consideration alongside TRMP water policy and rules when residual flows are addressed in resource consent applications for preferred site(s).

5.2 Inflow modelling using the Landcare Research WATYIELD model

To gain an initial assessment of the limits of storage able to be filled at each site, streamflow yields for the medium (M) and small (S) sites were estimated using WATYIELD water balance model (Fahey et al, 2004). A daily flow was simulated using rainfall from Golden Downs (1954-1980) and Kikiwa and Christies (1980-2005). Rainfalls for Rainy River were checked against 35 years of monthly rainfall (1967-2001) provided by retired farmer Arthur Hawke from his gauge at N28:924520. Each catchment for the proposed reservoirs was simulated with the current land cover (derived from LCDB II) and a postulated possible maximum forestry (where all pasture is replaced with exotic forestry). In discussion with MCWAC, the target security of supply for design is for the reservoir to fill nine years out of ten.

Testing of the model for the Motupiko catchment against the flow record at Christies (1990-2005) suggests that it is able to simulate the general trends but is under-predicting the high flows (Figures 9 and 10). No particular site calibration was attempted to improve the model runs and WATYIELD can be considered a conservative estimator of flows.

WATYIELD was designed for use in small catchments (<50 km^2) so the simulation for Christies (105 km^2) is larger than would normally be considered. However most catchments modelled in this study were well within the model's design range.

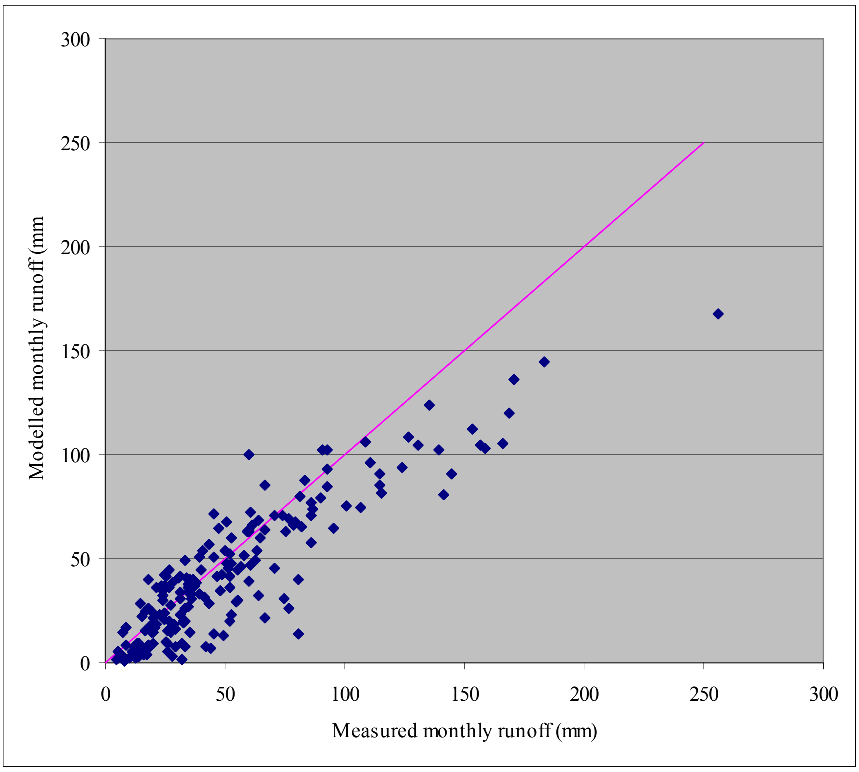

Figure 9 Measured vs modelled monthly runoff for the Motupiko River at Christies, 1990-2005. The pink line is 1:1 representing a perfect fit between measured and modelled runoff.

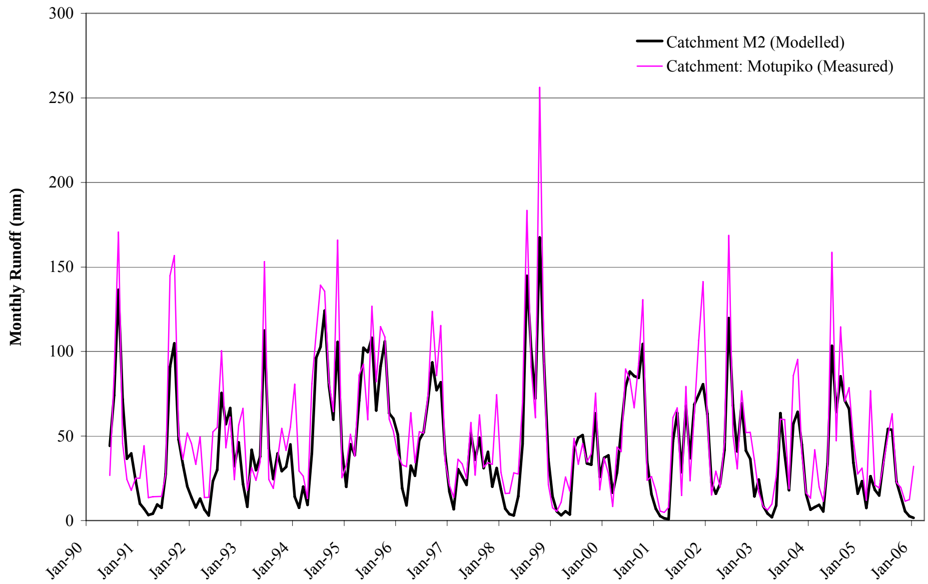

Figure 10 Time series of measured (pink) vs modelled (black) monthly flows at Christies.

The results from these simulations are shown in Table 6. All flows are for the irrigation year (1 May to 30 April) immediately preceding when the low flow intervals were simulated. Q_{50} is the 7-day duration low flow with a fifty year average recurrence interval, as calculated from the Christies river flow record. This occurred in May 1987 and this means the irrigation year of 1986/87 was used for simulating total inflows for a Q_{50} year. Depending on the statistical distribution used, this year's inflows have an average recurrence interval of between 50 and 80 years.

Q_{10} is the 7-day duration low flow with a ten year average recurrence interval, as calculated from the Christies river flow record. This occurred in May 2003 and this means the irrigation year of 2002/03 was used for simulating total inflows for a Q_{10} year. Depending on the distribution used, this year's inflows have an average recurrence interval of between 10 and 12 years. Q_{med} is the median input flow in an "irrigation year" (1 May to 30 April). This occurred in 1996/97 based on the Christies river flow analysis.

A conservative estimate for a residual flow, i.e. a minimum flow to be released from the storage, was calculated from the 90th percentile flow in the Motupiko at Christies flow duration curve. This was linearly scaled for the size of catchment above each dam site. Inflows to storage were then calculated releasing just the calculated residual flow, with no flushes. For the Rainy it was assumed the same residual flow applied as for Motupiko at Christies.

Forestry scenarios were simulated in WATYIELD by replacing pasture with forest and any recently cut forestry with mature canopy. For site M3 (Rainy) there was no available space for forestry and for S2 forestry is already the predominant land use. These forestry scenarios represent the worst case for inflows (i.e. a fully canopy cover on all available ground) without replacing any native vegetation.

Table 6: Annual flow volumes into proposed dam sites. All flows are millions (x 10^6) m^3 per year (MCM). Values in brackets are for full forest cover scenarios. Site references are for medium (M) and small (S) reservoir sites shown in Figures 6 & 7. Shading indicates adequate storage for 3 MCM for medium and 0.6MCM for small storages. Q_{50} is the flow in a 50 year drought (estimated to have an average recurrence interval of 50 years); Q_{10} is a ten-year drought and Q_{med} is the median flow (occurred 50% of the time of the modelled period).

Proposed dam site	Q_{50} (1986/87)	Q_{10} (2002/03)	Q_{med} (1996/97)	Lowest inflow	Comment
M1 Upper Motupiko	6.2 (5.6)	12.8 (11.5)	15.5 (13.9)	1986/87	Enough for 3M m^3 under all scenarios (n.b. no residual flow)
M1 with residual flow	2.88 (2.27)	9.47 (8.18)	12.19 (10.59)		Would not have enough flow in Q_{50} event – forestry exacerbates problem
M2 Kikiwa	13.80 (12.18)	28.50 (25.06)	34.49 (30.27)	1986/87	Enough for 3M m^3 under all scenarios (n.b. no residual flow)
M2 with residual flow	6.55 (4.93)	21.25 (17.81)	27.24 (23.02)		Enough for 3M m^3 under all scenarios. Enough for 10M m^3 except for Q_{50}
M3 Upper Rainy	9.77 ()	20.34 ()	24.97 ()	1986/87	Enough for 3M m^3 under all scenarios (n.b. no residual flow)
M3 with residual flow	4.23 ()	14.80 ()	19.43 ()		Enough for 3M m^3 under all scenarios. N.B. Residual flow is probably too low for Fish & Game. Forestry is unrealistic in this catchment
M4	3.26	6.80	8.28	1986/87	Can supply 2.5M m^3 under all

Horopito	(3.16)	(6.59)	(8.03)		scenarios but no allowance for residual flow.
M5 Ben&Alan	1.03 (1.00)	2.15 (2.09)	2.58 (2.51)	1986/87	No chance of filling 4M m3 and no allowance for residual flow. Would need transfer from Rainy
M6 Eyles	2.88 (2.17)	5.49 (4.55)	6.51 (5.43)	1986/87	Enough for 1M m^3 under all scenarios (n.b. no residual flow)
M7 Brewerton	1.66 (1.11)	3.05 (2.33)	3.61 (2.78)	1986/87	Enough for 1M m^3 under all scenarios (n.b. no residual flow). Would not need transfer if only 1M m^3
M8 Long Gully	4.42 (2.68)	7.83 (5.63)	9.22 (6.70)	1986/87	Can achieve 2M m^3 Large amount of "current" forestry is cutover so forestry scenario needs serious consideration.
S1 Rocky	1.92 (1.75)	3.92 (3.66)	4.72 (4.42)	1986/87	Can supply 1.5 at worst case and well over this at Q_{10}. NB no residual flow
S2 Melville	0.63 ()	1.33 ()	1.61 ()	1986/87	Can supply 0.6 at worst case and 1.3 at Q_{10}. NB no residual flow Forestry is already predominant land use
S3 Thompson	0.38 (0.30)	0.74 (0.64)	0.88 (0.76)	1986/87	Can supply 0.3 at worst case and 0.6 at Q_{10}. NB no residual flow
S11 Pinchback	0.61 (0.45)	1.28 (0.95)	1.56 (1.13)	1986/87	Can supply 0.4 at worst case and 0.9 at Q_{10}. NB no residual flow.
S13 Weyco	0.42 (0.36)	0.87 (0.76)	1.05 (0.90)	(0.26) – 1973/74	Can supply 0.35 at worst case and 0.75 at Q_{10}. NB no residual flow. Forestry has severe effect here, worst case could actually be 0.25
S13A Hyatt	0.68 (0.43)	1.42 (0.86)	1.69 (1.01)	(0.40) – 1973/74	Can supply 0.43 at worst case and 0.86 at Q_{10}. NB no residual flow Forestry has severe effect here, worst case could actually be 0.4
S15 Pinchback2	0.34 (0.16)	0.71 (0.33)	0.85 (0.38)	(0.11) – 1973/74	Can supply 0.16 at worst case and 0.33 at Q_{10}. NB no residual flow. Forestry has severe effect here, worst case could actually be 0.1
S17 Raine	0.25 (0.17)	0.53 (0.35)	0.62 (0.41)	0.21 (0.12) – 1973/74	Can supply 0.17 at worst case and 0.35 at Q_{10}. NB no residual flow Forestry has severe effect here, worst case could actually be 0.12

6. Dam Site Shortlist

The results shown in Table 6, and a further field visit with the MCWAC and local farmers on 17 October 2006 were used to shortlist the potential sites. This was based on a rough estimate of a storage volume of around three million m^3 (3 MCM) to supply 1000 hectares of irrigable area. The shortlisted sites were then put through a more rigorous modelling exercise to fully assess their capability (section 6.6). Factors affecting shortlisting are explained in the following sections.

6.1 Geology

The geology of the Motupiko catchment has been mapped and described in the geological map sheet N28 Motupiko at a scale of 1:50,000 (Johnston, 1983). The map indicates that the sediments in the Motupiko valley comprise recent and Pleistocene alluvial strata overlying older Pliocene Moutere Gravel, with Moutere Gravel forming the valley sides and surrounding hills.

The geological map describes the Moutere Gravel Formation as a clay-bound gravel comprising generally greywacke gravels, cobbles and scattered boulders. Overlying the Moutere Gravel are various alluvial strata, generally greywacke-derived gravel strata and re-worked Moutere Gravel. In addition deposits of loess (weakly cemented silt) are common within the alluvial gravels.

South (upstream) of Kikiwa the underlying strata changes as the Moutere Gravel wedges out. The alluvial strata in the valley bottoms are underlain by a complex sequence of older greywacke type deposits with intrusions of igneous strata and numerous fault traces. The active faults in the Motupiko area are the Waimea and Whangamoa Faults which run roughly south west to north east from Tophouse through the top of the Motupiko Valley towards Nelson. The other active fault is the Alpine Fault which runs roughly east to west from St Arnaud towards Blenheim along the Wairau valley.

For those dams north (downstream) of Kikiwa the major seismic risk will come from ground shaking during an earthquake. South of Kikiwa, the mapped fault traces crossing the valley would require careful consideration of the fault hazard for any dams in this upper Motupiko area. A seismic risk assessment is outside the scope of this study however the close proximity of the Alpine Fault and the Waimea/Whangamoa Faults for the dam sites south of Kikiwa would lead to higher peak ground accelerations for dam design than those dams in the Rainy and lower Motupiko Catchments.

6.2 Topography

The main Motupiko valley is wide and flat with steep sides. The tributaries to the main river however are generally steep, narrow sided valleys. The main Motupiko valley was formed by a large glacier which has carved out the U-shaped valley profile. The tributaries meanwhile were formed by smaller glaciers or more recent river action.

Dam sites off the main river tend to be disadvantageous to dam storage as they require relatively high dams to achieve a useable storage. This results in higher than normal costs per m^3 of water stored than those found in areas with more favourable topography.

6.3 Land Ownership

Land ownership affects the shortlisting of dam sites, as willingness to negotiate a sale of the reservoir area will affect the viability and timing of the project. However, landowners have been happy to allow access for this pre-feasibility phase.

The Horopito site affects dairy grazing and freehold forestry land. The dairy farmer (Michael Wilson) has indicated that he has no objection to the proposals. Weyerhaeuser (forestry) has indicated that they have no philosophical objection to either the Horopito or Ben&Alan proposals although they reserve judgement on support for any final proposal. The Melville tributary to the Rainy is scrub-covered farm land with minimal grazing; it was suggested by the local landowner as being preferable to a mainstem Rainy River site.

The Kikiwa site on the mainstem Motupiko is fertile grazing land which if removed from the current farm, may affect its viability. Rocky Gully is also privately-owned farm land and depending on the exact location of a dam, the reservoir may flood an existing large shed. Chinaman's Creek is also valley floor grazing land. The Ben&Alan gullies are forestry land operated under Crown Forest Licence by Weyerhaeuser. Portions of TDC road reserve and DOC marginal strips are also affected at most of these locations.

6.4 Water Delivery Options

There are three main delivery options with variations of them possible, namely:

- Release from storage into the river system and individual (or shared) farmer extractions from the river by pumping;
- Delivery from a large or community-based storage to farms via a piped network with on-farm booster pumping, the extent depending on what pressure may be available in the pipe at the farm gate;
- In the case of smaller scale (e.g. single) farm irrigation, pumping from an on-farm dam, which might also involve top-up pumping into the dam from available river flows.

As described elsewhere in this report, individual farm storage is not an option preferred by MCWAC. Of the first two delivery systems described, the second is more capital intensive and although it reduces pumping costs, it is rarely adopted, particularly in a situation such as exists in the Motupiko where the irrigation area is relatively long and narrow. The recent Downlands scheme in Otago is an exception, but the principal reason for adopting a piped network there, is that supply has to be pumped from the Waitaki over a high ridge, so the pressure available in a piped network below the ridge is sufficient to give on-farm pressure and avoid on-farm pumping plus a substantial power system upgrade.

Based on committee consultation, this study assumes that water delivery to farms will be by farmer abstraction of water released into the river system. Corresponding losses to groundwater have been considered in Section 6.6.

6.5 Shortlisting Sites

As the study and consultations with MCWAC progressed, the potential irrigation area and water demands were refined as outlined in Sections 3 and 4. This information was considered by the committee along with the range of storage possibilities described in Section 4.1 so as to select five storage sites for comparative technical and cost evaluation. Following a site inspection involving DOC, Fish and Game, TDC, MCWAC and the Landcare Research and Tonkin & Taylor consultants on 9 June 2006, the committee selected four sites from those previously identified and added a fifth small (S) site which had not been listed by the study team. At this stage the committee chose not to include a so-called turkey's nest example from the possibilities shown on the original list.

The selected five sites were;

- S1, labelled Rocky;
- S2, labelled Melville;
- S site, labelled Chinaman's (CG)
- M4, labelled Horopito;
- M2, labelled Kikiwa.

The location of these selected sites is shown on Figure 11 and photos in Figure 12. These sites are all located upstream of the Rainy/Motupiko confluence and only by mix and match or combinations in some cases would be able to serve the full area with the highest irrigation potential. Indicative cost estimates were calculated for each of these five short-listed sites. To assist with these cost estimates site visits were made to each of these potential storages and a taped (Abney) cross-sectional profile was measured across the approximate dam site.

Based on these cross-sectional profiles the approximate volume of earthworks at the dam sites was estimated and was the initial basis for the dam arrangement and therefore the indicative cost estimate. Details on the estimated costs are given in Section 8.

Following presentation of initial cost estimates for these five sites to MCWAC it was decided to look more carefully at one of the sites, M4 Horopito. In addition the work scope was extended and a sixth dam site M5 at Ben&Allan Gully was to be considered further and more detailed cost estimates drawn up based on an assumption of conjunctive use of released storage water plus naturally available streamflow in the Motupiko. However no tape and Abney profiling was carried out at the M5 site.

The Ben&Alan dam site M5 has a small catchment area which limits its potential unless additional flow is transferred into it from the Rainy or Big Gully Stream. An intake downstream of the Horopito site has been assumed with a gravity transfer to M5. Conceptually, this kind of arrangement makes M5 similar to turkeys nest storages which rely on diverted inflow for filling.

A comprehensive assessment of all storage options which examine how cost varies with storage volume and irrigation area served is beyond the scope of this study and also could be misleading because of the level of accuracy achievable at this stage without detailed field surveys. This initial assessment was based on assumed irrigable areas served by each storage, those areas being chosen in relation to infill/storage potential and judgement on anticipated relative storage costs. These sites, and the irrigation areas assumed to be served are described in more detail in Section 8 with the evaluation process and comparative costs.

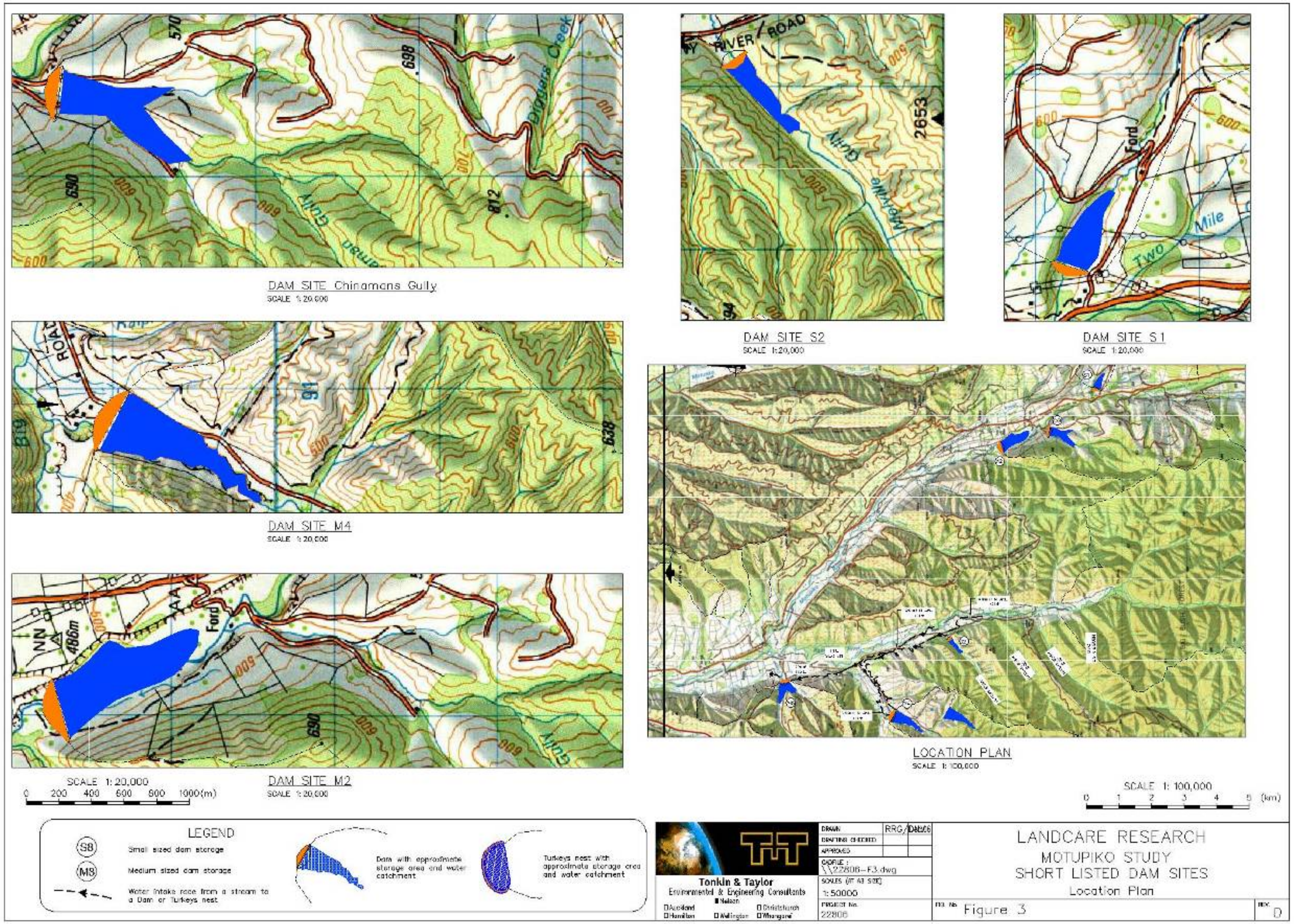

Figure 11: Map locations of shortlisted dam sites

 Chinaman's Gully	 Melville Gully (S2)
 Horopito Valley (M4)	 Rocky Gully (S1)
 Motupiko at Kikiwa (M2)	

Figure 12: Photographs of each shortlisted dam site.

6.6 Storage modelling

The determination of what size of dam was required was an iterative process using a series of linked models for different stages. The 3 stages were:
Model irrigation demand for the irrigable land previously identified.
Model the amount of water flowing into each potential reservoir using WATYIELD.
Simulate a time series of reservoir storage volumes based on preliminary site topography measurements and the release required to meet the irrigation demand in step 1.
The aim was to calculate the actual amount of irrigation water that would have been required to meet full demand 9 years out of 10 if the scheme had been operating for the period of climate record, i.e. since 1954.

6.6.1 Irrigation demand

Irrigation demand was modelled using a rule-based, soil moisture balance approach. The model operates by taking irrigation practice and soil parameters (Table 7) and a time series of daily rainfall and monthly potential evaporation to calculate the amount of irrigation required to keep the soil moisture above a certain deficit. This is then multiplied by the area of land under irrigation to produce an irrigation demand figure in m^3/day.

Table 7: Input parameters and variables used in irrigation demand model.

Parameter or variable	Notes
Irrigation season (start and end month)	The months when irrigation could occur if the soil is dry enough. Set at October to May for grass
Irrigation trigger (mm)	The soil moisture deficit value at which irrigation is triggered. Set at 25mm for grass.
Readily available water (mm)	The amount of water in the soil able to be accessed by plants. Set at 60mm for Motupiko valley soils
Daily rainfall (mm)	Obtained from Tapawera rain gauge
Monthly potential evaporation from a grass surface (mm)	Obtained from nearest Meteorological station (Nelson Airport) and disaggregated to daily values.

Figures 13 and 14 use the year between June 1981 and May 1982 to illustrate the way the model works for irrigating pasture. The irrigation season defines the time when irrigation is likely to be needed (red line in Figure 13). Irrigation is applied when the soil moisture deficit reaches 25mm (for grass).

The amount of water applied depends on the time of year and is designed to match potential evaporation. In this way the irrigation maintains the soil moisture at a 25mm deficit and irrigation continues until rainfall recharges the soil moisture. In this way continuous irrigation occurs, which simulates the moving of irrigation equipment around a farm.

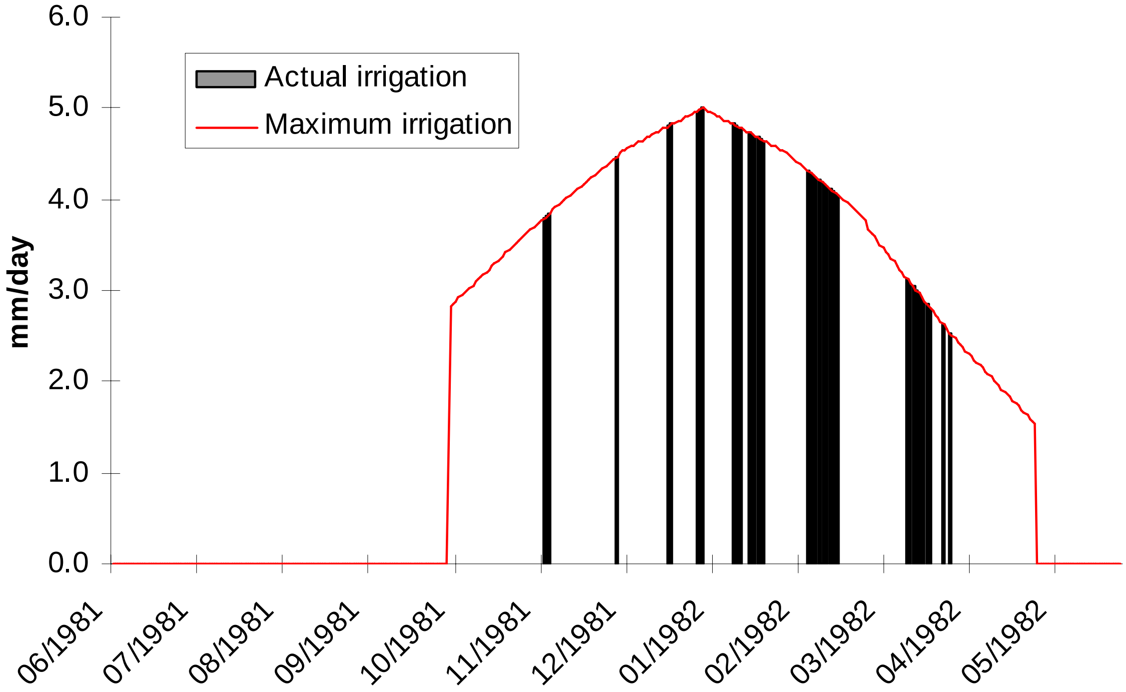

Figure 13 Modelled irrigation demand for 1981-82. The red line is the maximum irrigation that would be applied at a site without rain. Bars show the irrigation which would have been applied whenever the soil moisture was dry enough.

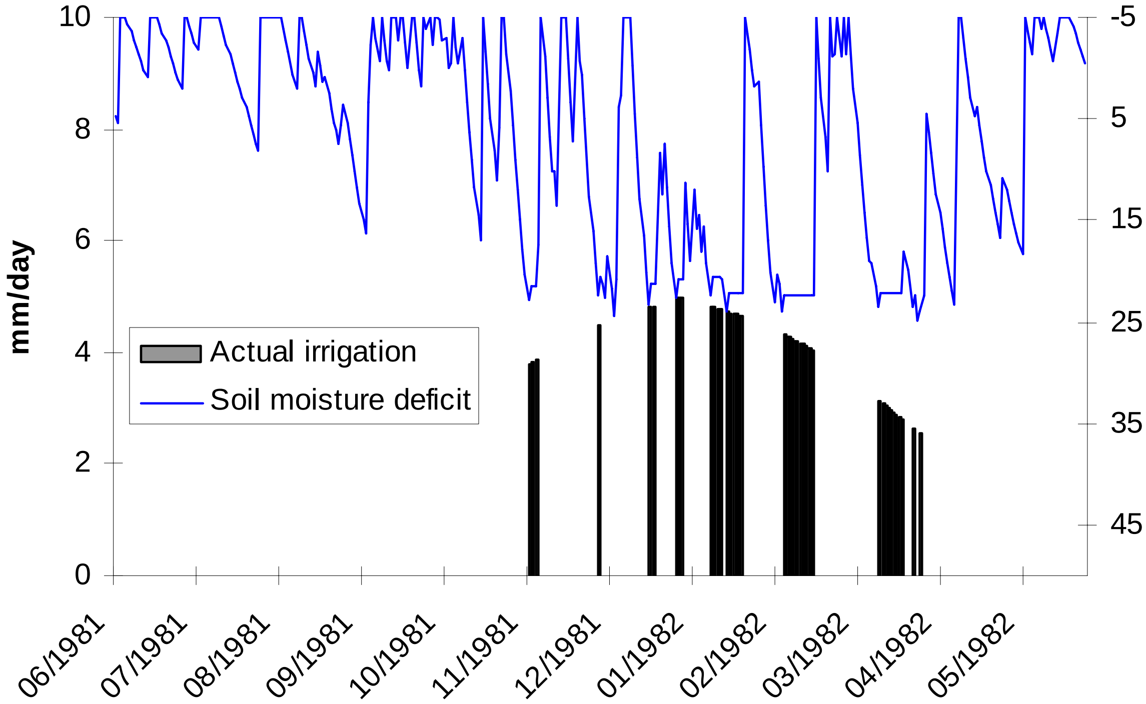

Figure 14 Soil moisture deficit and modelled irrigation for 1981-82. The blue line is the soil moisture deficit. The bars show the irrigation applied (hypothetically) when the soil moisture deficit reached 25mm.

The parameters in Table 7 can be altered for different vegetation covers. For the purposes of this project, the model was run from 1954 to 2006 assuming irrigated pasture for the irrigation demand. The model was checked against a short dataset of recorded water extraction for 33 hectares of irrigated pasture in the Wangapeka (summer of 2005-06). Figure 15 shows the observed vs predicted extractions for the 16 week period. There is a wide scatter in the graph, suggesting that the model is poor at predicting the time of high and low irrigation rates; however, over the total 16 week period the model predicted 92% of the water actually used, i.e. it predicted 8% less than was actually extracted. For irrigation demand spread over a large area with a range of irrigation scheduling habits (i.e. conservative water use as well as non-conservative) the model performs adequately for predicting water demand.

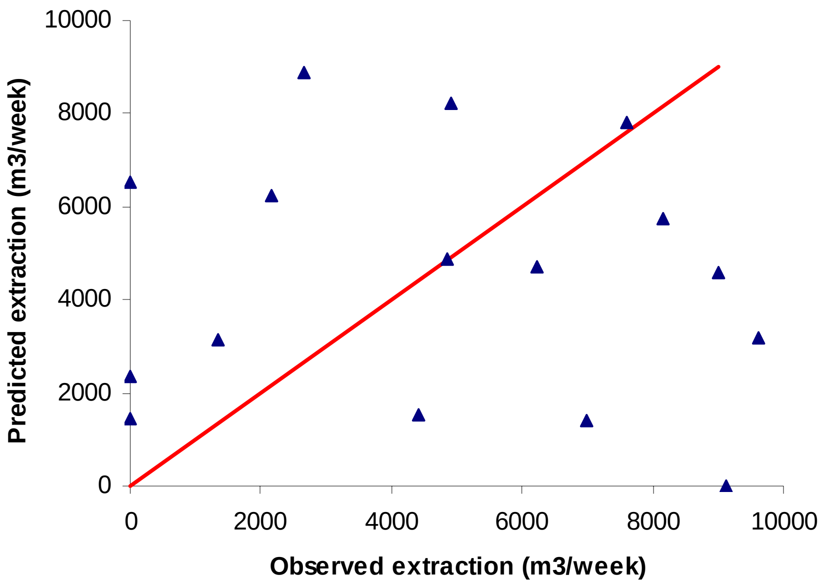

Figure 15: Observed vs predicted irrigation extraction for a farm at Wangapeka with 16 weeks of weekly meter readings during summer of 2005-06. Red line is 1:1. Although the scatter is large the total volumes extracted over a 16 week period agree within 8%.

6.6.2 Reservoir inflows

For the shortlisted sites, the WATYIELD model described in section 5.2 was used to simulate daily inflows to a hypothetical reservoir over the period 1954 to 2006. The rainfall was scaled from Tapawera and other nearby gauges to provide the best estimate for the catchment of concern. Land cover was assumed fixed, based on the 1996 LCDB II land cover maps.

For several scenarios extra water was diverted into the reservoir from nearby streams. In this case a rule-based system was used whereby the diverted flow was limited to a defined maximum (i.e. the size of the diversion channel) unless the modelled streamflow for that stream source fell below a critical threshold (e.g. a drought flow Q_{95} naturally occurring for less than 5% of the time).

6.6.3 Reservoir storage and release

Reservoir storage was modelled based on measurements of the valley dimensions. This allowed relationships to be drawn up between dam height and storage volume (for example, Figure 16). The daily storage in the reservoir was then calculated based upon:

- Modelled input from the catchment above (m3/day);
- Evaporation from the surface of the reservoir: modelled from potential evaporation data (m3/day);
- Spillage from the reservoir when it filled to the dam height (m3/day);
- Release of water from the reservoir to meet the irrigation demand (m3/day);
- Release of water to meet a residual flow requirement (m3/day);
- A release of an additional 10% of irrigation demand to allow for non-recoverable flow losses to groundwater (m3/day).

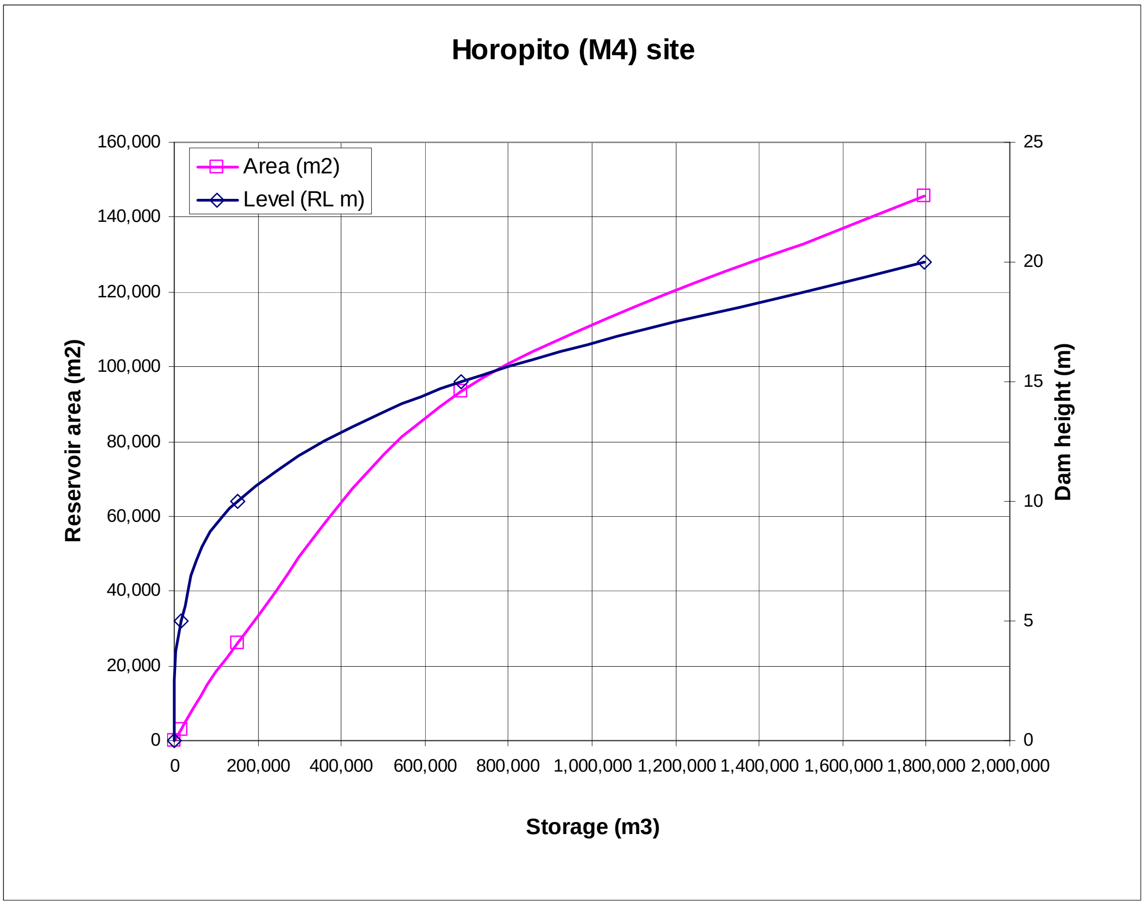

Figure 16: Relationship between: reservoir storage and area (pink line); and reservoir storage and dam height (blue line) based on topo mapping and Abney survey only

The reservoir storage and release model was set up for the 52 years of rainfall with the dam height and the amount of irrigated land able to be altered. An iterative process was then undertaken to find the maximum amount of land that could irrigated for a certain dam size given a 1:10 year frequency of the reservoir being emptied during the simulated 52 years.

Examples of the model output are shown in Figure 17 and 18. In this example the reservoir is emptied 6 times in the 52 year record which indicates that 750ha is the maximum amount of land able to be irrigated with the 9:10 year security.

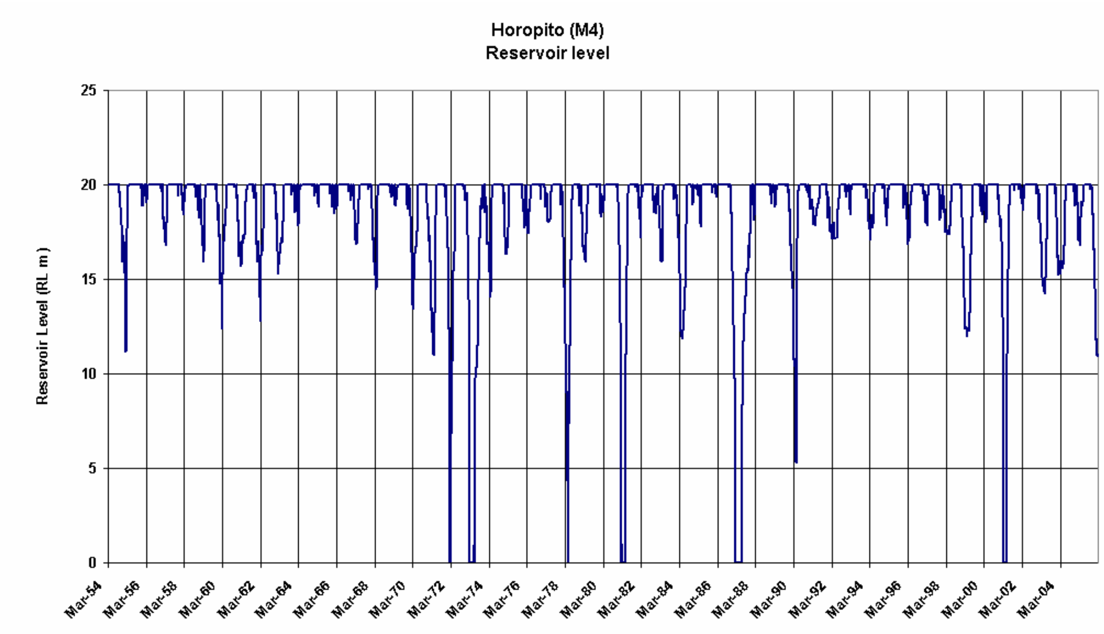

Figure 17: Simulated reservoir level for a 20m high dam on the Horopito (site M4) irrigating 750ha of grass.

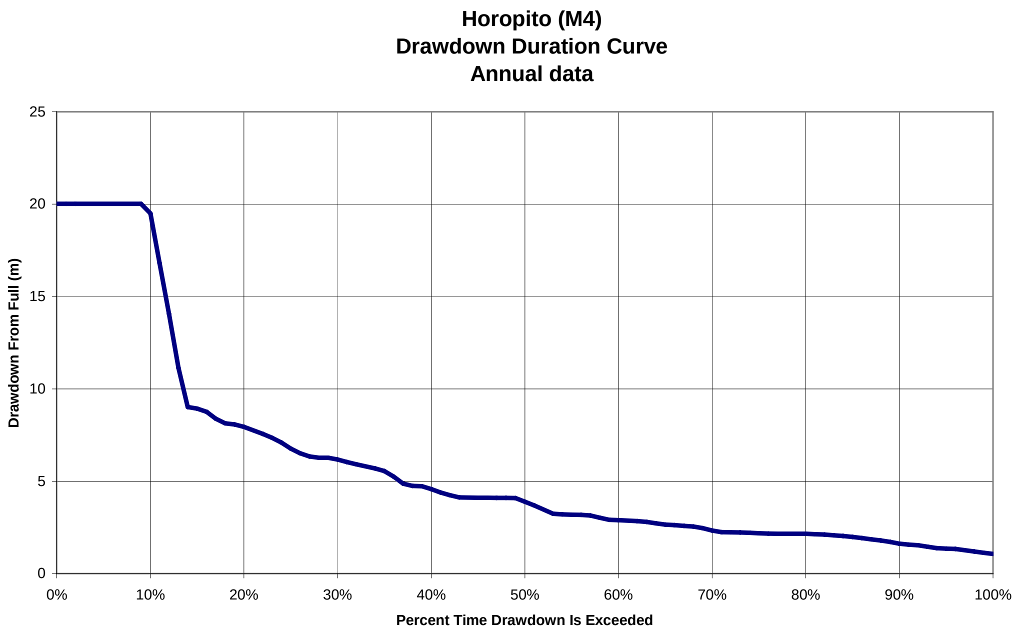

Figure 18: Drawdown frequency for a 20m high dam on the Horopito (site M4) irrigating 750ha of grass. 10% of the time the reservoir is drawn down the full range (20m).

6.7 Summary of storage needed

The results of the modelling of storage requirements are given in Figure 19 and Table 8. Figure 19 shows that only the mainstem Motupiko at Kikiwa (M2) and the Horopito (M4) have enough storage volume and catchment area to service 2000ha of irrigated pasture for a 9 year out of 10 security of supply (1:10).

After discussion with the MCWAC and further consideration of sites able to be filled with a diversion, the 15.2 km^2 Horopito (M4) and 5.7 km^2 Ben&Alan (M5) were re-evaluated. The Horopito scenario incorporated a diversion from the Rainy and the Ben&Alan was considered with a possible diversion from the Horopito. The final shortlisted options are summarised in section 8.

In the case of the diversion from the Rainy into the Horopito, the Rainy River was never allowed to drop below an estimated Q_{90} flow (the flow exceeded 90% of the time) except where it did so naturally. The results from this modelling are summarised in Table 8. This shows that for the Horopito (M4), a diversion would allow the dam height to be 5m less than without a diversion for 2000ha of irrigated land. For the Ben&Alan (M5) site a diversion makes the site feasible. Without a diversion the dam height would have to be 50-60m, whereas with a diversion the height could be 33m for 2000ha of irrigated land.

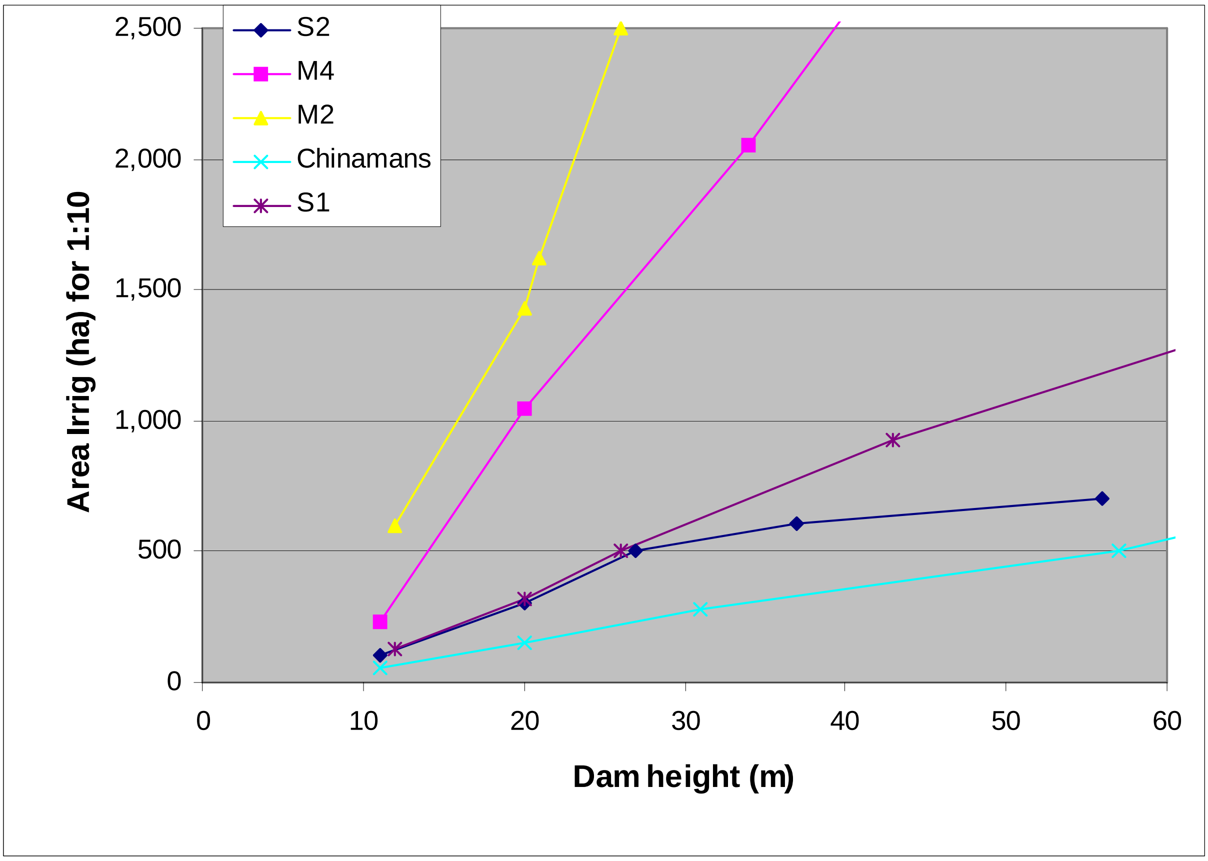

Figure 19: Summary of modelled scenarios. Dam height vs maximum irrigated area for a reservoir not fully filling 1 year out of 10.

Table 8: Dam heights and storage volumes required to irrigate 1000ha (first 2 columns) and 2000ha (last 2 columns) for the Horopito (M4) and Ben&Alan (M5) sites with and without additional diverted inflow. N.B. The Ben&Alan site without any diversion cannot provide enough water to feasibly irrigate 2000ha. Dam heights do not include any allowance for freeboard.

Reservoir	**Dam Height (1000ha)**	**Storage (1000ha)**	**Dam Height (2000ha)**	**Storage (2000ha)**
Horopito (M4)	20m	1.8M m^3	34m	4.9M m^3
M4 + diversion	18.5m	1.5M m^3	29m	3.8M m^3
Ben + Alan (M5)	19m	2.3M m^3	Unfeasibly high	>6.6M m^3
M5 + diversion	14m	1.6M m^3	33m	4.0M m^3

7. Qualitative Effects Assessment

7.1 RMA issues including residual flow needs

Resource consents will need to be obtained for construction works, damming and discharging water from the proposed reservoir. Dam construction on Moutere Gravel sites has been commonplace in Tasman District and consent processes are well established. Water planning issues relating to the Motueka Water Conservation Order and the Council's Tasman Resource Management Plan were discussed above in section 5.1.

7.2 Sedimentation and water quality

Sedimentation and water quality risks arise from two phases of a water augmentation project: the construction phase and the operational phase. Nelson construction firms are well versed in controlling sediment generation during construction of dams in Moutere Gravels, as evidenced by the recent completion of the Wai-iti Community Dam. Conditions would also be applied to resource consents for the project to control these risks.

A longer term sedimentation risk is deposition within the reservoir. As the Motupiko catchment is underlain by clay-bound Moutere Gravel, any reservoir site in a tributary catchment is likely to have a low sediment load. Most sediment transported from Moutere Gravel catchments is carried as suspended load during flood events well above the mean flow. A review of sediment yields across the Motueka catchment (Basher and Hicks, 2003) suggests a likely specific sediment yield in the range 5 t/km^2/yr based on a small native forest catchment at Big Bush to 170 t/km^2/yr based on yields from the mixed forest and pasture of the much larger Stanley Brook. These figures suggest that sedimentation potential for a Horopito dam would be of the order of 1300 to 46000 m^3 every ten years, and for Ben&Alan around 500 to 17000 m^3 every ten years. Given the land cover in both catchments, sedimentation is more likely to be at the low end of these ranges. When compared with water storage volumes in the millions of cubic metres, sedimentation rates appear relatively low.

Water quality may be different in flow releases from a dam than that of the original stream. Beneficial effects include improved water clarity because of sediment interception by the storage, reduced daily temperature fluctuations and reduced organic matter. If the reservoir becomes stratified, which may occur in its early life, the bottom waters may become anoxic and reduced dissolved oxygen levels may increase phosphorus, iron and manganese levels. This can be avoided with a multi-level discharge outlet from the reservoir, and is offset in any case by the likely higher than naturally occurring residual flow below the dam and the dilution with mainstem natural river flow.

The expansion of irrigation in the Motupiko and intensification of land use likely with irrigation are likely to have consequential water quality impacts in the Motupiko River because of increased nutrient and pathogen discharges via groundwater leaching and runoff. This could have effects in the Motueka below the Motupiko confluence, and highlights the importance of using irrigation water efficiently. Under current TRMP rules, these effects of intensification are unlikely to be a consideration in obtaining resource consents for the scheme.

7.3 Aquatic ecology

A qualitative study of present fishery values at shortlisted sites was carried out in conjunction with Neil Deans of Fish & Game in winter 2006, and using electric fishing found:

- South Branch Big Gully at Horopito (M4) - 11degC - bullies, trout, longfin eel, dwarf galaxias
- West Branch Big Gully at Dean Walker's (adjacent tributary) - longfin eel, bullies, juvenile trout
- Chinamans Gully - shortfin and longfin eels, koura, upland bully (no trout, no dwarf galaxias)
- Motupiko at Kikiwa (M2) - poor abundance - 11degC - longfin eel, yearling trout, upland bully.

Based on these observations and comments from DOC and Fish & Game staff during the two field visits, effects on aquatic ecology for tributary sites are not considered to be a major issue. Most native fish would be unaffected, although eel passage may need consideration. Trout passage is unlikely to be an issue and it is possible a population of trout could establish in the reservoir.

Creation of a reservoir will over time result in a shift from running water species to still water benthic species. As the Motupiko shortlisted sites are on tributaries which dry up in some summers, creation of a reservoir with even a small residual flow is likely to be beneficial overall. The reservoir will also provide habitat for aquatic birds.

7.4 Indigenous vegetation

Headwaters for both the Horopito and Ben&Alan sites comprise mixed native bush in conservation estate, and pine forest managed by Weyerhaeuser. At the Horopito site, mature pines are due for harvest within the next five years, while the Ben&Alan is being harvested now. Timing water augmentation with forest harvesting would make good financial sense.

7.5 Recreational effects

Creating a reservoir at any of the listed sites could bring recreational benefits from waterfowl hunting to fishing to boating, depending on access arrangements. Flow releases will increase summer flows in the Motupiko River with consequent enhanced fishery and swimming benefits.

7.6 Dam break hazard

Dam break has to be considered under the Resource Management Act as a low probability effect of high potential consequence. Because of the high potential consequence, the approach taken is to engineer the risk as completely as reasonably possible out of the dam through defensive design, construction, quality assurance, periodic reviews benchmarked against increasing industry knowledge of flood and earthquake risk, how dams perform, and ongoing monitoring. Dambreak considerations are taken into account in the new Dam Safety Act and the precautions depend on whether the dam is classed as High, Medium or Low Potential Impact. Resource consents will require the potential flood path from dambreak to be estimated.

Dambreak towards the peak of an extreme flood (e.g. through spillway inadequacy) may not add substantially to the physical damage downstream and in such a flood, those at risk are likely to be evacuated before the flood peak, thus reducing or eliminating the risk to life. If dambreak occurs from an extreme earthquake, there will normally be insufficient time for any downstream evacuation, it typically taking only half an hour or so for the dam to fail if it has a weakness. Earthquake (or sunny day) failure risk is therefore usually the more critical case adopted for analysis.

Dambreak development time and peak flow capacity is related to stored water depth and while analytical methods vary and the characteristics of the dam influence the result, there is some consistency in flood size estimates which can provide an indication of what might be expected for a theoretical dambreak of the likely size of dam which could be built to serve the Motupiko area. As the flood wave travels down the valley, it spreads out and reduces in size, but given the nature and gradient of the valley upstream of the confluence with the Motueka in relation to where the dam is likely to be located, not much flow reduction is expected in the Motupiko Valley, based on prior detailed studies.

At this stage of Motupiko study, dambreak considerations can only be broadly indicative and useful in appreciating the issues to be faced in more detailed studies. For the sizes of dam shortlisted, the likely depth of water storage for a sunny day dambreak is in the range 15 to 25m. Peak discharges could therefore be in the range 1000 to 1500 m^3/s. This compares with the estimated 100 year flood of around 400 m^3/s, just below the Rainy confluence.

Rough order estimates of the extent of flooding indicate that around 600 to 800m of the approximate 1000 m wide river flats would be flooded. Were this to occur, then there are likely to be low lying dwellings below the dams which would be in the flood path, albeit with a relatively modest flow depth. Also at risk would be any traffic on the Tophouse-Korere Road and on State Highway 6. Thus, while a full technical assessment of dambreak hazard and potential effects will be needed later once a preferred damsite is chosen, indications are that a dam for the Motupiko area is likely to be at least in the Medium Impact Category.

7.7 Iwi 'fatal flaws' assessment

The Motueka Iwi Resource Management Komiti (MIRMAK, now Tiakina Te Taiao) has been represented on MCWAC by Mick Park (Te Atiawa). As part of this project, MIRMAK was also contracted to provide an iwi perspective, at the level of a 'fatal flaws' analysis for shortlisted sites. The aim was to identify any barriers based on iwi values which might affect the prioritisation of shortlisted sites. If the water augmentation project proceeds to feasibility, design and consent stages, a more detailed Cultural Impact Assessment would be needed for the chosen site. The MIRMAK 'Fatal Flaws' report is attached as Appendix 1. No fatal flaws were found for the sites identified.

7.8 Potential for mitigating effects

The following mitigation measures could be considered (excluding land acquisition issues):
- provision of replacement forestry access road to upper Horopito or Ben and Alan gullies
- provision for public access and use of the reservoir area for recreation
- wetland plantings around the margins or headwaters of the proposed reservoir
- provision for a continuous residual flow and potential eel passage

7.9 Summary matrix of effects

Table 9 summarises qualitatively the major factors – apart from cost - affecting selection of sites for further investigation.

Table 9: Summary Matrix of Effects for Shortlisted Sites

Feature	M2 Kikiwa	M4 Horopito	S1 Rocky	S1a Chinaman	S2 Melville	Ben & Alan
Materials availability	Expect from near site	Expect on-site	Expect from near site	Expect on-site	Expect on-site	Expect on-site
Construction access	OK	OK	Track needed?	OK (river crossings)	OK	OK
Sedimentation potential	Low-moderate	Low	Moderate (landslide)	Low	Low	Low
Downstream hazard potential	Moderate	Moderate	Low	Low	Low	Low-moderate
Required design standard	Higher	Low	Low	Low	Low	Low
Cost of piped delivery	Highest (to lower valley)	Lowest (to lower valley)	Highest (Motupiko above Korere)	Mid-range (Motupiko above Korere)	Lowest (Rainy above Korere)	Lowest (to lower valley)
Land tenure (incl road reserve)	3 owners	3 owners	2 owners	1 owner	2 owners	2 owners
Potential electricity generation	Possible (near Kikiwa substation)	Maybe	Unlikely (too small)	Unlikely (too small)	Unlikely (too small)	Unlikely (too small)
Aquatic ecology impacts	Moderate (fish passage)	Low-moderate	?	Low (dries at times)	Low (dries at times)	Low (dries at times)
Water quality impacts from dam	Unlikely	Low	Low	Low	Low	Low
Regulatory constraints	WCO prevents damming mainstem Motupiko	Consents considered obtainable	Consents considered obtainable	Consents considered obtainable	Consents considered obtainable	Consents considered obtainable
Vegetation impacted at dam site	Pasture & some bush	Pasture & pines (near harvest size)	Pasture & some bush	Pasture & pockets of manuka	Scrub & some bush	Newly planted pines
Reservoir effects on current production values	Moderate (farming)	Low (forestry and some farmland)	Low (farming)	Low (farming)	Insignificant (scrub)	Low (forestry)
Cultural impact – low (negative impact) ratings in Fatal Flaw report	7	4	4	2	3	N/A
Ease of public access	Moderate	Good	Poor	Poor	Good	Good
Recreation potential	Moderate	Maybe	Poor	Poor	Poor	Maybe

8. Cost Estimates

8.1 Scope and basis for costings

The range of options adopted for indicative comparative costings is set out in Table 10:

Table 10: Sites and assumed irrigable areas for costing. The size of dam is the smallest possible to serve the assumed irrigated area with a 9:10 year surety of supply.

Site Name	Assumed Area Served (ha) (ha)	Infill Source	Required Storage Volume (MCM)	Dam Height (m)
Chinamans	200	Own catchment	0.5	28 (2)
Rocky (S1)	500	" "	1.2	31 (2)
Melville (S2)	500	" "	1.48	30 (2)
Horopito (M4)	500	" "	1.1	20 (2)
Horopito (M4)	1 000	" "	2.4	27 (2)
Kikiwa (M2)	2 500	" "	5.7	31 (2)
Horopito (M4)	500	" "	0.71	19 (3)
Horopito (M4)	1 000	" "	1.77	23 (3)
Horopito (M4)	1 350	" "	2.6	27 (3)
Ben&Alan (M5)	1 000	Own catchment plus diversion	1.62	16 (3)

(1) Initial selection based on Figures 6 and 7

(2) Height to achieve storage plus judgement based allowance for flood storage/passage plus freeboard above flood level, ranging 3 to 5 m depending on dam and flood peak size.

(3) Based on revised storage assessment including run of river usage (per section 6.7)

The approach to costing has been consistent to presume relativity and has drawn on the team's experience and cost database, which include involvement in earth dams in the region and Wai-iti dam in particular. A key assumption is that tight Moutere formation material can be keyed into at shallow depth to cut off leakage through surficial valley deposits. Various exposures in the banks of the Motupiko River indicate that this is a reasonable assumption. However, a contingency or uncertainty allowance of 20% has been included in costings.

Dam heights are based on the storage analyses summarised in section 6.7 with allowances for flood storage/freeboard and a small amount of dead storage, resulting in an additional 3 to 5m of height depending on catchment size and size of large floods.

It should be noted that indicative costings cannot be assigned particular accuracy, given the preliminary nature of the study and limited data able to be utilised. For example, there have been no geotechnical or subsurface investigations, and except for valley profiling at damsites (Ben/Alan site excluded due to late addition), the only topographical information used is from published maps at 20m contour interval, from which elevation versus storage volume relationships have been derived. However, a consistent approach has been adopted so that relativity between options is preserved with reasonable confidence.

Where relevant, comparable precedents have been drawn on for lump sum costing of certain structures; e.g. inlet/outlet pipework. After totalling the base costs for the dam, the following have been applied to derive the total indicative cost:

- Add 50% to base cost to cover contractor establishment, engineering costs and a contingency/uncertainty allowance of 20% on the base cost;
- Land acquisition at anticipated costs for farmland and forestry;
- 8% on the above costs as a likely allowance for construction financing.

These capital costs allow for arrangements to release from the dam into the river system but exclude operating and maintenance costs and the costs of extracting from the river and on-farm irrigation systems.

Dam construction items included in the base cost are:

- Dam footprint stripping
- Borrow area stripping
- Bulk dam fill
- Dam filters and riprap protection
- Dam internal drainage and monitoring
- Instrumentation
- Local access roading
- Exposed borrow and dam face topsoiling
- Stream diversion
- Spillways
- Irrigation release systems

To give an indication of the percentage costs for these construction items we have averaged our cost estimates for M4 Horopito and M5 Ben&Alan for a 1000ha irrigable area in Table 11 below. Note for comparative purposes the costs exclude the river diversion for M5.

Table 11: Cost Estimate Breakdown for Dam Construction

Description of works	% total of total cost
Bulk earthworks – fill	26
Bulk earthworks – stripping of dam footprint and borrow area	4
Dam filters and rip rap protection	14
Dam internal drainage, monitoring and instrumentation	2
Local access roads	2
Dam structures, spillway and release systems	11
Contingency/uncertainty, designers fees, contractors establishment	28
Land and financing	13

8.2 Initial Cost Estimates

Prior to carrying out our costing exercise a review was made of the dam heights and potential storage volumes to determine which of the dams would be most cost effective and those dams which were clearly less economic. These findings are discussed below.

The dam site at Chinaman's has a small yield potential (200 ha irrigable) and to achieve that potential, a high (28m) and expensive dam is required. Thus Chinaman's has been put to one side and not costed.

When Rocky and Melville are compared (and for 500 hectares which appears near the optimum size of development for each), Melville appears the better option because:

- There would be less embankment works and costs for Melville
- There would be less gravel carried into the reservoir due to the different catchment geology
- The location of Melville is closer to potential irrigable areas.

Thus Rocky also has not been costed, but if an appreciation of costs is required, it may be around 10% higher than the Melville cost, which as will be seen later, already appears unaffordable.

Table 12 gives the results of the costings for Melville, the two Horopito cases and Kikiwa with all irrigation demand met from dam releases, i.e. without any of the irrigation demand met from natural river flows The indicated costs for these three prompted extending costing to other Horopito cases, along with the refinement of storage volumes discussed in preceding sections and assuming use of available run-of-river flows.

Table 12: Initial indicative costings, with all irrigation demand met from dam releases

Site Name	Assumed area served (ha)	Cost including land and financing ($ million)	Comparative cost/ha ($/ha)
Melville S2	500	4.60M	9,200
Horopito M4	500	3.15M	6,300
Horopito M4	1 000	5.90M	5,900
Kikiwa M2	2 100	10.29M	4,900

8.3 Second Stage Costings

After the presentation of the initial costings to MCWAC it was decided to carry out a further review of Horopito site M4, and the Ben&Alan site M5. The extra analysis considered two further factors: the use of natural flows in the Motupiko before drawing on the storage reservoir; and the cost benefits of transferring water from another catchment into the proposed reservoirs.

Calculation of the amount of run-of-river flow able to be taken from the Motupiko before flow releases from the dam were needed used the relationship between the permanent river flow gauge at Christies and the flow at Quinneys (obtained from Martin Doyle at Tasman District Council). An extra rule was inserted into the combined models to say that where there was an irrigation demand, the water was extracted first from the river and additional demand then supplied from the reservoir.

The amount available for extraction from the river was determined as the flow above that needed to prevent the river at Quinneys Bush from drying up. TDC measurements have shown that when the Motupiko at Christies falls below 166 l/s the river below Quinney's Bush starts to dry up. Therefore any flow above 166 l/s at Christies was deemed "available" for irrigation. Note that this does not 'flat line' the Motupiko hydrograph as the majority of the time there was no irrigation demand and the river flowed well above 166 l/s. Overall the impact on dam sizes of using Motupiko natural flows was small, i.e. it only reduced the dam heights by a small amount. This was because the time of irrigation demand is normally when the Motupiko is flowing at low levels and there is little available natural flow.

For the Ben&Alan dam site to be workable, a transfer of water from either the Rainy or Big Gully is required. The cost of this transfer is an additional cost not required for Horopito.

It was anticipated that the cost effectiveness of Horopito could improve by transfer of inflow from the adjacent tributary (West Branch of Big Gully) and preliminary consideration was given to this case, using the revised hydrological/abstraction assumptions. The results showed only a small improvement in the 500-1000 hectare range, probably not offset by the cost of the transfer. Costing was not taken further for this possibility.

With the revised hydrological/abstraction assumptions, the dam heights and base costs reduced for the Horopito site (Table 13). For a dam height of 27m (including freeboard) at Horopito the area served increased from 1000 hectares to 1350 hectares. Table 12 gives the results for what appear to be the most promising options, using the revised storage analysis and extending costs to include land acquisition and construction financing.

Table 13: Second stage (final) costing

Site Name	Assumed area served (ha)	Cost including land and financing ($ million)	Comparative capital cost/ha ($/ha)
Horopito M4	500	3.15M	6,300
Horopito M4	1 000	4.8M	4,800
Horopito M4	1 350	6.17M	4,570
Ben/Alan M5	1 000	5.20M	5,200

8.4 Affordability

Affordability of water augmentation based on the capital costs for the two preferred sites given in Table 13 depends on returns likely from future irrigated land uses, the individual geography and financial situation for landowners joining the project, and funding arrangements. One of the main advantages of irrigation is that it increases production and minimises variability in year to year production caused by climate variability.

To decide whether to participate in a Motupiko water augmentation scheme, landowners in the Motupiko catchment will need to make a judgement based on factors such as:

- Their outlook for returns from potential irrigated land uses, the timeframe for that outlook, and in some cases their willingness to change their farming from dryland to irrigated production
- Effect of secure water availability on the capital value and versatility of their farms
- Pressures for regional irrigated production to move towards the upper Motueka catchment from coastal areas because of subdivision and increased property prices
- Increasing versatility for irrigated land uses as global warming over 50 years increases summer temperatures and reduces frost risk, potentially extending the growing season
- Their farm's financial situation, and assessment of risk associated with investing in irrigation
- The funding arrangements for the scheme, including the repayment period for the capital works, and the percentage contribution to scheme costs from community sources such as rates.

Table 13 indicates per hectare capital costs for the Motupiko Water Augmentation Scheme in the range $4570 to $6300 per hectare, with lower per hectare costs for larger scale options. *A preliminary economic analysis indicates that based on repaying the capital cost over a 20, 30 or 40 year period at 8% interest rate for a dam servicing 1000 ha the cost per hectare per year for the Horopito M4 would be $489, $426 and $403 respectively and for the Ben/Allen M5 option would be $530, $462 and $436. At a higher interest rate these costs would be higher.

Comparing these costs with other schemes suggests a similar level of affordability. Annual charges for the Wai-iti scheme recently commissioned are $280/ha/yr for existing water permit holders and $380/ha/yr for new users for a 30 year loan term. Charges for the Hunter Downs scheme in South Canterbury and the North Otago Irrigation Company are $660 and $720/ha/yr respectively. The Wai-iti scheme is similar to the Motupiko options in that water is released into the river for downstream abstraction, and operating costs will be low. However, landowners face the additional costs of on-farm capture and delivery of their share of the water.

Costs for a Motupiko scheme will be influenced by the ownership structure chosen for the scheme. Any scheme would be voluntary with landowners able to nominate the number of hectares of land for which they require irrigation water. The Wai-iti scheme operates on this basis and is funded through Tasman District Council, who recover the annual per hectare charge through a rate proportional to the weekly water allocation on their individual water permits. All users pay the same annual rate per hectare of irrigation, but new users also pay an upfront single capital contribution of $1,060/ha (amortised over 30 years, this equals the further $100/ha/yr mentioned above).

The main alternative ownership structures would be a private entity such as a cooperative company, incorporated society or partnership, or a public company with shareholders potentially from beyond the group of irrigators utilizing the scheme. Raising the capital required may be a barrier for a private entity, and more costly than funds raised through a Council loan. However, the option of an investor (e.g. a landowner of the damsite) providing some of the capital needed to initiate a scheme is worth considering.

Finally, an economic analysis of the affordability of the scheme for a variety of irrigated crops is beyond the scope of this pre-feasibility study. At this stage, Motupiko landowners should consider their individual circumstances to make a judgement on whether to express interest in taking the concept further. To assist this buy-in, MCWAC is considering supporting a detailed cost-benefit analysis.

9. Recommendations

This study has shortlisted and costed two preferred options for a run-of-river water augmentation scheme in the Motupiko. For a scheme to proceed, a preferred site needs to be chosen, the level of support (irrigable area) needs to be determined from potential water users, and a feasibility study carried out.

These steps will provide the information needed for detailed design, resource consent applications, amendments to TDC water allocation rules and implementation of whatever system of charges is decided.

From an engineering standpoint, scheme development could potentially involve two separate storages or Horopito alone could be designed to be increased in capacity in a second stage. Transfer from an adjacent catchment could also be part of Stage 2 of a two staged development for either the Horopito or Ben&Alan sites.

To refine costs for input to the cost/benefit and development strategy, the following are recommended:
- improved topographical data for reservoir storage volume/height accuracy
- more detailed hydrological modelling for the chosen site
- on-site geotechnical investigations, at least involving pitting and logging to map valley floor deposits and depths to Moutere clay foundation
- outline design of dams and associated components enabling more accurate sizing and costing, with cost versus height or area served curves for each site within the agreed irrigation area limits.
- detailed assessment of environmental effects, in particular to determine any residual flow requirements and factors affecting the design
- assessment of changes to water allocation rules for the Motupiko which would need to be notified for submissions in the TRMP
- if rating on the basis of water allocated to landowners is chosen as the charging mechanism, decisions on setting the rates level through Council's Annual Planning process.

10. Acknowledgements & Applicability

Thanks to members of the Motupiko Catchment Water Augmentation Committee chaired by Edwin Newport, and to MCWAC project manager Joseph Thomas for guidance and review comments on the report, and to John Grimston of Tonkin & Taylor for early input into selection of sites for storages.

This report has been prepared for the benefit of the Motupiko Catchment Water Augmentation Committee and Tasman District Council based on the brief of work given to Landcare Research, and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

11. References

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12. Appendix I: Fatal Flaw Analysis of the Motupiko Water Augmentation Scheme: A tangata whenua ki Motueka perspective

Appendix 1 has been compiled by Dean Walker on behalf of Tangata Whenua ki Motueka following a field trip in October 2006 to some of the five initially shortlisted sites and a hui held immediately following that field visit.

12.1 Introduction

This statement is that of Tangata Whenua Ki Motueka developed through the regional iwi resource management advisory service Tiakina te Taiao Ltd. Tangata whenua ki Motueka whakapapa to Te Äwhina Marae through Ngäti Rarua and Te Atiawa and have manawhenua status in the Motueka catchment. Ngäti Tama, Whakatü Incorporation and Ngäti Rarua Atiawa Trust also have an interest in the Motueka catchment.

This "fatal flaw analysis" has been developed in order to give the Motupiko Water Augmentation Committee an indication of the type and scale of issues that are of concern to tangata whenua in the development of a Motupiko Water Augmentation Scheme. In particular its purpose is to identify any cultural impact or impacts of the project that would preclude the construction or operation of the scheme as well as any possible mitigation measures. In the case of "fatal flaws", often the mitigation costs are extremely high, or amending the proposal is impractical.

This analysis is not meant to replace any cultural impact assessment of the proposed scheme or give any solutions to the concerns of tangata whenua. This report does not represent the support or otherwise of tangata whenua for the Motupiko Water Augmentation Scheme nor any of the dam sites. The nature of the process (being brief) means that some issues of concern to tangata whenua may not have been raised. It is, however, unlikely that any new issues that are raised through the cultural impact assessment process will be what could be considered to be "fatal flaws".

12.2 The Proposal

The Motupiko catchment in the upper reaches of the Motueka catchment has a relatively low rainfall. Low summer flows in the Motupiko and limited groundwater opportunities have served to restrict growth in irrigated agriculture. Currently there are only 13 water permits in the area, covering the irrigation of about 191 ha and subscribing to the allocation limit of 110 l/s in the Tasman District Council's water management plan. The Tasman District Council considers the current water resources of the Motupiko to be fully allocated and is not in the position of being able to permit further abstraction from the system.

Following discussions about the problem the Motupiko Water Augmentation Committee (MCWAC) was established to look at various opportunities for the augmentation and harvest of water. A study is currently underway which aims to enhance water availability for both current consumptive users and potential new users. The study also aims to enhance flows in the Motupiko River for potential environmental/community benefits downstream.

The Tasman Regional Water Study, completed in 2003, initially identified a total of about 7200 ha of land suitable for irrigated agriculture in the catchment. It mainly comprised the fertile alluvial flats. The catchment has a further 150 landowners (without water permits) who could potentially benefit if there was more water available. Further work by Landcare Research and MCWAC members reduced the feasible irrigable area down to 2,830 hectares. This figure has been reduced to 2000 hectares for practical reasons. Preliminary crop assessment showed that other crops apart from pasture could be irrigated in the Motupiko. These included potatoes, seasonal vegetables, other market gardening crops, berries, hops and possibly even cherries.

The initial study reported that the most feasible options for the harvest of water would be the construction of one or more small to medium sized dams. The dam(s) would be designed to harvest and store water during the wetter winter and spring months and release it during the drier months (typically summer and early autumn). The release of water would be directly into the river system. Under this design no pipes would be used save for those used by the farmers to draw water from the river or groundwater system.

To date five options for water storage dams have been shortlisted. Two sites are in the Rainy River part of the catchment. These are M4 (Horopito) and S2 (Melville). The other three sites are in the Motupiko proper. These are M2 (Motupiko), S1 (Rocky) and alternative S1 (Chinaman's). The letters *M* and *S* refer to medium and small respectively. It has been suggested at this stage that for the 2000 hectares described above to be fully irrigable (9 years out of 10) a medium AND a small dam would be required. Smaller schemes could operate on either one or two small dam options or staged dependent on demand. However due to economies of scale the one medium/one small option is probably the most cost effective.

12.3 The Process to Date

The Resource Management Act 1991 affirms guarantees set out in Te Tiriti o Waitangi particularly through the often quoted sections 6(e), 7(a) and 8. These are: S6 (e) *"The relationship of Maori and their culture and traditions and their ancestral lands, water, sites, waahi tapu, and other taonga",* S7 (a) *"Kaitiakitanga."* and S8 whereby local authorities must *"Take the principles of the Treaty of Waitangi into account."* The principles of the Treaty of Waitangi" were initially outlined in the Treaty of Waitangi Act, 1975.

In the past tangata whenua have often received notification of a development through the resource consent process. Often this was too late to incorporate the concerns of iwi into the development or avoid, remedy or mitigate these concerns. Unproductive outcomes such as iwi reluctantly giving their consent, iwi holding up the process due to consultation issues or iwi objecting to the proposal outright were not uncommon.

In this process tangata whenua were consulted early on in the process prior to the development of the proposal through the previous Motueka Iwi Resource Management Advisory Komiti (MIRMAK). An iwi representative was appointed to the MCWAC to relay progress to tangata whenua on the development of the proposal. He has attended a number of MCWAC meetings and reported back to MIRMAK. On 17 October 2006 MIRMAK members attended a site visit to the five shortlisted water storage sites with the MCWAC, the project manager and consultants' representatives.

This document has been developed from the site visit, examination of previous cultural impact assessments and discussions with tangata whenua. The Ngä Atua Kaitiaki model assisted in this analysis to identify potential cultural impact issues and from this any fatal flaws for the shortlisted sites (Figure 12.1 below).

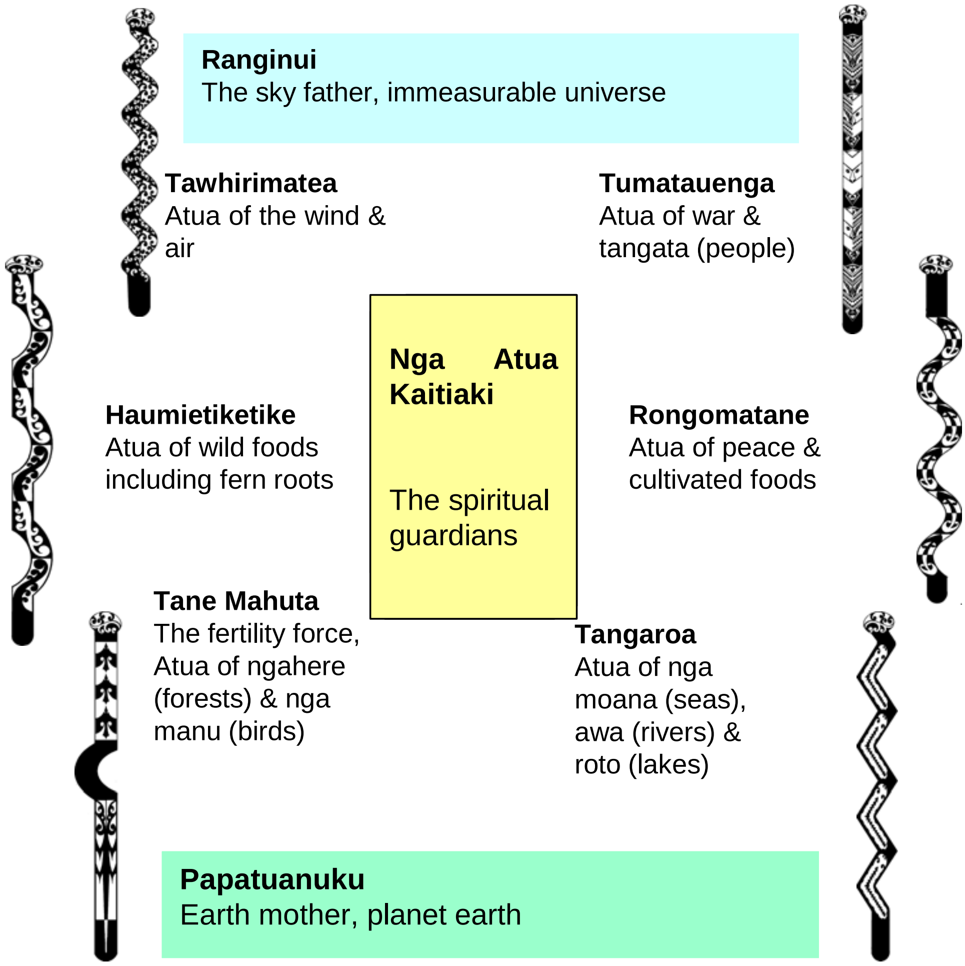

Figure 20: Nga Atua Kaitiaki model

The Ngä Atua Kaitiaki model illustrates the environmental domains of six key spiritual guardians within the embrace of Ranginui and Papatuanuku. In essence these Ngä Atua Kaitiaki were “consulted” through tangata whenua ki Motueka in order arrive at a holistic overview of the proposal and its potential effects. These atua are Tangaroa, Täne Mahuta, Tawhirimatea, Haumietiketike, Rongomatane, and Tumatauenga. Their kōrero (statements) are outlined in that order.

12.4 Ngä Kaitiaki Statements

The statements are a brief outline. They do not cover the issues of concern or benefit in detail or indeed even cover all of the issues. Neither do they present any solutions. These need to be dealt with through the cultural impact assessment process.

Tangaroa is the atua of the ocean, the freshwater that flows into it and wetlands. The concerns of Tangaroa include;

- The maintenance or enhancement of cultural and spiritual values of the Motupiko including mauri (life supporting capacity or productivity) and wairua (spiritual essence).
- Current and future abstractions of water. The scheme is designed to provide a secure supply for these abstractions.

- Reduction in the quality of water, particularly for downstream "users" including the environment. Over abstraction and intensification of landuse are both seen as factors contributing to deteriorating water quality.
- Improvement in water quality. Water augmentation is seen as a possible way of alleviating this problem, e.g. during low flows.
- Increased biosecurity risks through "normalising" the water flow. Flooding and droughts may be an inconvenience but they do serve to make river systems less hospitable to alien plants and animals.
- The retention of gravel and sediments in a storage reservoir may lead to erosion, impact on instream values and reduce the supply of the said material downstream for utilisation.
- The maintenance or enhancement of fish and eel populations including issues of fish passage.

Täne Mahuta is the atua of the forests, birds and other creatures. He is also the atua of fertility. The concerns of Täne include:

- The loss and/or reduction in native vegetation. This is both on site (i.e. under the area taken up by the dam and reservoir) and off site (on native remnants downstream on land that becomes irrigable).
- Opportunities for the restoration and management of native vegetation.
- Pressure on remnant wetlands downstream due to intensification of landuse.
- Opportunities to create wetlands associated with the dam.
- Potential reduction in birdlife and bird pathways associated with dam construction and operation.
- Potential opportunities for increasing bird numbers particularly waterfowl.

Tawhirimatea is the wind atua of wind, weather and climate. The concerns of Tawhirimatea include:

- Climate change and the effect that this may have on the predictions for water availability, modeling and contingency plans.
- CO_2 emissions from the construction and operation of the dam and New Zealand's commitment to the Kyoto protocol
- Intensification of landuse through increased irrigation and an associated increase in pesticides, herbicides and other airborne chemicals.

Rongomatane is the atua of peace and cultivated foods. The concerns of Rongo include:

- The loss or gain of commercial opportunities created by the development of the scheme.
- Landuses that use high volumes of water for low value use versus low volumes for high value (i.e. water demand and crop suitability).

Haumietiketike is the atua of wild foods. The concerns of Haumie include:

- The loss of opportunities to manage and harvest mahinga kai or wild foods.
- The gain in opportunities to manage and harvest mahinga kai or wild foods.

Tumatauenga is the atua of war and people. The concerns of Tumatauenga include:

- The recognition of the role of tangata whenua as kaitiaki and their ability to practice rangitiratanga, kaitiakitanga and manaakitanga.
- The protection of waahi tapu or sites of cultural significance.

- o The health of people, particularly those who swim, drink or harvest resources from in and around the river systems.
- o The equitable and fair allocation of water.

12.5 Analytical Matrix

For an initial assessment, the 5 sites were rated by those tangata whenua members that attended the site visit on 17 October 2006. Using the values under each of the Ngä Atua Kaitiaki as criteria each was given a rating as part of the screening process. These appear in the matrix below.

The initial screening of the five alternative sites was primarily qualitative and used three ratings, high, medium and low:

The "high" rating applied to those issues that potentially may produce positive effects, the "medium" rating applies to those issues that will probably produce little or no effect, and the "low" rating applies to those issues that are likely to produce negative effects (or the opportunities for mitigation are deemed to be low). From this the tangata whenua determined the prospect of "fatal flaws" in any of the proposed sites. Fatal flaws were defined as: severe constraints or combinations of constraints that from a tangata whenua perspective made a particular site not viable.

Table 14: Preliminary indicators of acceptability of different sites.

	M2 Motupiko	M4 Horopito	S1 Rocky	S1 Chinaman	S2 Melville
Tangaroa					
Mauri/ Wairua					
Water abstraction	High	High	Med/Low	Med/Low	Med/High
Water quality	Low	Low	Med	Med	Med
Biosecurity risk	Low	Low	Med	Med	Med
Gravel flow	Low	Low	-	Med	Med
Fish management					
Täne Mahuta					
Native vegetation/ wildlife loss	Low	Med	Low	-	Low
Native vegetation opportunities	Low	Med/High	Med	Low	High
Wetland opportunities	Med	High	Low	Med	Med/High
Wildlife opportunities	Med/High	Med/High	Low	Med	Med/High
Tawhirimatea					
Climate change	Med	Med	Med	Med	Med
CO2 emissions	Low	Low	Med	Med	Med
Intensification of landuse	Med	Med	Low	Low	Low
Rongomatane					
Commercial opportunities	High	High	Med	Med	Med/High
Water demand/crop suitability	High	High	Med/High	Med/High	Med/High
Haumietiketike					
Loss of mahinga kai	Low	Med	Med	Med	Low
Opportunities for mahinga kai	Med/High	Med/High	Med/High	Med/High	Med/High

Tumatauenga					
Kaitiakitanga, etc loss	Med	Med	Med	Med	Med
Kaitiakitanga, etc opportunity	Med/High	Med/High	Med/High	Med/High	Med/High
Wähi Tapu					
Public health and use					
Equitable allocation of water					

NB: This table is indicative only. Its purpose is to highlight concerns and benefits of the proposal Motupiko Water Augmentation Scheme as well as possible opportunities for enhancement or mitigation. The table does not represent tangata whenua preference for any site or indeed support for the scheme.

Parts of the matrix have been left blank for various reasons. In terms of the mauri/ wairua it was felt to be inappropriate to grade these things (at least at this stage). Other blanks indicate a lack of information or the rating was dependent on the degree of mitigation, or it simply did not make sense. In terms of *wähi tapu* the feeling was to rate all of the sites *low* based on general information about the site. As yet this has not been done as more specific lines of inquiry have not yet produced the information to make this call or refute it. This line of inquiry is ongoing. In terms of *water allocation* tangata whenua do not have information relating to this. There is an assumption however, that the allocation will be fair and that sufficient water left in the system for the benefit of aquatic flora and fauna, and recreational users i.e. that minimum flows will be generous and socially and scientifically based.

In conclusion no “fatal flaws” have been identified from the perspective of tangata whenua ki Motueka for all or any of the shortlisted dam sites. It is unlikely that any new “fatal flaws” will come to light in the future. The support or otherwise of this Motupiko Water Augmentation Scheme has not been secured through this process. This will emerge through the development of a cultural impact assessment of the preferred scheme.

13. Appendix II: Community Consultation

13.1 Motupiko Catchment Water Augmentation Committee

This study has been guided by the Motupiko Catchment Water Augmentation Committee who met six times, attended three field visits - in two cases with a wider group of farmers from the valley – and two public meetings to discuss the findings.

The MCWAC comprises Edwin Newport (chairman), Evan Baigent, Tom Carson, Mick Park (Te Atiawa), Neil Deans (Fish & Game), Cr Stuart Bryant (TDC), Cr Richard Kempthorne (TDC), Murray Earwaker, John Hyatt, Julian Raine, Martin Rutledge/Rudi Tetteroo (DOC), Mark Freeman and project manager Joseph Thomas.

13.2 Community meetings 2007

Preliminary results of the project including the final costings were presented to a public meeting at Tapawera on 22 February 2007 by Andrew Fenemor, Mark Dawson and Tim Davie. The meeting was attended by about 30 people. Landowners in attendance were supportive of the work done and had a wait-and-see attitude on the costings. The MCWAC noted there was no negativity towards the proposal nor extreme support. Among the queries were effects on gravel movement below a dam, recreational opportunities on a reservoir, affordability, and potential changes of land use to use the water. There was support for a cost-benefit study to be carried out pending decisions on completion of a full feasibility study for a preferred site. A second community meeting was held at Tapawera on 5 July 2007 to present the final results of this study. Results were also presented to the Environment and Planning Committee of Tasman District Council and to Tiakina te Taiao Ltd.

13.3 Landowner survey

On 23 April 2007, TDC sent a Motupiko Catchment Landowner Survey to 216 property owners in the catchment to gauge support for 1000ha of irrigation from the shortlisted Horopito and Ben&Alan options. There were 31 survey forms returned. TDC's analysis of survey responses is reproduced below.

Motupiko Landowners Final Report

Executive Summary
The Motupiko Catchment Water Augmentation Committee (MCWAC) received a total of 31 responses to its landowner survey. This represented a response rate of 14%. Council works on obtaining a minimum 3% response rate for its surveys and public consultations. Because the survey base was relatively small, responses made by at least 6% of landowners have been included in the survey results.

From the responses it appears the majority (46%) of people think water augmentation is required. The age distribution of this answer was

Age	%
Under 30	12.5%
31-50	31%
51-70	50%
71+	6.25%

22.5% said no, the age distribution of this answer was

Age	%
50-70	71%
71+	28%

16% didn't know. The age distribution of this answer was

Age	%
31-50	33.3%
51-70	50%
71+	16%

And 15.5% didn't answer for various reasons.

The main issues raised in the survey included:

- 32% of respondents said that there was currently no water available for allocation and there was need to increase the amount of water available for irrigation. Of these the age distribution was

Age	%
Under 30	12.5%
31-50	12.5%
51-70	75%

- 13% of respondents said water augmentation would make better use of the water. Of these the age distribution was

Age	%
31-50	50%
51-70	25%
71+	25%

- 6% said water augmentation would provide the ability to carry more stock. Of these the age distribution was

Age	%
Under 30	50%
31-50	50%

- 30% of respondents thought the cost would be too high. Of these the age distribution was

Age	%
50-70	75%
71+	25%

- 16% thought they were too far from the proposed scheme to take part. Of these the age distribution was

Age	%
31-50	40%
51-70	60%

- 32% preferred Horopito. Of these the age distribution was

Age	%
Under 30	22%
31-50	22%
51-70	50%

- 32% said they would support a broad assessment of the cost and potential benefits. Of these the age distribution was

Age	%
Under 30	18%
31-50	28%
50-70	55%

- 45% indicated that they did not want to be part of a water augmentation scheme. Of these the age distribution was

Age	%
Under 30	8%
31-50	15%
51-70	77%

Questions in the survey solicited both qualitative and quantitative responses. The quantitative responses are recorded by the number of yes, no, or don't know responses. The qualitative responses record the number of people who raised a particular issue.

This report has captured the priority outcomes under each of the questions asked in the survey.

Background
The Motupiko Catchment Water Augmentation Committee undertook a survey of residents in various parts of the catchment including the Rainy, Upper Motupiko, Lower Motupiko and Korere to gauge support for a community dam on the Motupiko River

The Motupiko River and its tributaries are the water sources that recharge the aquifers in the catchment that in turn supply irrigation water to landowners. At present the water in the Motupiko catchment is fully allocated.

Two dam sites have been shortlisted for further investigation. One at Horopito and one in the Alan and Ben gullies.

Landowners in the area were surveyed to gauge support for a community dam that would allow for a further 1000 hectares of land to be irrigated.

Objectives
- To conduct a questionnaire survey of landowners in the Motupiko catchment
- Determine the level of support for a water storage (dam) option among landowners in the catchment
- Provide a report on the findings and report back to the Motupiko Catchment Water Augmentation Committee.

Methodology

The Motupiko Catchment Water Augmentation Committee prepared a questionnaire titled 'Motupiko Catchment Landowner Survey' that was posted to 216 property owners in the Motupiko catchment. The survey questionnaire sought both qualitative and quantitative responses. There were a total of 10 questions as follows:

1. Do you think water augmentation is required in the Motupiko catchment?

Yes	No	Don't know

1a. Can you give some reasons why or why not?

2. Would you want to be part of a scheme that would provide more water to the Motupiko area? Please note that any indication of support at this stage is not going to be taken as an absolute commitment, but will help the Committee measure the level of support for augmentation.

Yes	No	Don't know

2a. Please give reasons why or why not

3. Two sites have been shortlisted for water storage – one at Horopito and one at Alan and Ben gullies. Please give reasons why you may prefer one site over the other

4. Would you support a cost/benefit analysis on storage options for this catchment?

Yes	No	Don't know

5. How many hectares would you potentially want to irrigate if you took part in a water augmentation scheme?
5a. Short term ha (next 5 years)?
5b. Longer term ha?

6. Which part of the catchment are you in?

Rainy	Upper Motupiko	Korere	Lower Motupiko

7. Would you use water for any purpose other than irrigation and if so, what equivalent area?

8. Is there anything else you would like to raise regarding water augmentation in Motupiko?

Would you please tell as a little about yourself:

Male	Female

Age bracket:

0-30 years	31-50 years	51-70 years	71+ years

The survey aimed to gauge the level of support for the water storage option (dam) among landowners. It also sought qualitative responses to get a picture of what people believe the issues regarding water shortages and water storage.

A total of 32 responses were received from landowners, which equates to a 14% response rate. Council works on a minimum 3% response rate for its consultations. As this was a targeted survey that went out to only 216 people, only issues raised by 6% or more people have been included in the outcome statements.

Timeframe

The surveys were posted to households in the Motupiko catchment around the 23 April 2007. Respondents were asked to return the questionnaires by 4 May 2007.

How the survey described the scheme

Residents in the Motupiko Catchment have experienced water shortages in the summer for many years. This is because there is not enough water in the rivers and underground aquifers to cope with the demand for irrigation, drinking water supplies, and other supply needs.

The Motupiko River and its tributaries are the water sources that recharge the aquifers that in turn supply irrigation water to landowners in the catchment. At present the water in the Motupiko catchment is fully allocated.

Landowners in the area led an augmentation study that began in 2005. The study has defined irrigation needs and has identified the extent of irrigable land in the Motupiko catchment. Over the past two years the committee has looked at a range of possible dam sites with the aim of establishing a community water augmentation scheme to meet both current and future demand.

Two dam sites have been shortlisted for further investigation. One at Horopito and one in the Alan and Ben gullies. The preliminary costs are based on a minimum of 1000 hectares of irrigable land, which is considered an economic size for a community dam. The capital cost for the Horopito site is estimated at $4,800 per hectare and for Alan and Ben gullies it would be $5,200 per hectare. This would be a one-off capital investment. If the funds were to be borrowed over a 20-year period, the cost to landowners would be around $500 per hectare per year for the period of the loan.

Site	**Capital Cost per hectare**	**Annual cost per hectare over 20 years**
Horopito	$4,800	$500 (minimum 1000 hectares
Alan and Ben Gullies	$5,200	$500 (minimum 1000 hectares)

Fish and Game, the Department of Conservation and Iwi have reviewed of the sites. No fatal flaws were identified by these groups.

The community dam proposal would be a 'run of the river' store in the winter and release in the summer scheme, which would enhance the minimum flow of the river in summer. Water could then be pumped from the river or from wells by landowners. The store and release option also has ecological benefits in terms of enhancing the natural river flows in dry seasons.

The committee sought feedback on the proposed solution to water shortages. The following responses give a picture of the priorities and concerns raised by landowners in the Motupiko Catchment.

Outcomes from the Motupiko Catchment landowner survey

We received 31 survey forms back, but not all respondents answered all the questions. The response totals do not always add up to 31.

1. Do you think water augmentation is required in the Motupiko Catchment?

From the responses it appears the majority (46%) of people think water augmentation is required. The age distribution of this answer was

Age	%
Under 30	12.5%
31-35	31%
50-70	50%
71+	6.25%

22.5% said no, with an age distribution of

Age	%
50-70	71%
71+	28%

16% didn't know
with an age distribution of

Age	%
31-35	33.3%
50-70	50%
71+	16%

and 15.5% didn't answer for various reasons.

1a. Why or why not?

22% of respondents said water augmentation was needed because there was no water available for allocation to farmers for irrigation.

Age	%
Under 30	16.5%
31-50	16.5%
51-70	67%

13% said water augmentation would keep maintain the flow in the river year round and would make better use of the water

Age	%
31-50	31%
50-70	50%
71+	25%

10% said augmentation would boost low river flows in summer and recharge the aquifer

6% said it was uneconomic for sheep and beef farming

Age	%
50-70	100%

6% said augmentation would provide ongoing local benefits

Age	%
31-50	100%

2. *Would you want to be part of a scheme that would provide more water to the Motupiko area?*

45% said no.

Age	%
0-30	8%
31-50	15%
51-70	77%

23% said yes

Age	%
0-30	15%
31-50	30%
50-70	65%

30% were unsure

Age	%
50-70	75%
71+	25%

2a. Why or why not?

30% thought the cost would be too high

Age	%
50-70	75%
71+	25%

16% said they were too far from the proposed sites

Age	%
31-50	40%
50-70	60%

6% said they already have a flooding problem

Age	%
50-70	100%

6% said irrigation would allow them to carry more stock

Age	%
0-30	100%

6% said they have suitable land for irrigation

Age	%
31-50	100%

3. *Preferred site – Horopito or Alan & Ben?*

32% of respondents preferred the Horopito site because it was the cheaper option, better catchment, more farms could be involved

Age	%
Under 30	22%
31-50	22%
51-70	56%

9% had no preference

4. *Would you support a broad assessment of the cost and potential benefit of storage options for this catchment?*

32% said yes

Age	%
Under 30	18%
31-50	28%
51-70	54%
71+	6.25%

26% said no

Age	%
31-50	11%
51-70	78%
71+	11%

10% were unsure

Age	%
31-50	25%
51-70	50%
71+	25%

5. *How may hectares would you potentially want to irrigate if you took part in a water augmentation scheme?*

In the short term: 10% said between 2-2.5 hectares

Age	%
Under 30	50%
51-70	50%

6% said 30 hectares

Age	%
31-50	100%

In the long term: 10% said 20 hectares

Age	%
31-50	33%
51-70	66%

6% said up to 100 hectares

Age	%
31-50	100%

6. Which part of the catchment were respondents from?

Rainy 6%

Age	%
31-50	100%

Upper Motupiko 16%

Age	%
31-50	15%
51-70	85%

Korere 26%

Age	%
31-50	12.5%
51-70	62.5%
71+	25%

Lower Motupiko 23%

Age	%
Under 30	12.5%
31-50	12.5%
51-70	62.5%
71+	12.5%

Not stated 29%

Age	%
Under 30	25%
31-50	50%
51-70	25%
71+	6.25%

7. Would you use water for any purpose other than irrigation and if so what equivalent area?

No – irrigation only – 19%

Age	%
Under 30	33%
31-50	33%
51-70	33%

8. Is there anything else you would like to raise regarding water augmentation for Motupiko?

- One may only want to irrigate 20ha out of 100ha in one year according to crop rotations. But to commit to 100ha may be too expensive.
- Don't support it – live within your own sustainable means
- Any scheme would have to be voluntary
- Current permit holders should contribute
- Because other water augmentation projects have gone over budgets, don't think this one would be cost-effective either
- Not viable in this valley
- Would not want to pay towards a scheme we would not benefit from
- What would happen to the dams in the event of a flood?
- What can b e produced in this area?
- While in native forest catchment didn't dry up

- Could assist with control of autumn/winter flooding
- Believe cost is very much at top end of scale for grass growth
- Smaller turkey next or any potentially lower cost options should be fully explored
- Should be combined with gravel extraction right through the Motupiko which would also resists river flows
- Augmentation would benefit the wider community not just farming. Capital costs should be shared by all who would benefit including recreational users
- Would like committee to look at cost benefit analysis of small on-site dams

Respondents who stated they were not in the catchment – 19%

Male	61%
Female	13%
Not stated	26%

Age groups

31-50	23%
51-70	45%
71+	23%

The way forward

While 43% of respondents thought water augmentation was required in the Motupiko Catchment only 23% said they wanted to be part of an augmentation scheme. This suggests that people think it will be too costly or they are not in the right part of the catchment to take advantage of the proposed scheme (from either site).

Horopito is clearly the preferred site – only one respondent preferred Alan and Ben Gullies.