AQUALINC RESEARCH LIMITED

Manuherikia Catchment Study: Stage 3a (High Level Options)

Prepared for the Manuherikia Catchment Water Strategy Group

Report C12040/3

June 2012

AQUALINC RESEARCH LIMITED

Disclaimer:

This report has been prepared solely for the benefit of the Manuherikia Catchment Water Strategy Group (MCWSG). No liability is accepted by Aqualinc Research Ltd or any employee or sub-consultant of this Company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to other persons for an application for permission or approval or to fulfil a legal requirement.

Quality Control			
Client:	Manuherikia Catchment Water Strategy Group		
Report reference:	Title: Manuherikia Catchment Study: Stage 3a (High Level Options)		No: 3
Prepared by:	Peter Brown		
Reviewed by:	Ian McIndoe	Approved for issue by:	Ian McIndoe
Date issued:	June 2012	Project No:	C12040

Document History			
Version: 1	Status: Draft	Author: PB	Reviewer: IM
Date: 26-04-12	Doc ID: Manuherikia Stage 3a draft	Typist:	Approver: IM
Version: 22-06-12	Status: FINAL	Author: PB	Reviewer: IM
Date:	Doc ID: Manuherikia Stage 3a FINAL	Typist:	Approver: IM
Version: 25-10-12	Status: FINAL (minor corrections)	Author: PB	Reviewer: IM
Date:	Doc ID: Manuherikia Stage 3a FINAL	Typist:	Approver: IM

www.aqualinc.com

CHRISTCHURCH PO Box 20-462, Bishopdale 8543, Christchurch ♦ Phone: (03) 964 6521 ♦ Fax: (03) 964 6520

HAMILTON PO Box 14-041, Enderley 3252, Hamilton ♦ Phone: (07) 858 4851 ♦

TABLE OF CONTENTS

Page

List of Tables:

List of Figures:

EXECUTIVE SUMMARY

The Manuherikia River system in Central Otago is a unique catchment in terms of climate, topography and water management history. The community's long-term goal is to realise the potential growth within the region. It is generally believed that the growth potential is constrained by water availability for irrigation.

In our Stage A (ii) study we concluded the catchment was water short and there was no more in-catchment water available on a run of river basis. Consequently, any expansion of the area of irrigation will require the construction of storage dams to harvest winter and spring water, efficiency improvements below Ophir and/or the use of Clutha River water.

In March 2012 two workshops were held, with the community asked to contribute ideas on development options for closing the gap between the irrigation demand and the water supply. We undertook a high level assessment of the 10 most popular options identified at these workshops. Of these 10 options, we recommend 5 options progress to Stage B pre-feasibility investigations. We suggest it is optional whether or not a sixth less promising option (Mt Ida dam) progress to Stage B investigations.

Option	Rank[1]	Progress to Stage B?
Raise Falls Dam	1	Yes
Hope Creek dam (lower site)	2	Yes
Improve Manuherikia Irrigation Scheme efficiency	3	Yes
Lake Dunstan gravity piped supply	4	Yes
Dam supply to Galloway	5	Yes
Mt Ida dam	6	Optional
Lake Dunstan pumped pipe supply as far as Tiger Hill	7	Already assessed
Winter fill on-farm storage	8	No
Hope Creek dam (upper site)	9	No
Dams on Dunstan Creek	10	No
(1) How promising is the option in contributing towards a catchment wide water solution? 1 = Best option. 10 = Worst option.		

High level assessment results are summarised below.

Option	Regional economic benefit	Cost risk	Uptake risk	Geological risk	Environmental risk
Raise Falls Dam 6m	Medium	Medium	Low	Low to medium	Low
Raise Falls Dam 27m	Very high	Medium	Medium	Low to medium	Low to medium
Hope Creek dam (lower site)	High	Low	Low	Low to medium	Low
Improve Manuherikia Irr. distribution efficiency	Medium	Low	Low	Low	Low
Lake Dunstan gravity piped supply	Medium	Medium to high	Medium	Low	Low
Dam supply to Galloway	Low to medium	Medium to high	Medium	Low to medium	Low
Mt Ida dam	High	High	Medium	Medium to high	Low
Lake Dunstan pumped pipe supply as far as Tiger Hill	High to very high	High to very high	High	Low	Low
Winter fill on-farm storage	Low	Very high	Low	Low	Low
Hope Creek dam (upper site)	Medium	Very high	High	Medium	Low
Dunstan Creek dam (upper site)	High	High to very high	High	Medium to high	High
Dunstan Creek dam (lower site)	High	High to very high	High	High	High

The Dairy Creek proposal was not assessed because this proposal does not impact on other options, the proposal is well advanced and is likely to proceed on its own merits, and technical reports are not in the public domain. Furthermore this option is outside of the Manuherikia catchment and therefore will not have an environmental impact on the Manuherikia River.

1 Background

The Manuherikia River system in Central Otago is a unique catchment in terms of climate, topography and water management history. The community's long-term goal is to realise the potential growth within the region. The potential growth in the catchment is closely linked to water. It is generally believed that the growth potential is constrained by water availability for irrigation.

The Manuherikia Catchment Water Strategy Group (MCWSG) was set up to develop and oversee the implementation of a water strategy for the catchment. The MCWSG has proposed that a project be undertaken in three sections to:

- Define the potential irrigation demand in the Manuherikia River catchment (land);
- Provide an initial assessment of the water availability for meeting this demand (hydrology); and
- Options to close the gap between supply and demand (options).

The project has been broken into two parts, Part A (Sections (i), (ii) and (iii a)) and Part B (Section (iii b)). Part A provides the initial big-picture information to understand the overall water resources in the catchment. Part B looks in more detail at specific options to progress water resources development. The MCWSG envisages that the project will provide information to help the community make informed decisions, leading to a comprehensive Manuherikia catchment water strategy.

Aqualinc has been contracted to complete Part A of the project. This report summarises the findings for Part A (iii) - a high level assessment of development options.

2 General methodology

This study (Part A (iii)), includes a high level engineering and environmental assessment of the main ideas put forward by the community during two workshops held in March 2012. The purpose of these assessments was to identify options that were worthwhile to investigate in more detail as part of the Stage B series of pre-feasibility studies. This high level approach is a 'brainstorming' process, focusing on the big picture but not on details.

The high level nature of this study means price estimates, environmental assessments, and geological risk assessments are indicative only and should not be relied on for community consultation, resource consent applications, or investment decisions. Future pre-feasibility studies will give greater certainty in these areas.

This report should be read in conjunction with the Part A (i) (Aqualinc 2012a) and Part A (ii) (Aqualinc 2012b) reports.

3 Assessment criteria

We assessed options against the following five criteria:
1. Regional economic benefit
2. Cost risk
3. Uptake risk
4. Geological risk
5. Environmental risk

The regional economic benefits are the expected regional increase in GDP as a result of development. We expect regional benefits will be closely linked to the new water made available for irrigation. Economic benefits on a per cubic metre basis are expected to be higher in the Ida Valley than the Manuherikia Valley, because the area is much more water short. For comparison with Table 1 classes, current water use is about 60 Mm^3/y in the Manuherikia Valley, and 25 Mm^3/y in Ida Valley.

Table 1: Regional economic benefit criteria

Regional economic benefit	New water available for irrigation (Mm^3/y)	
	Manuherikia Valley	Ida Valley
Low	0-5	0-3
Medium	6-20	4-12
High	21-50	13-30
Very high	>50	>30

The cost risk is the risk development does not proceed because the per hectare cost of new irrigation, or of improved reliability, is too high. We expect farmers in Ida Valley will be willing to pay more for water because of the water scarcity. This view is supported by the observation some farmers in the Ida Valley have spent the equivalent of over $15,000/ha for full irrigation, to construct large on-farm dams that are primarily filled in the winter. This practice is less common in the Manuherikia Valley.

Table 2: Cost risk criteria

Cost risk	Cost per hectare of irrigation[1]	
	Manuherikia Valley	Ida Valley
Low	<$2,500	<$4,000
Medium	$2,500 - $5,000	$4,000 - $7,000
High	$5,000 - $10,000	$7,000 - $14,000
Very high	>$10,000	>$14,000
(1) Capital cost of supplying unpressured water to the farm boundary sufficient for full irrigation. Excludes on-farm development costs and any land purchase costs. Any scheme pumping was converted to a Present Value and added to the capital cost.		

The uptake risk is the risk development does not proceed, because not enough farmers sign up to a proposal to allow it to get off the ground. The uptake risk depends on the per hectare cost, the size of the development, the percentage of the command area that needs to be irrigated for development to be viable, the location, and the ability to stage development. We subjectively assigned options an uptake risk level from low to high based on our general experience of irrigation development in other areas.

The geological risk is the risk development does not proceed because of geological difficulties. Geological risks are principally associated with dam sites. We subjectively assigned options a geological risk level from low to high. Our assessment only involved a review of geological maps. We have not undertaken any site visits.

The environmental risk is the risk development does not proceed because potential environmental impacts are deemed to be unacceptable to the community. We subjectively assigned options an environmental risk level from low to high. Our assessment was based on our general experience of environmental issues from irrigation development in other areas, and from discussions with Fish and Game.

Future studies should also consider the cultural risk – that is the risk of development not proceeding due to cultural concerns. We have not attempted to assess cultural risk in this study, since time constraints meant we were unable to undertake the necessary consultation.

Other development risks include land owner and water right issues. These issues are best dealt with at a community level and do not require the input of outside consultants.

Our assessment criteria are somewhat subjective. This subjective approach is appropriate for deciding which options should proceed to more detailed Stage B pre-feasibility investigations, but should not be used for community consultation, consent applications or for making investment decisions. It was not possible to undertake a more in-depth quantitative assessment, for the several options considered, within the Stage 3a scope and timeframe.

4 Dams

The Stage A (ii) study concluded there was no new run of river water available in the Manuherikia Catchment, and the majority of any new in-catchment water for irrigation would need to come from the construction of dams that could capture winter and spring flows.

We evaluated 10 natural dam sites:

- Raise Falls Dam 6 to 27 m;
- Dam on Dunstan Creek (upper and lower site);
- Hope Creek dam (upper and lower site);
- Lower Manor Burn dam (alternative to existing dam);
- Little Valley Creek West Branch dam;
- Speargrass Creek dam;
- Mt Ida dam; and
- On-farm storage (not location specific)

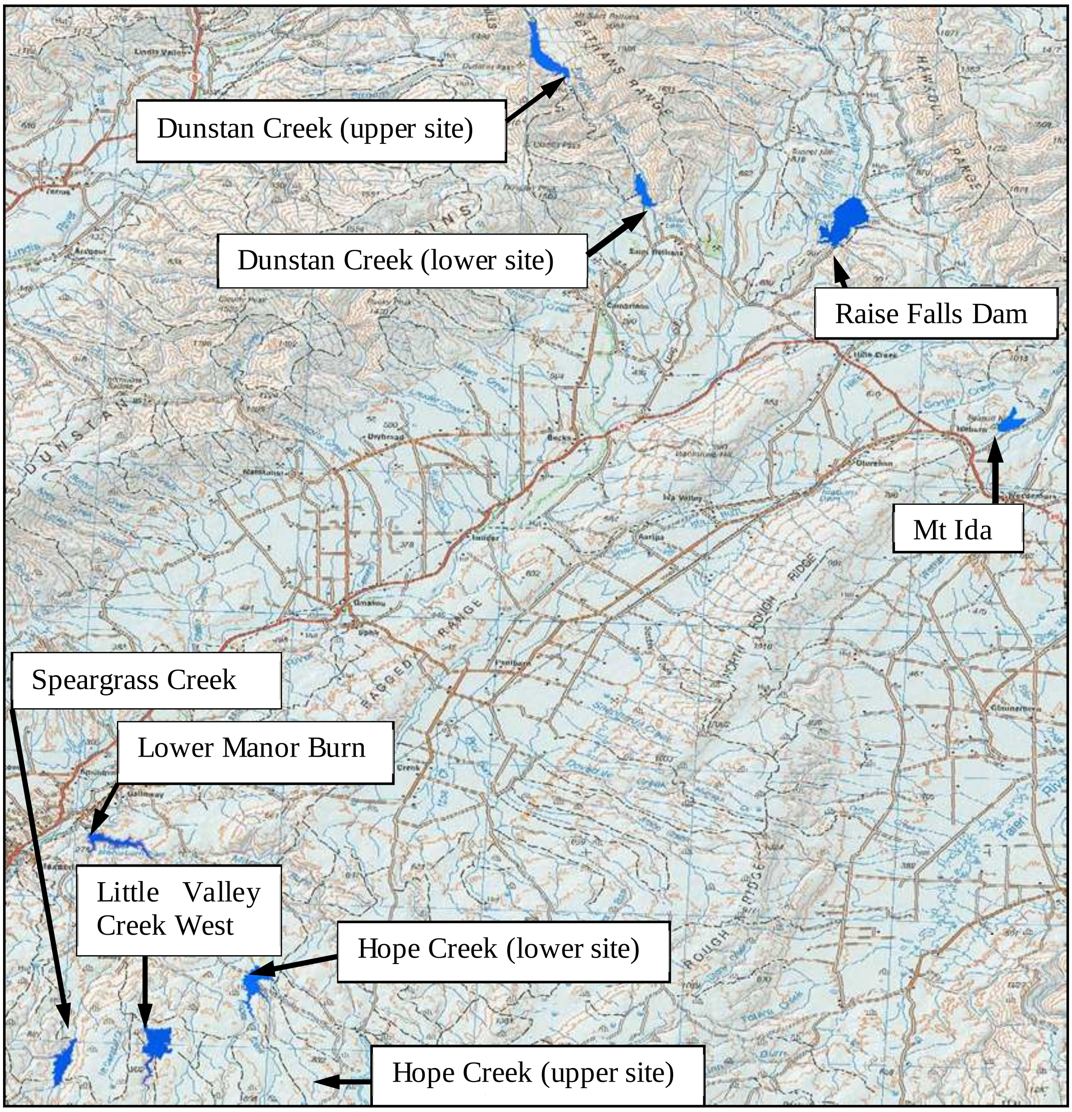

Figure 1: Possible dam sites

4.1 Raise Falls Dam

4.1.1 Overview

The Falls Dam site is probably the best dam site in the Manuherikia Catchment, with good inflows, a small valley opening to a wide basin, a strategic location for the downstream supply of irrigation, and favourable geology. The existing Falls Dam utilizes only a fraction of the potential storage capacity at the site. The idea of raising Falls Dam predates the construction of the dam (Ellis 2009). However, when the dam was actually constructed in the early 1930's, the economics and irrigation requirements of the day meant the dam was only built to its current height of 33.5 m.

It appears likely that Falls Dam will be raised, given that upgrades to the dam spillway are necessary anyway to comply with current dam legislation. The main decision that needs to be made is how much to raise the dam. We recommend the option of raising the dam somewhere from 6 to 27 m should be considered in a future pre-feasibility study.

4.1.2 Hydrology

In the Stage A (ii) study we estimated annual usable storage from Falls Dam in a dry year was between 10 Mm^3/y [given the existing dam height] up to 100 Mm^3/y [given a maximum lake level of 587 m amsl]. The dam's maximum usable storage is limited by inflows in a dry year, which are about 100 Mm^3/y. Given the existing dam has an annual usable storage of 10 Mm^3/y, raising the dam could potentially create an additional 90 Mm^3/y of usable storage.

Future studies should undertake storage and demand modelling at a daily time-step to refine the hydrological understanding of the system. This model should be used for the design of an environmental flow regime downstream of the dam, to more accurately calculate the potential irrigable area, and for assessing the impact on power generation.

4.1.3 Dam site

The topography of the dam site and reservoir are illustrated in Figure 2, Figure 3 and Figure 4. Figure 5 illustrates the favourable geology. The dam abutments and base are greywacke. There are no known faults (active or inactive) in the near vicinity of the dam. The reservoir walls are generally not steep and are predominately conglomerate, siltstone, and alluvial gravel deposits. The risk of dam leakage or instability, or of large landslides collapsing into the reservoir, is expected to be low.

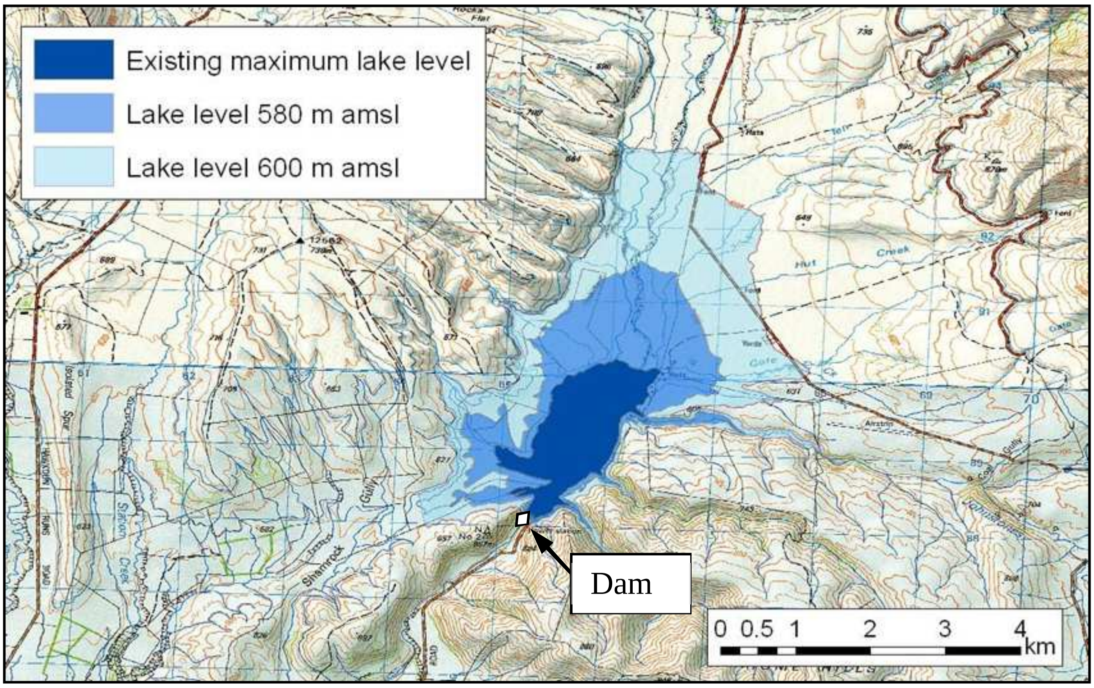

Figure 2: Falls Dam - topography

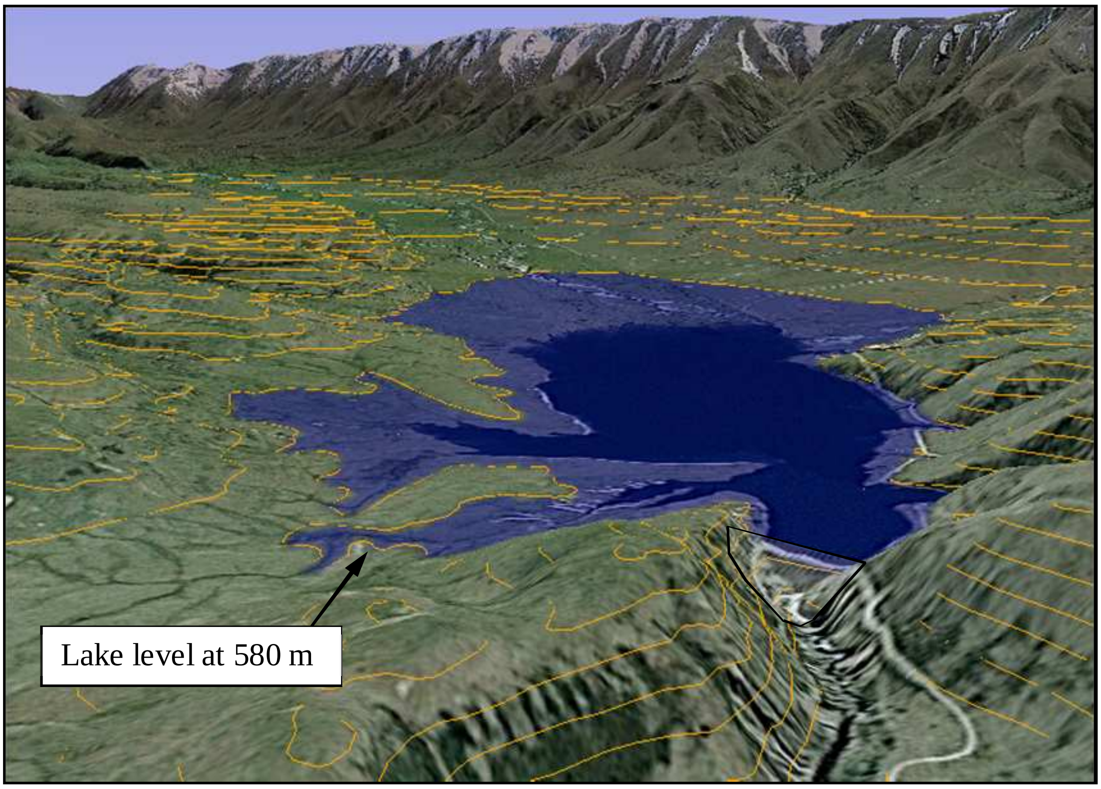

Figure 3: Falls Dam – 3D visualisation

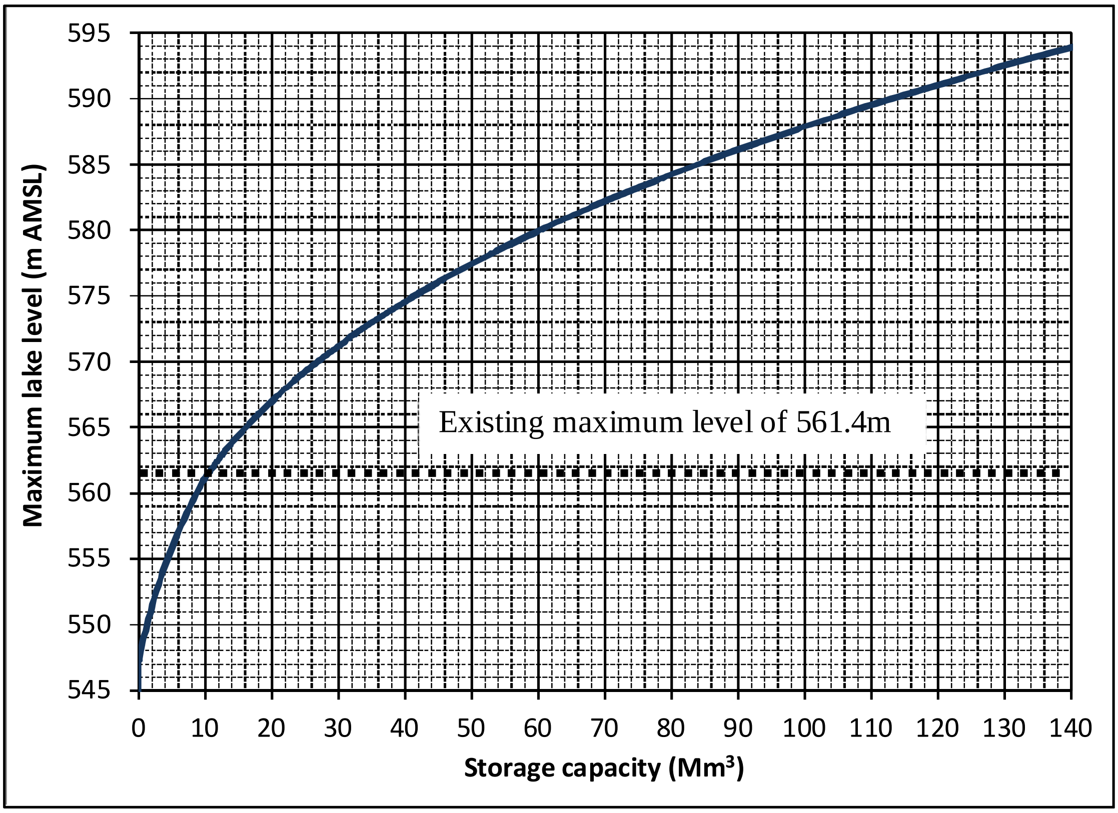

Figure 4: Falls Dam – stage storage relationship

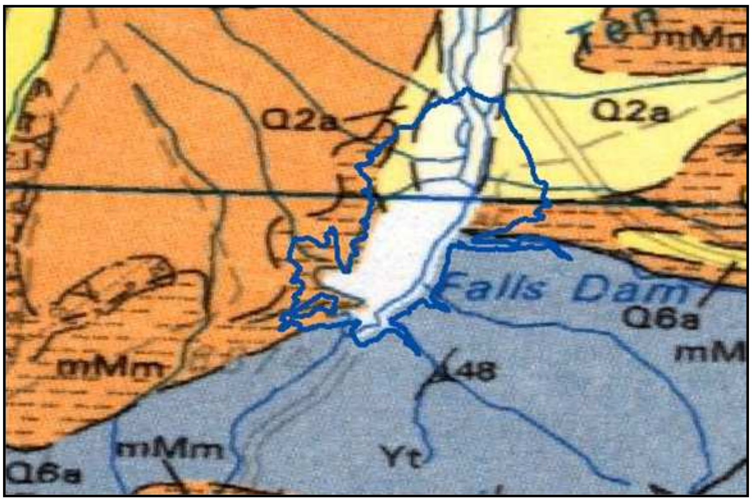

Figure 5: Falls Dam - geology

4.1.4 Distribution

In the Stage 2 study we estimated a large dam at Falls could indicatively supply up to 20,000 ha from a hydrological perspective. From a demand perspective we expect it may be challenging to get full uptake for an additional 20,000 ha. While theoretically there is in excess of 20,000 ha that could be supplied from a raised dam, high distribution costs to some areas may mean in practice a lesser area can be irrigated. We suspect a figure of 15,000 ha may be a more realistic upper limit.

Figure 6 presents a possible command area of a scheme that could be supplied from a larger dam. The scheme would require a new headrace (between 60 – 120 km in length, depending on the amount of earthworks) supplied from a new intake on the Manuherikia River at an elevation of about 460 m amsl. The new headrace would be integrated with the existing Dunstan, Lauder, and Thomsons Creek scheme takes. The gross irrigable area within the command area is about 23,000 ha.

We estimate the equivalent of only 5,000 – 5,500 ha is fully irrigated within this 23,000 ha command area. This estimate is based on Omakau and Blackstone irrigation schemes having access to 3.36 m^3 of 90% reliable water (refer Stage 2 study). Given an average efficiency of 60%, and an effective system capacity[1] of 3.5 mm/d, 3.36 m^3 would only allow for 5,000 ha of full irrigation. We estimate private water rights would irrigate at most the equivalent of only 500 ha of full irrigation. In practice water is spread much further than is required for full irrigation, with a larger area (perhaps as much as 10,000 to 12,000 ha) being partially irrigated. Aerial photographs support the view much of the command area is only partially irrigated.

Assuming 90% of the gross 23,000 ha is irrigated in the future, the potential 'new' area that could be supplied from raising Falls Dam would be about 15,000 ha. This 'new' area includes providing a reliable supply to areas that are currently only intermittently or partially irrigated

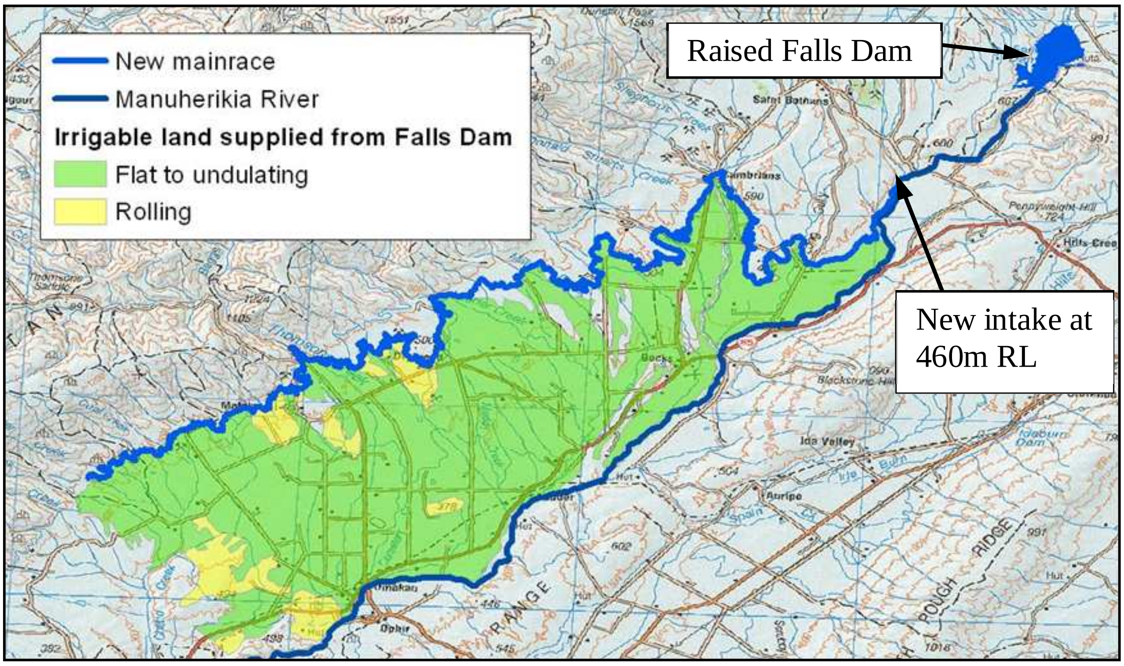

Figure 6: Possible raised Fall Dam command area

Other supply options could include an expansion of the Blackstone Irrigation Scheme, additional water to the Lower Manuherikia, and/or a race to take water into Ida Valley. We recommend all these options be considered in Stage B investigations.

[1] Effective system capacity is the irrigation system capacity multiplied by the efficiency.

If Falls Dam were only raised 6 m, it would be unlikely new distribution would be necessary, since the additional 10 Mm^3/y would mostly be used to improve reliability to existing users, and to partially off-set the reduction in water available caused by Upper Manuherikia Valley irrigators converting to more efficient irrigation systems.

We expect the uptake risk of raising Falls Dam 6 m to be low.

We expect the uptake risk of raising Falls Dam 27 m to be medium. There is some potential to stage development, since about 70% of the capital cost would be associated with new irrigation distribution and only 30% associated with the dam. The risk is further reduced because of the potential for the dam to be used for winter power generation if there is not full irrigation uptake initially (see below).

4.1.5 Hydro-generation

Falls Dam is currently used to generate power. Whether or not raising the dam increases hydropower revenue will depend on how the timing of dam releases is affected. This depends on both the dam capacity and the amount of irrigation uptake.

If Falls Dam were raised 27 m, power generation opportunities could be a key factor in minimizing the irrigation uptake risk. If there was not full uptake in the dam initially, excess storage capacity could be used for generation in the winter and other times of higher power prices. The low marginal cubic metre storage cost of raising the dam the full 27 m (~\$0.20/m^3), makes this option particularly attractive. When Opuha Dam in South Canterbury was proposed a similar situation existed, where there was not enough initial irrigation interest to finance the dam. The resulting partnership between Alpine Energy Ltd and local farmers was key in getting the project off the ground.

4.1.6 Environmental

We expect the main environmental impacts of raising Falls Dam would be:

(1) A change in the Manuherikia River flow regime downstream of the dam. Mid to high flows would reduce while low flows would remain unchanged or increase.
(2) The inundation of a section of the Manuherikia River and some of the minor lake tributaries; and
(3) The impact of land use intensification on water quality.

We expect the direct impacts of raising the dam would be low relative to other dam sites. The reason for this is because there is already an existing dam, and the area to be inundated is mostly low intensity pastoral farmland (refer Figure 8). Raising the dam may also provide some environmental enhancement through an improved fishery associated with a bigger lake.

We expect with appropriate mitigation, other environmental impacts would likely be acceptable to the community. Environmental mitigation would need to include the design of an appropriate environmental flow regime below the dam, and systems to manage farm nutrient losses.

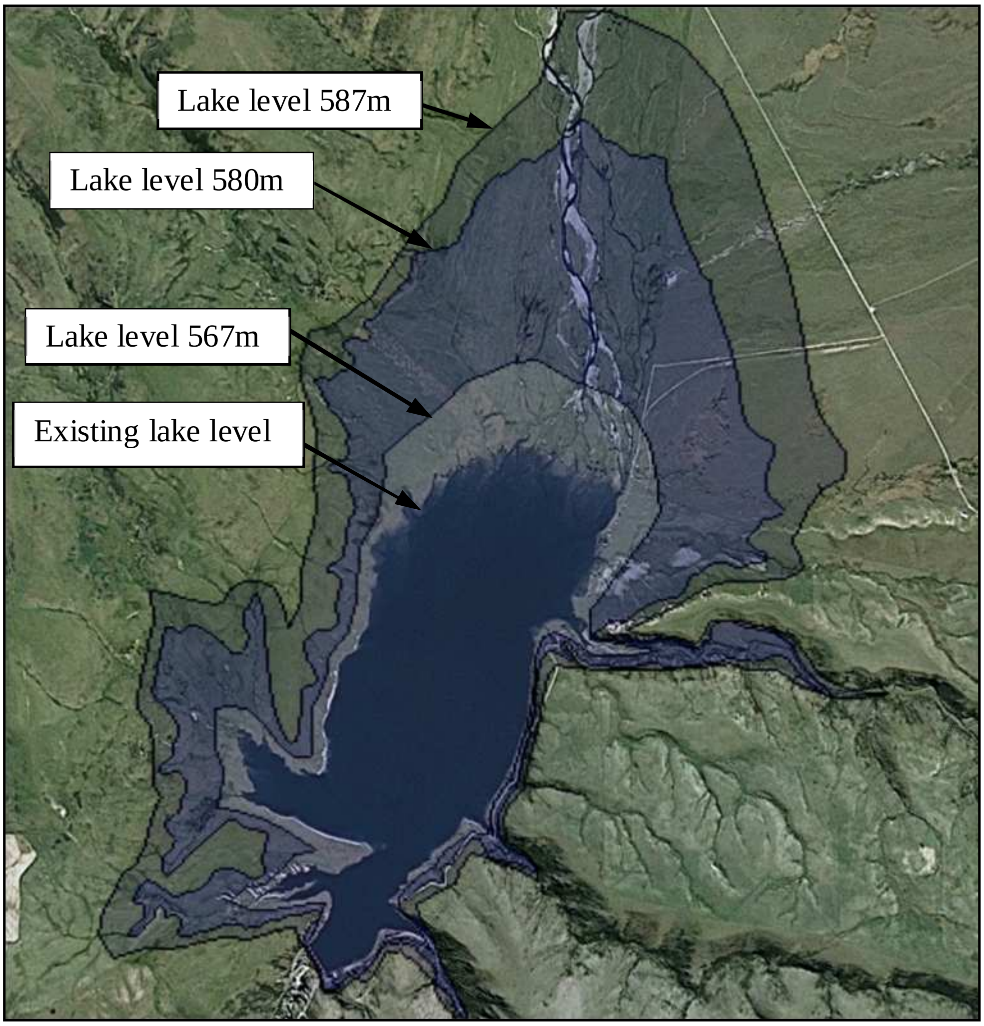

Figure 7: Raised Falls Dam inundation areas


Figure 8: Typical low intensity pastoral farmland that would be inundated by raising Falls Dam

4.1.7 Cost

Indicative costs for raising Falls Dam are given in Table 3. Costs exclude power generation facilities. From this table we expect the cost risk for raising the dam to be 'medium'.

Table 3: Indicative costs of raising Falls Dam

Parameter	Raise dam 6m	Raise dam 27m
New usable storage	10 Mm^3/y	90 Mm^3/y
New irrigated area[1]	1,700 ha	15,000 ha
Dam construction[2]	$5M[3]	$20M[4]
Storage costs/m^3	$0.50	$0.22
New distribution	0	$45M
Distribution cost/ha	0	$3,000/ha
Total cost	**$5M**	**$65M**
Total cost/ha	**$3,000/ha**	**$4,300/ha**

1. Equivalent area of full irrigation. The area will be less if some new water is used to improve reliability to existing irrigators.
2. Excludes $5M associated with bring the existing spillway up to current standards
3. Based on Falls Dam Board estimates of $10M to raise the dam and enlarge the spillway. We assumed ½ this cost was associated with raising the dam.
4. Based on the Opuha Dam present day replacement cost of $33M. The Falls Dam would be about 60% of the size of the Opuha Dam [the Opuha Dam is a similar height but the crest is twice as long]. Flood flows at Falls would be about 50% of Opuha Dam flood flows.

4.1.8 Conclusions

Our high level assessment of raising Falls Dam is summarised in Table 4. From this assessment we conclude raising Falls Dam is promising and recommend this option progress through to a more detailed Stage B pre-feasibility study.

Table 4: Raised Falls Dam high level summary

Criteria	Raise dam 6m	Raise dam 27m
Potential new water	10 Mm^3/y	90 Mm^3/y
Regional economic benefits	Medium	Very high
Cost risk	Medium	Medium
Uptake risk	Low	Medium
Geological risk	Low to medium	Low to medium
Environmental risk	Low	Low to medium

4.1.9 Scope of future investigations

We recommend a Stage B pre-feasibility study on raising Falls Dam should cover the following topics:

- Engineering estimates of raising the dam 6 m, 15 m, and 27 m.
- Daily time-step hydrological storage and demand modelling.
- Distribution alignments and costs. Command area options should at least consider an enlarged Omakau scheme (see Figure 6), an enlarged Blackstone scheme, water to Ida Valley, and additional water to the Lower Manuherikia.
- An assessment of the environmental impacts of lake inundation and a change in the flow regime downstream of the dam.
- An assessment of the environmental impacts of an expanded area of irrigation.
- Hydropower options, including modelling the option for a portion of the lake storage to be reserved for maximizing electricity revenue.
- Small dam(s) on Lauder and Thomsons Creek.
- Iwi consultation.

Small dam(s) on Lauder and Thomsons Creek have been considered in historical studies. Since the associated irrigated area is relatively small we recommend these are best investigated as part of a larger Falls Dam study.

Another option that has been considered in the past by Pioneer Generation is a second dam about 1.5 km downstream of the existing Falls Dam. We expect raising Falls Dam to be more favourable than this option; Pioneer Generation concurs with this view.

Raising Falls Dam will have an impact on the entire Manuherikia Valley. Because of the link between the upper and lower Manuherikia Valley, the study needs to incorporate the findings of the three parallel Lower Manuherikia studies, namely Manuherikia Irrigation Scheme efficiency improvements, Lake Dunstan gravity piped supply, and Galloway dam supply.

4.2 Dam on Dunstan Creek

4.2.1 Overview

In the Stage A (ii) study we identified two large natural dam sites on Dunstan Creek, from a hydrological and topographical perspective. One site is at the start of the gorge and one site is near St Bathans. After further investigation we have concluded a dam at the lower site would be difficult because of the very challenging geology. The upper dam site is likely to be more feasible, but would still be much more expensive than a mega dam at Falls, on a per m^3 of stored water basis. Both sites are likely to be more environmentally controversial than a mega dam at Falls.

4.2.2 Hydrology

In the Stage A (ii) study we estimated annual usable storage from a dam on Dunstan Creek was 40 Mm^3/y at the upper site and 45 Mm^3/y at the lower site. The maximum usable storage is limited by inflows in a dry year, which are 40-45 Mm^3/y.

4.2.3 Upper dam site

The topography of the upper dam site at the start of the Dunstan Creek gorge is illustrated in Figure 9, Figure 10 and Figure 11.

The site's geology is illustrated in Figure 12. The abutments and base of the dam is weakly foliated greywacke. A landslide exists in the near vicinity of the proposed dam. The reservoir walls are very steep weakly foliated greywacke on the western side, and steep alluvial deposits on the eastern side. These steeply sloping reservoir walls raises the risk of a large landslip falling into the reservoir resulting in a wave that overtops the dam.

Access to the site would be difficult. Access would probably be via an existing 4WD tracks over the Chain Hills.

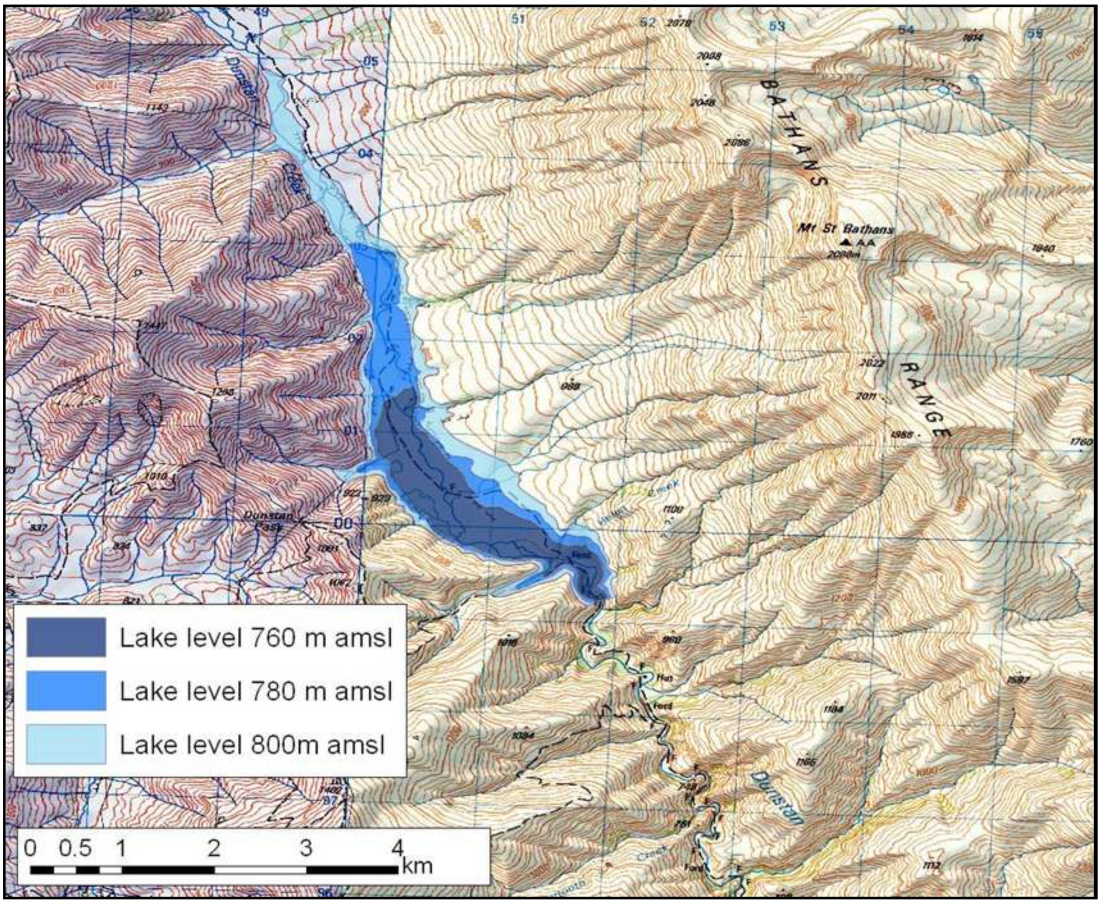

Figure 9: Upper Dunstan Creek dam – topography

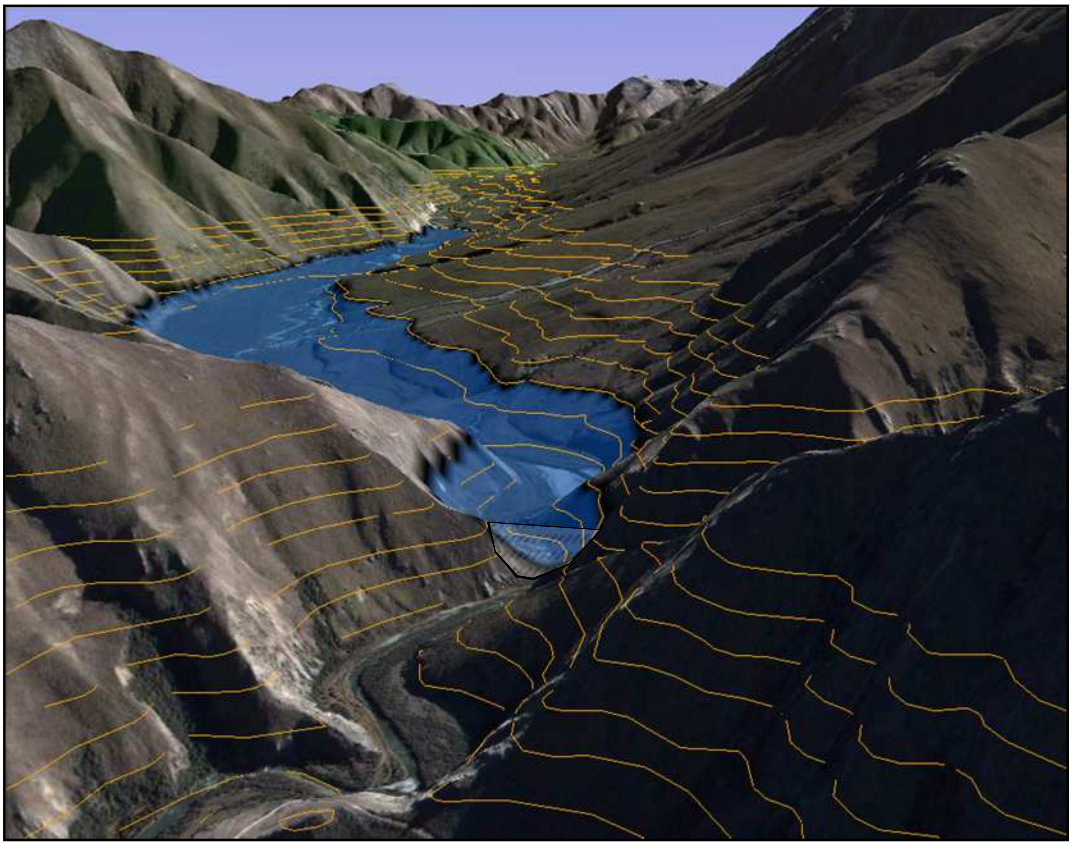

Figure 10: Upper Dunstan Creek dam – 3D visualisation

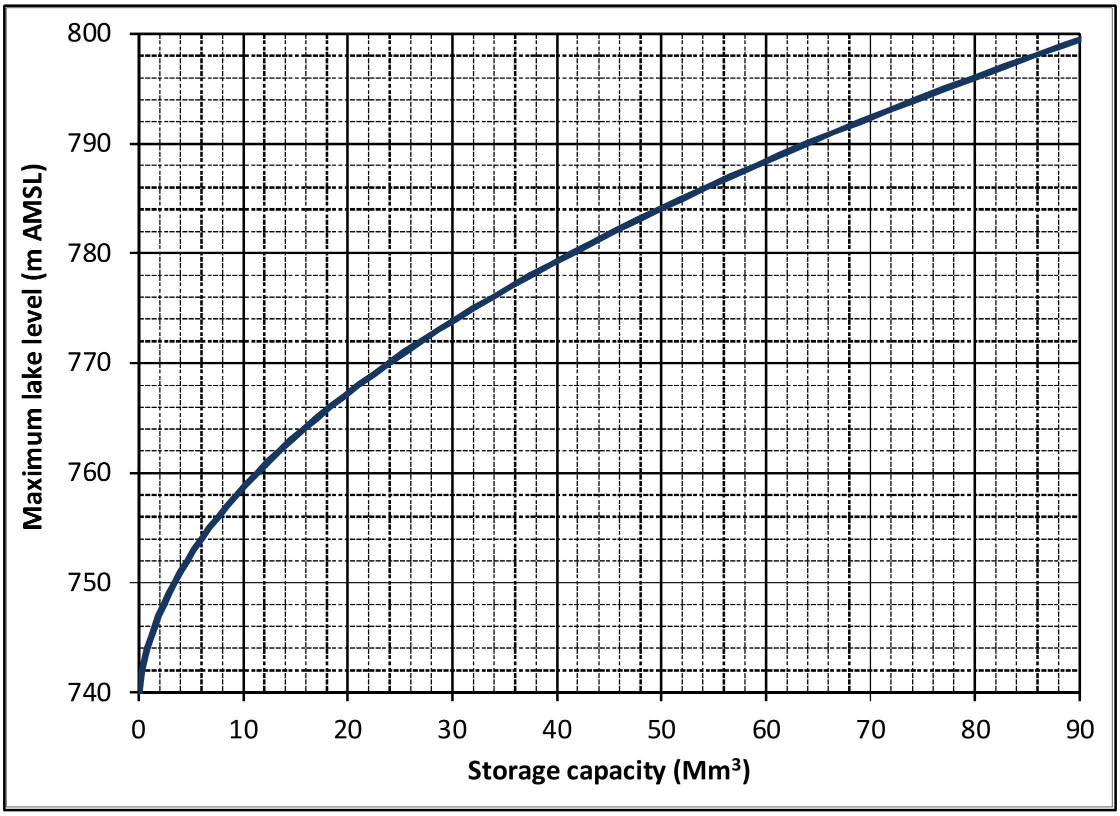

Figure 11: Upper Dunstan Creek dam – stage storage relationship

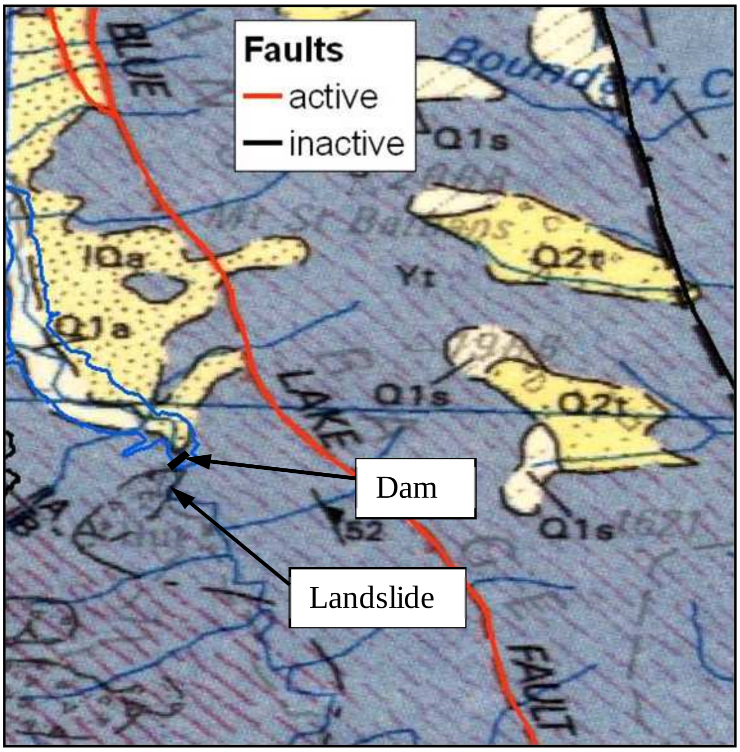

Figure 12: Upper Dunstan Creek dam – geology

4.2.4 Lower dam site

The topography of the lower dam site near St Bathans is illustrated in Figure 13, Figure 14 and Figure 15.

The site's geology is illustrated in Figure 16. The geology is very challenging. Abutment and reservoir walls are weakly foliated greywacke and semi-schist sandstone. The active Blue Lake fault passes through the eastern abutment. Movement of this fault could compromise a dam in an earthquake. The crush zone associated with this fault could also create dam leakage. The base of the dam is alluvial gravel, which is not a good foundation. These deposits could be tens of metres deep. The steeply sloping reservoir walls raise the risk of a large landslip falling into the reservoir resulting in a wave that overtops the dam.

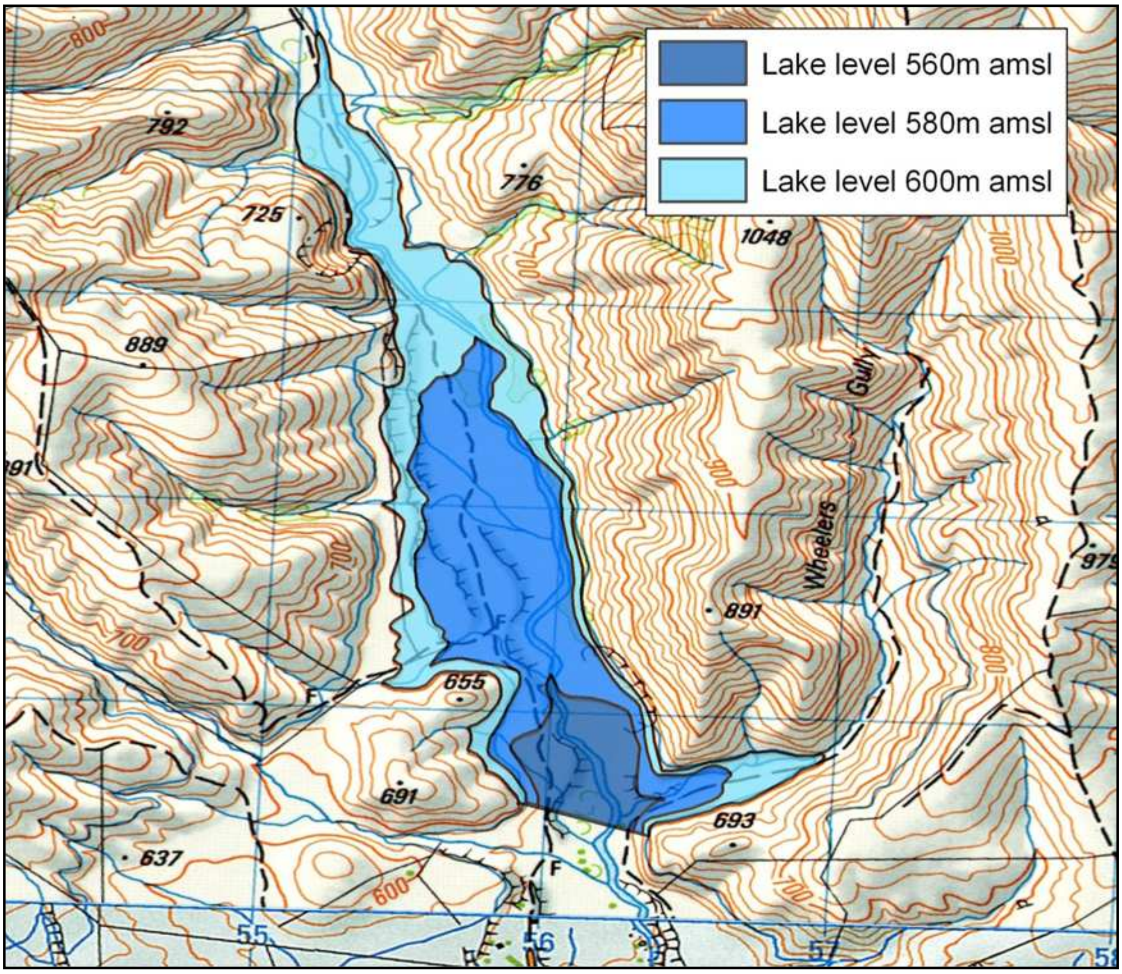

Figure 13: Lower Dunstan Creek dam - topography

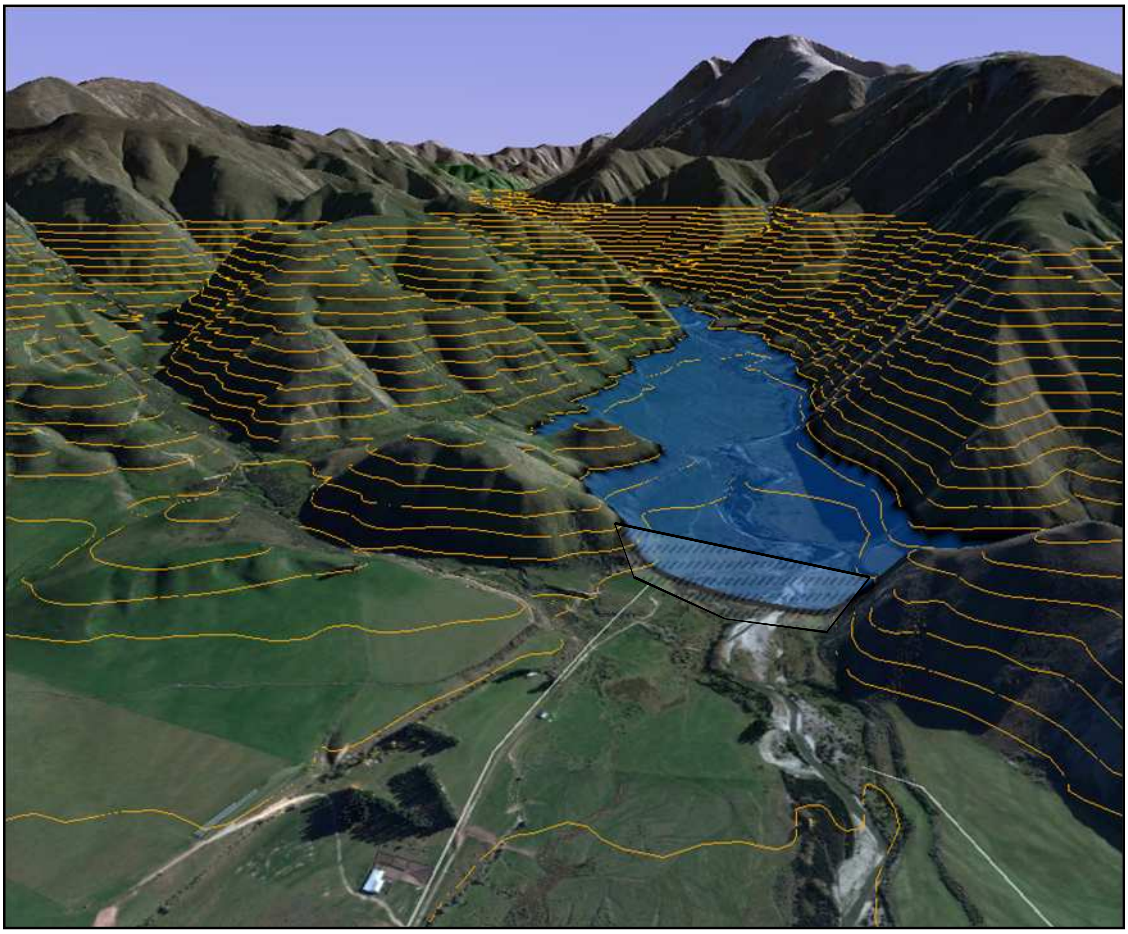

Figure 14: Lower Dunstan Creek dam - 3D visualisation

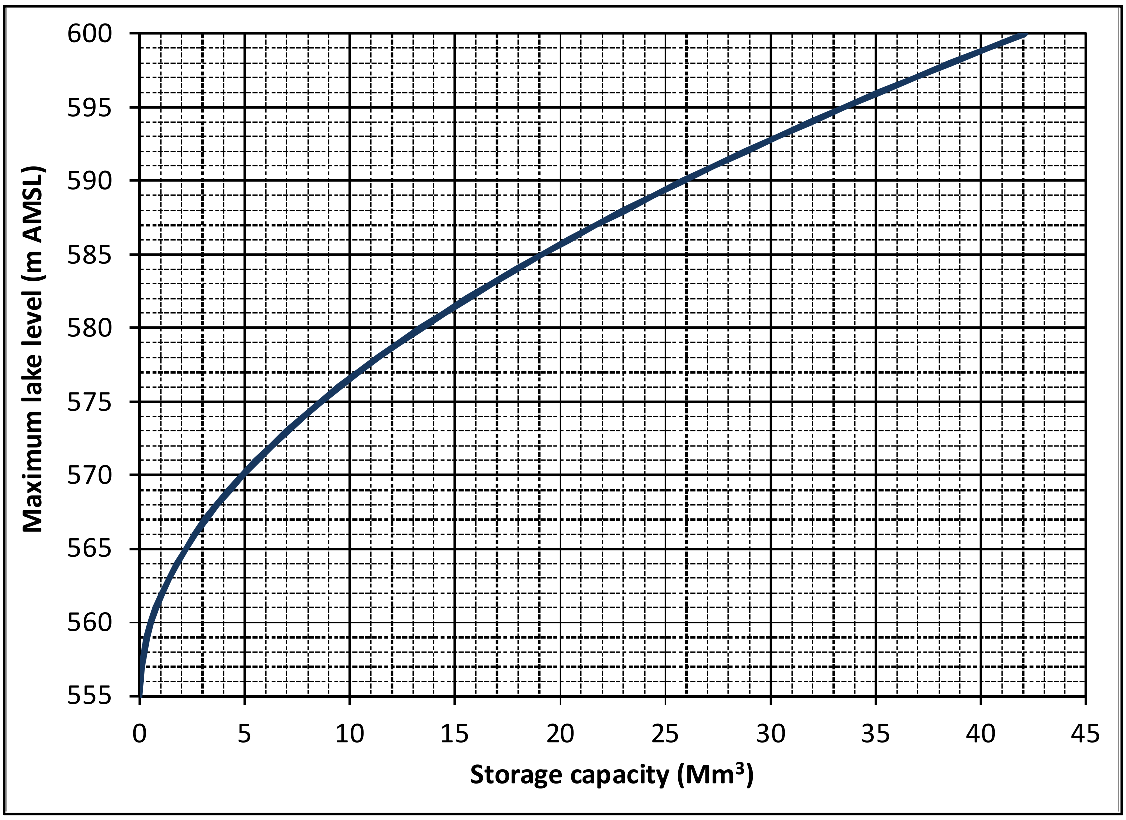

Figure 15: Lower Dunstan Creek dam – stage storage relationship

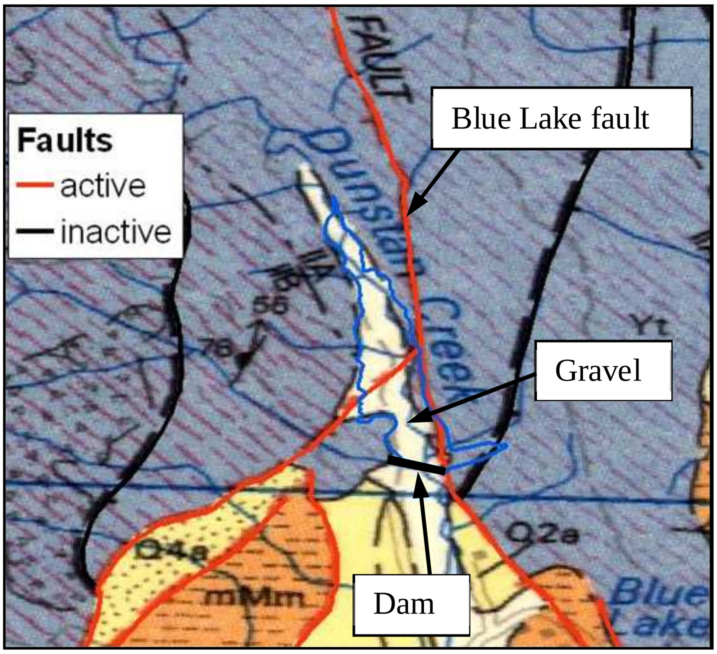

Figure 16: Lower Dunstan Creek dam – geology

4.2.5 Costs

Geological risks and/or access difficulties would add significant cost to a dam on Dunstan Creek. Costs are difficult to estimate without further investigations. We expect the cost of a dam to be significantly higher than raising Falls Dam 27 m. We expect dam and distribution costs to be in the range 'high to very high'.

4.2.6 Environmental

We expect the main environmental impacts of a dam on Dunstan Creek would be:
(1) Fish would be prevented from travelling up past the dam;
(2) There could be a significant reduction in sediment transport below the dam, in both Dunstan Creek and the Manuherikia River;
(3) A change in the Dunstan Creek and Manuherikia River flow regimes downstream of the dam;
(4) The inundation of a section of Dunstan Creek; and
(5) The impact of land use intensification on water quality.

The environmental impacts of a dam on Dunstan Creek are expected to be much more controversial than raising Falls Dam. A dam would have a significant impact on Dunstan Creek, which is a highly regarded small stream fishery largely in its natural state. Furthermore, since Falls Dam already exists, it would mean the two main Manuherikia River tributaries would be dammed.

4.2.7 Conclusion

Our high level assessment of a dam on Dunstan Creek is summarised in Table 5. From this assessment we conclude a dam on Dunstan Creek is not promising and recommend this option not progress through to a more detailed Stage B pre-feasibility study.

Table 5: Dam on Dunstan Creek high level summary

Criteria	Upper site	Lower site
Potential new water	40 Mm^3/y	45 Mm^3/y
Regional economic benefits	High	High
Cost risk	High to very high	High to very high
Uptake risk	High	High
Geological risk	Moderate to high	High
Environmental risk	High	High

4.3 Hopes Creek dam supplying Ida Valley

4.3.1 Overview

The possibility of damming Hope Creek and transferring the water to the Ida Valley Bonanza Race has been considered for many decades. The idea pre-dates the construction of the Upper Manor Burn and Pool Burn reservoirs. We considered two options. The first is a natural dam site at a stream bed elevation of about 615 m. A 9 km race and short section of pipe would connect this dam to Bonanza Race. The second option is a dam at a stream bed elevation of about 710 m. A 3.6 km tunnel would connect this second dam to the Upper Manor Burn reservoir.

4.3.2 Hydrology

In the Stage A(ii) study we estimated average annual usable storage for the lower dam site would be about 17 Mm^3/y. To make maximum use of Hope Creek water, the Hope Creek, Upper Manor Burn and Pool Burn dams need to be managed together. In general, Hope Creek water would be used first, with the dam being drawn down to the minimum level most years. The Upper Manor Burn and Pool Burn dams store water for several seasons, and in dry years, a greater proportion of water would come from these dams.

The upper dam site would capture significantly less water than the lower site. The reason is because the supply catchment is smaller, and because the small capacity of the dam means not all flood flows would be captured. Indicatively we estimate this upper site could supply about 10 Mm^3/y to the Upper Manor Burn reservoir.

4.3.3 Lower dam site

The topography of the lower dam site is illustrated in Figure 17, Figure 18, Figure 19 and Figure 20.

The site's geology is illustrated in Figure 21. The geology is favourable with dam abutments and foundation, and reservoir walls all schist. Reservoir walls are not steep. The risk of dam leakage or instability, or the risk of large landslides collapsing into the reservoir, is expected to be low.

The contour race connecting the dam to the Bonanza race is predominately around gentle to moderately steep schist slopes. The difficulty in constructing this race will depend on the depth and type of soil overlying the schist bedrock. If the depth to bedrock is very shallow, race construction may be more difficult.

The first 1 km of the contour race is along a steep schist slope and would require the race to be cut into the rock. An alternative solution to a rock cutting would be a 1 km long siphon from the outlet of the dam, past the steep slope, with an outlet feeding the contour race at the point the hill slope flattens.

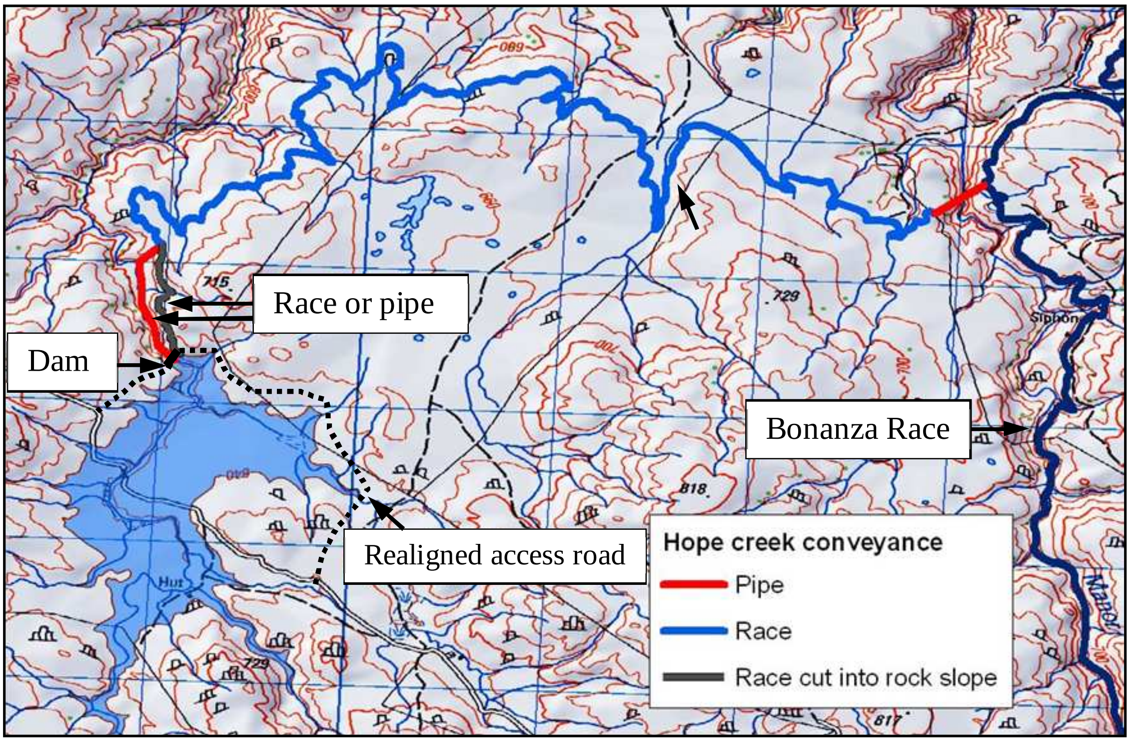

Figure 17: Lower Hope Creek dam– topography

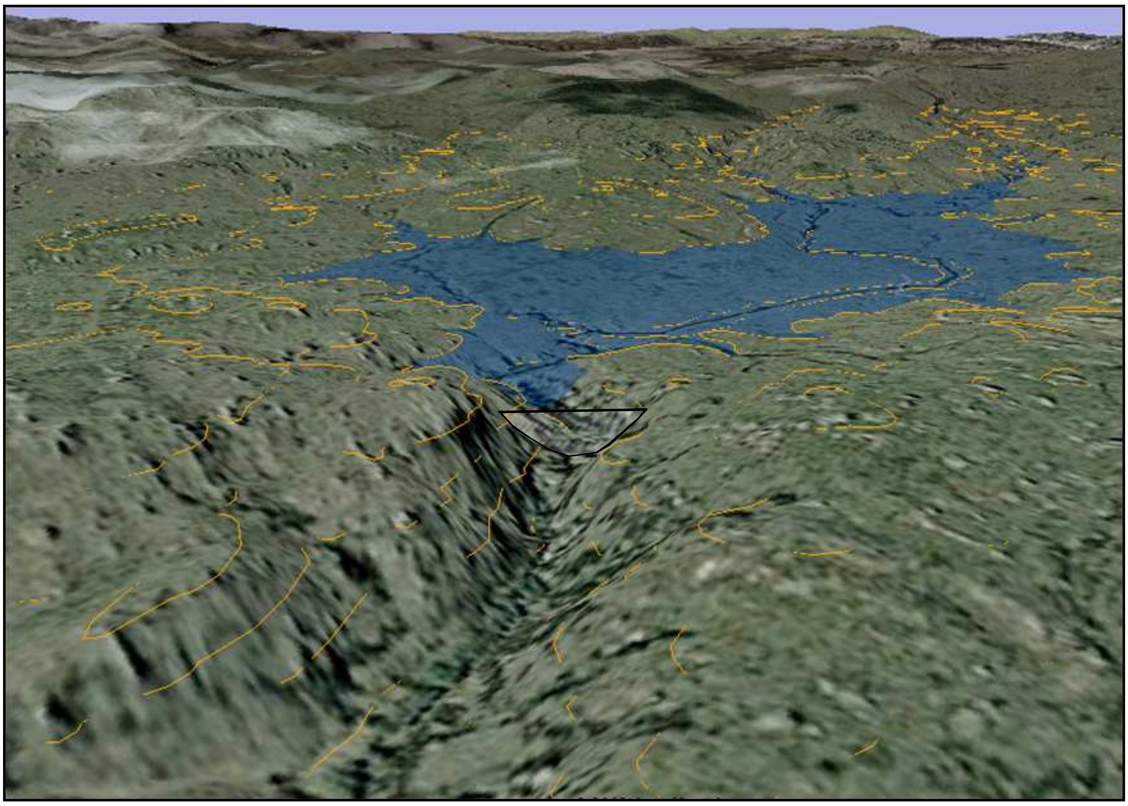

Figure 18: Lower Hope Creek dam – 3D visualisation

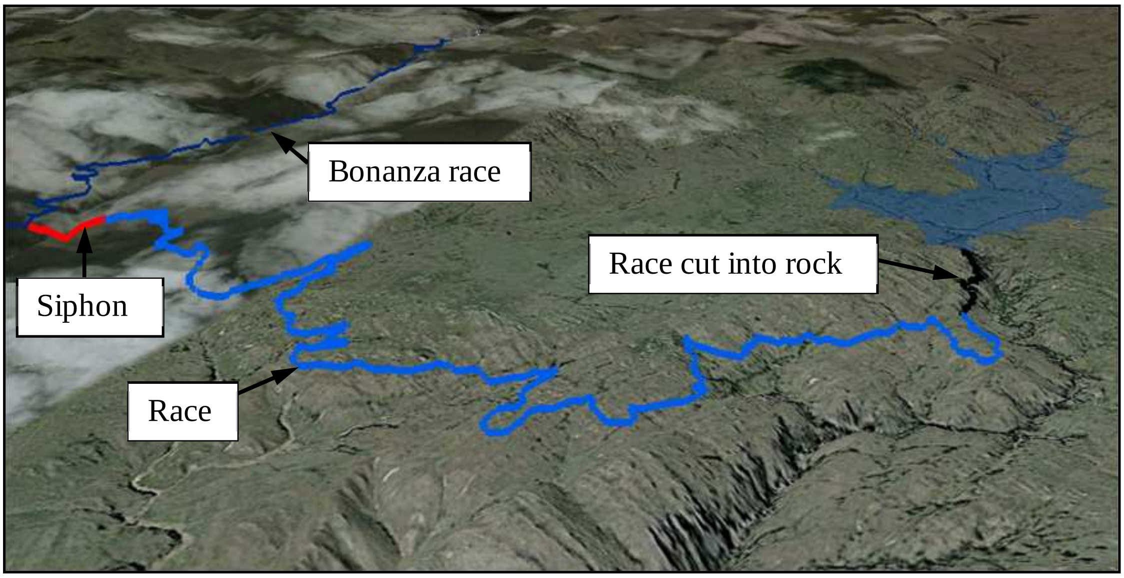

Figure 19: Lower Hope Creek dam – conveyance 3D visualisation

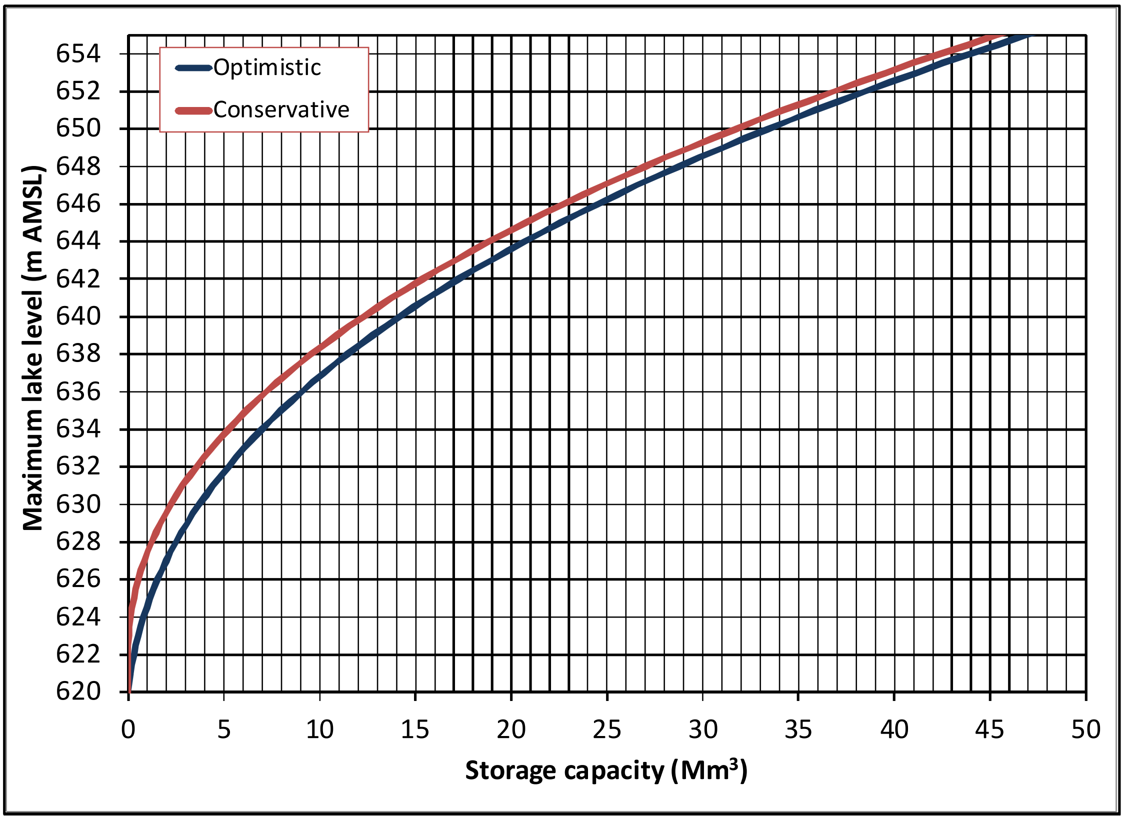

Figure 20: Lower Hope Creek dam – stage storage relationship

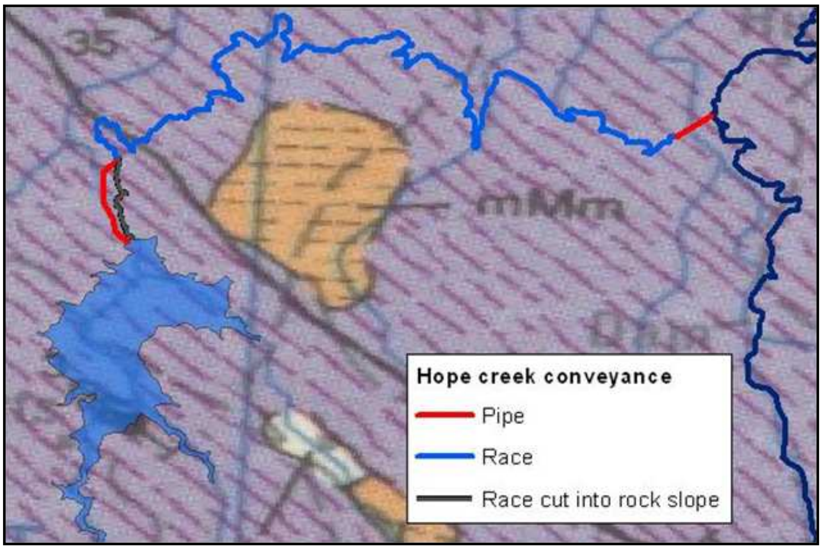

Figure 21: Lower Hope Creek dam - geology

4.3.4 Upper dam site

The upper dam site and tunnel is illustrated in Figure 22. Storage capacity in the dam would be minimal: consequently not all flood flows could be captured. This option requires a 3.6 km long tunnel. The dam and tunnel are in schist.

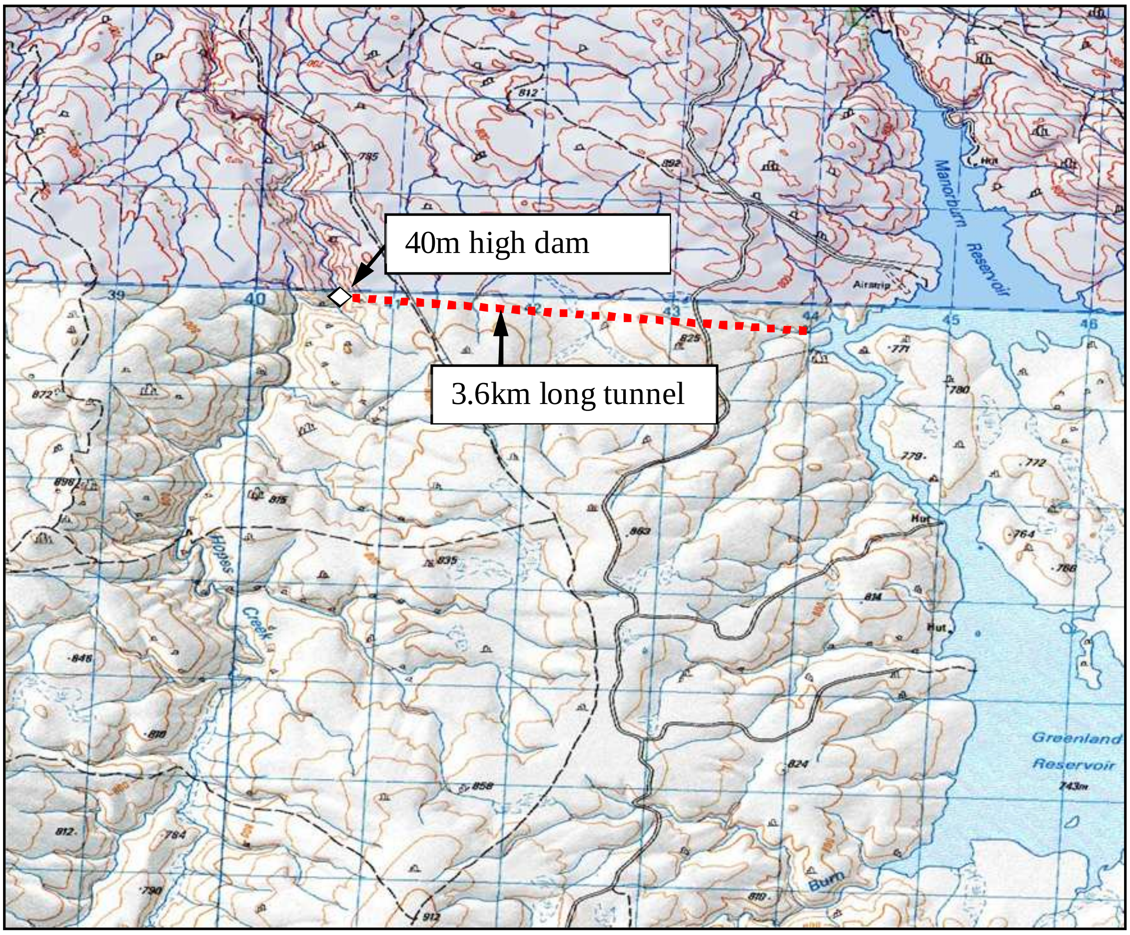

Figure 22. Upper Hope Creek dam

4.3.5 Distribution

We expect distribution costs to be minimal. Distribution would be via the existing Bonanza race and Ida Valley Irrigation distribution system. The Ida Valley Irrigation command area is about 15,000 ha. The additional water would be used to more fully irrigate land within the Ida Valley scheme, which is currently only partially irrigated.

4.3.6 Environmental

We expect environmental impacts of both the upper and lower dam sites to be low. The reason is the Hope catchment is very dry in summer. We suspect the river bed will naturally go dry in summer and autumn, however this requires confirmation. For the lower dam site the area that would be inundated is depleted tussock grassland (refer Figure 23). Land use intensification in Ida Valley would require appropriate systems to manage farm nutrient losses.

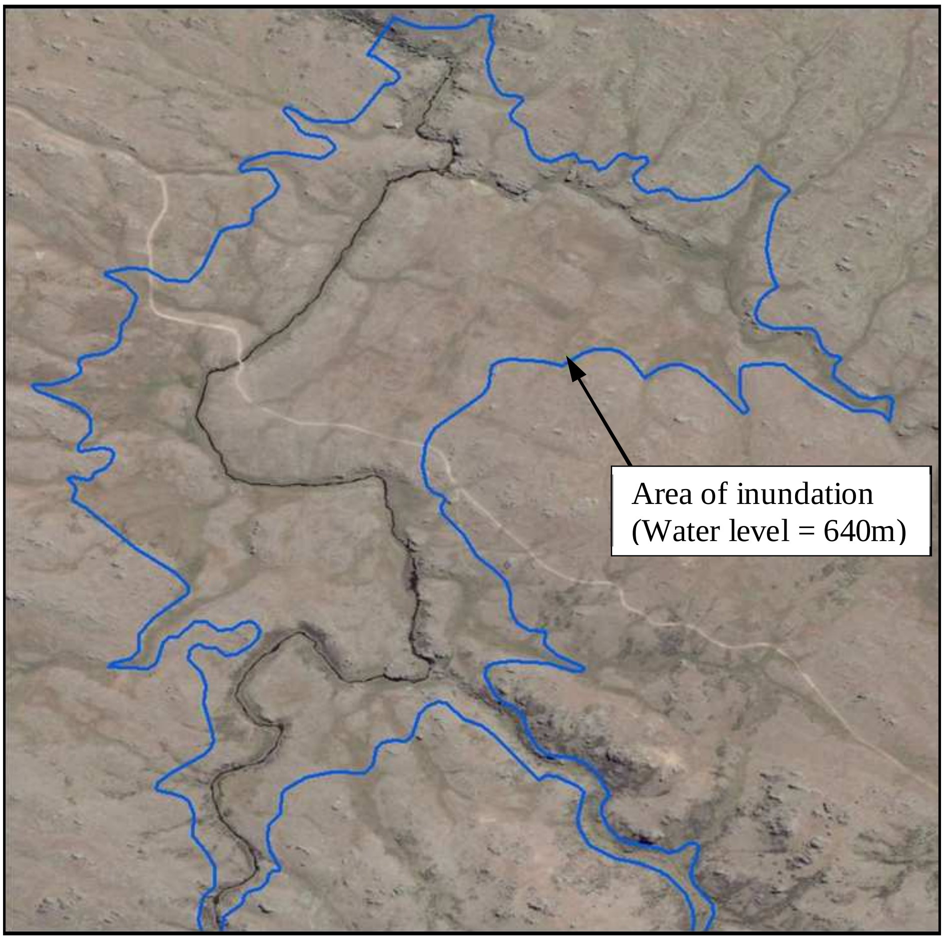

Figure 23: Hope Creek lower dam inundation area

4.3.7 Cost

Indicative costs for the two Hope Creek dam sites are given in Table 6 and Table 7. The lower dam site assumes a dam crest height of 647 m and requires a small amount of pumping (<15m). An alternative to pumping is raising the dam crest to about 654 m.

Table 6: Indicative costs of Hope Creek dam (lower site)

Parameter	Value
New water	17 Mm^3/y
New irrigated area[1]	3,000 ha
Dam cost[2]	$3.0M
Transmission and pumping capital cost[3]	$1.0M
PV of on-going pumping costs[4]	$1.5M
1km race cut into rock (@$1,000/m)	$1.0M
8km race (@$250/m)	$2.0M
320m pipe siphon (1,200mm Ø @ $1,500/m)	$0.5M
Bonanza race and Ida Valley distribution upgrades	$0.5M
Total cost	**$9.5M**
Cost/m^3	**$0.56/$m^3$**
Cost/ha	**$3,200/ha**

(1) Equivalent area of new irrigation. In practice in Ida Valley we expect most water would be used to fully irrigate land that is currently only partially irrigated.
(2) Given a dam crest of 647m. Based on earth dam (110,000 m^3 fill @ $15/$m^3$)×150% (P&G, engineering ,& contingency) + $500k for spillway.
(3) Present Value = $90,000/y ÷6% = $1.5M. Assumes electricity costs $0.20/kW-hr

Table 7: Indicative costs of Hope Creek dam (upper site)

Parameter	Value
New water	10 Mm^3/y
New irrigated area[1]	1,800 ha
Dam cost[2]	$11M
3.6km tunnel @ $8,000/m	$29M
Total cost	**$40M**
Cost/m^3	**$4.00/$m^3$**
Cost/ha	**$22,000/ha**

(1) Equivalent area of new irrigation. In practice in Ida Valley we expect most water would be used to fully irrigate land that is currently only partially irrigated.
(2) 40m high dam, 200m wide crest. Costs are very rough.

4.3.8 Conclusion

Our high level assessment of a dam on Hope Creek supplying Ida Valley is summarised in Table 8. From this assessment we conclude the lower dam site is promising but the upper site is not. We recommend only the lower site progress through to a more detailed Stage B pre-feasibility study.

Table 8: Dam on Hope Creek high level summary

Criteria	Lower site	Upper site
Potential new water	17 Mm^3/y	10 Mm^3/y
Regional economic benefits	High	Medium
Cost risk	Low	Very high
Uptake risk	Low	High
Geological risk	Low to medium	Medium
Environmental risk	Low	Low

4.3.9 Scope of future investigations

We recommend a Stage B pre-feasibility study on the lower Hope Creek dam site should cover the following topics:

- Engineering estimates of the cost of the low dam (647 m crest with pumping) and high dam (654 m crest without pumping), and conveyance costs to the Bonanza Race.
- Monthly time-step hydrological storage and demand modelling.
- Review of Ida Valley Irrigation distribution system, and the capacity to accommodate the additional water.
- Engineering costs of reducing existing leakage in the Bonanza Race.
- An assessment of the environmental impacts of land use intensification.
- Iwi consultation.

The existing 5 – 6 head (3 Mm^3/y) of leakage from the Bonanza Race needs to be addressed. We recommend this is best investigated as part of a larger Hope Creek dam study.

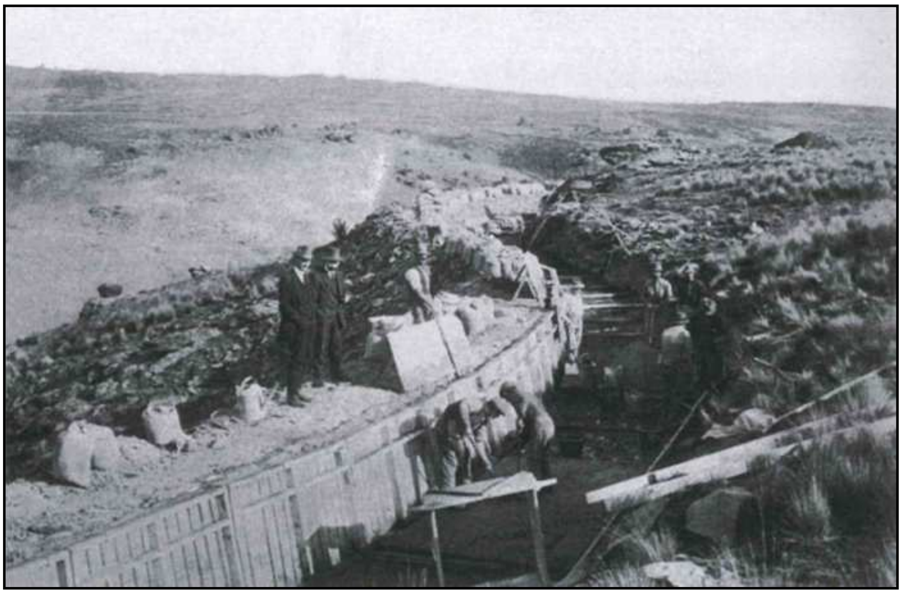

Figure 24: Concrete lining of the Upper Bonanza Race to reduce leakage c. 1916 (Ellis 2009)

4.4 Dam supply to Galloway

4.4.1 Overview

The Manor Burn currently has little abstractive pressure on an annual basis. There is also a number of promising natural dam sites within the Manor Burn catchment. Development of one or more of these dam sites would allow the Galloway Irrigation Scheme to be gravity supplied exclusively from the Manor Burn, thereby freeing up valuable Manuherikia River water and reduce or eliminating Galloway scheme pumping costs.

We investigated three sites:

- Lower Manor Burn (300 m upstream of existing dam).
- Little Valley Creek West Branch; and
- Speargrass Creek.

The lower Manor Burn and Little Valley Creek West dam sites would individually each have more than enough capacity to fully supply Galloway. Speargrass Creek is a smaller dam, which could partially supply Galloway or provide additional irrigation to Little Valley.

4.4.2 Hydrology

Annual usable storage estimates from the Stage A (ii) study are given in Table 9. Usable storage at the Little Valley Creek west and Speargrass Creek sites is limited by inflows, while at the Lower Manor Burn site usable storage is limited by the dam capacity.

Indicatively, 5 Mm^3/y of storage would be required to supply Galloway exclusively from a dam.

Table 9: Hydrology of Manor Burn dam sites

Dam site	Catchment area (km^2)	Inflow[1] (Mm^3/y)	Capacity (Mm^3)	Usable annual storage (Mm^3/y)
Lower Manor Burn	410[(2)]	50	16	16
Little Valley Creek west	40	7	15	6
Speargrass Creek	22	3	10	2

(1) Average annual inflow
(2) Catchment would be reduced by 90 km^2 if the Hope Creek dam described in Section 4.3 was constructed.

4.4.3 Lower Manor Burn dam

The idea of a dam, 300 m upstream of the existing Lower Manor Burn dam, predates the construction of the current dam. Prior to construction in the early 1930's both this upper and the existing (lower) sites were investigated. Studies concluded both sites have good geology, while the upper site was marginally cheaper (Ellis, 2009). Eventually, the lower site was selected, perhaps because a siphon was not required[2].

The topography of a Lower Manor Burn dam 300 m upstream from the existing dam is illustrated in Figure 25, Figure 26 and Figure 27.

The site's geology is illustrated in Figure 21. The geology is favourable with dam abutments and foundation, and reservoir walls all schist. The risk of dam leakage or instability is expected to be low. Reservoir walls are moderately steep. While landslide risk would need to be assessed, given the dense schist at the Manor Burn dam site, we suspect landslides are unlikely to be an issue.

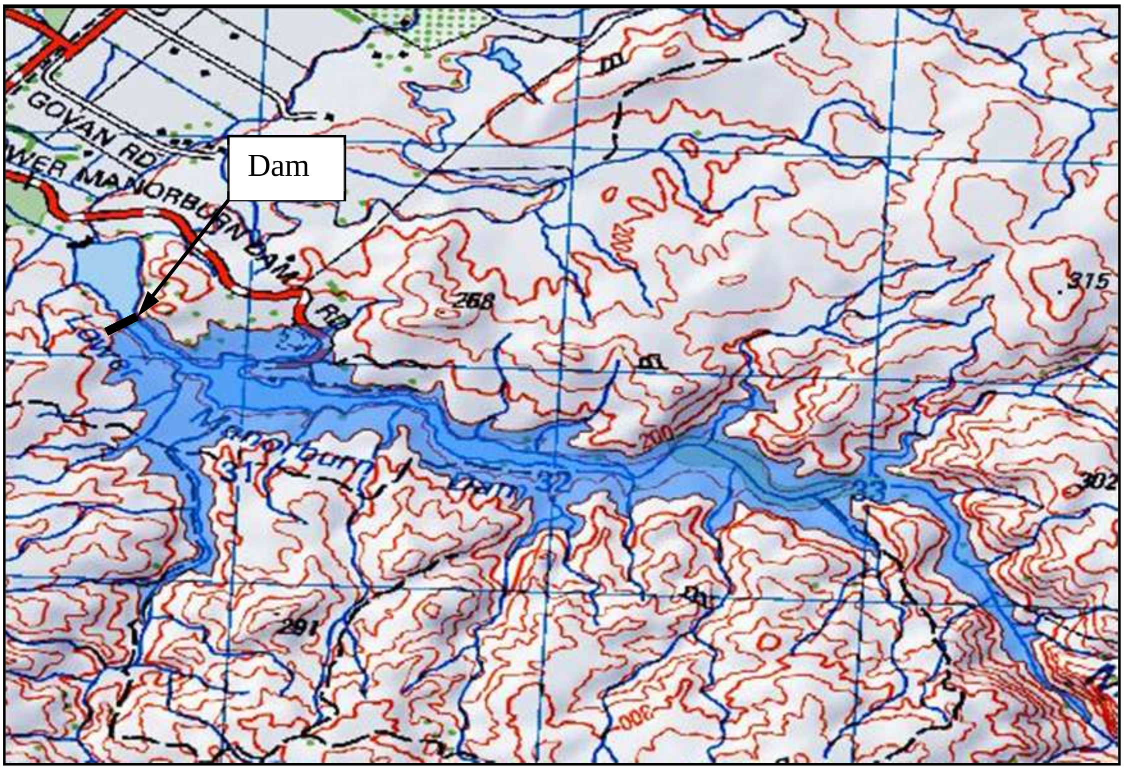

Figure 25: Lower Manor Burn dam – topography

[2] Over half the cost of the upper site was associated with a siphon from the dam outlet to the Galloway races – a feature potentially no longer required because the existing dam raises the water level to the height of the lower mainrace.

Figure 26: Lower Manor Burn dam – 3D visualisation

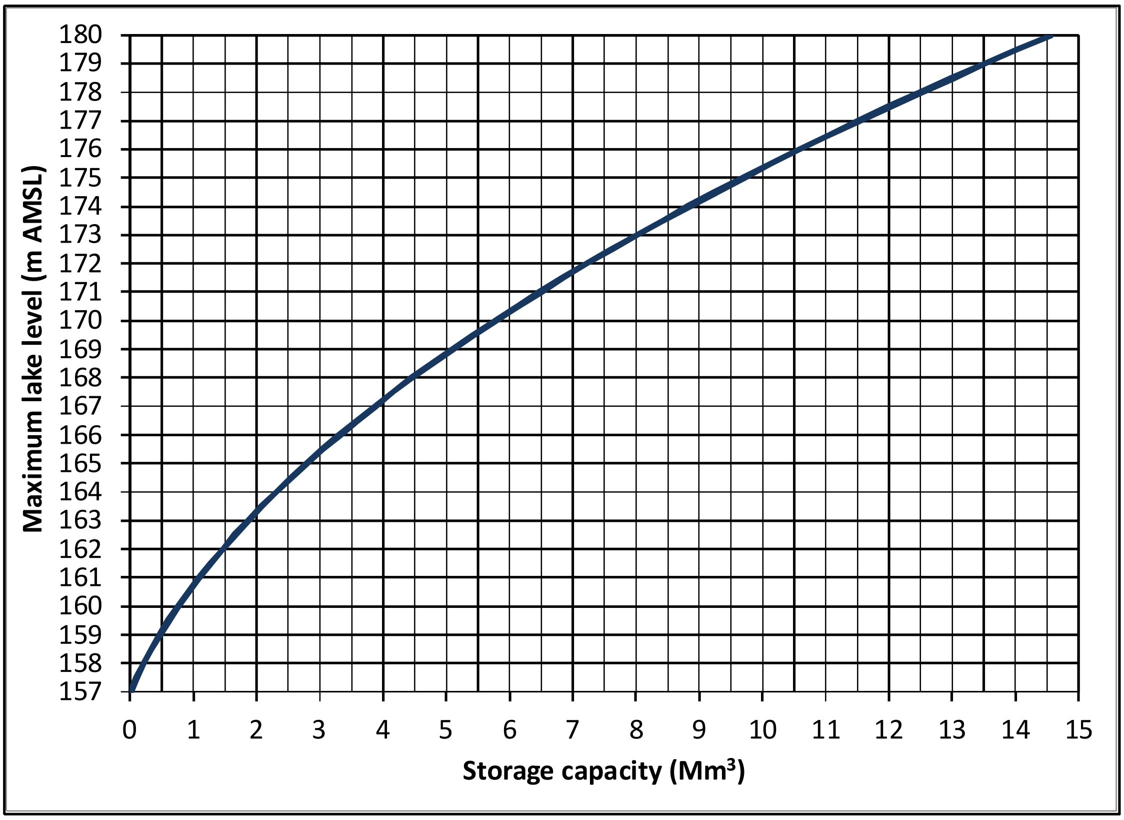

Figure 27: Lower Manor Burn dam – stage storage relationship

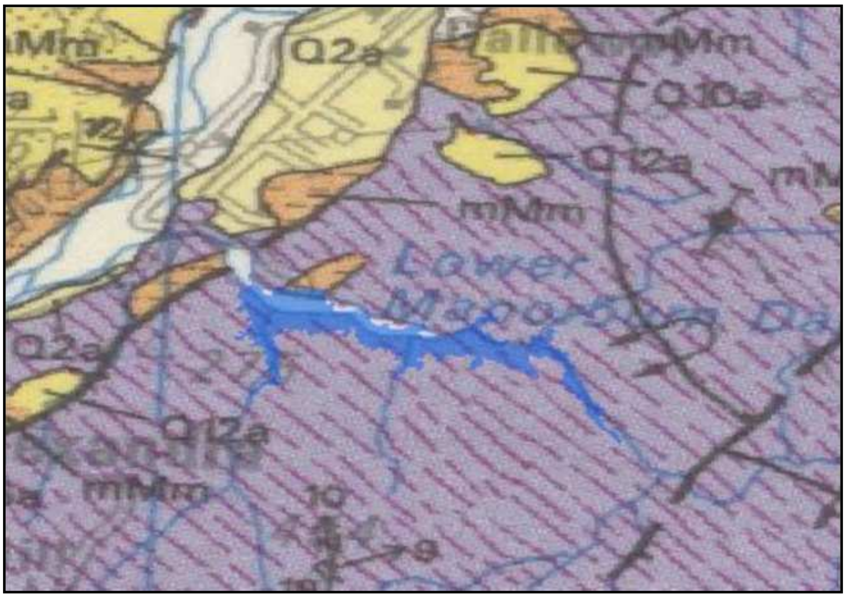

Figure 28: Lower Manor Burn dam - geology

4.4.4 Little Valley Creek West Branch dam

The topography of a dam on Little Valley Creek West Branch is illustrated in Figure 29, Figure 30 and Figure 31.

The site's geology is illustrated in Figure 32. The geology is favourable with dam abutments and foundation, and reservoir walls all schist. Reservoir walls are not steep. The risk of dam leakage or instability, or the risk of large landslides collapsing into the reservoir, is expected to be low.

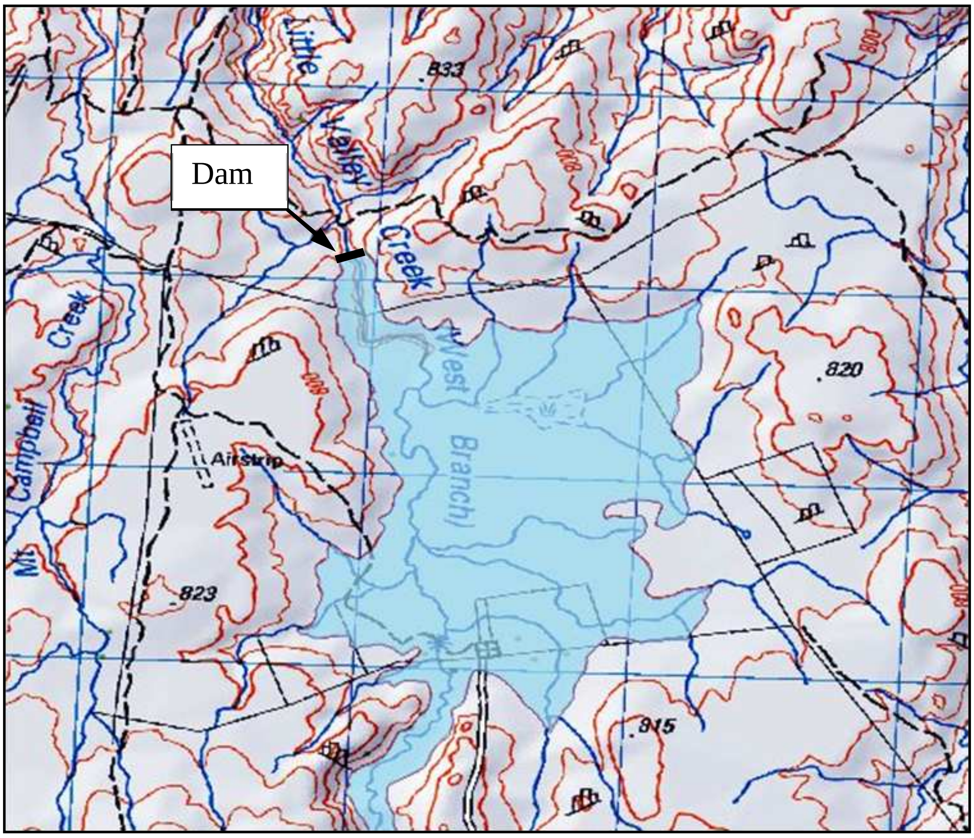

Figure 29: Little Valley Creek West dam – topography

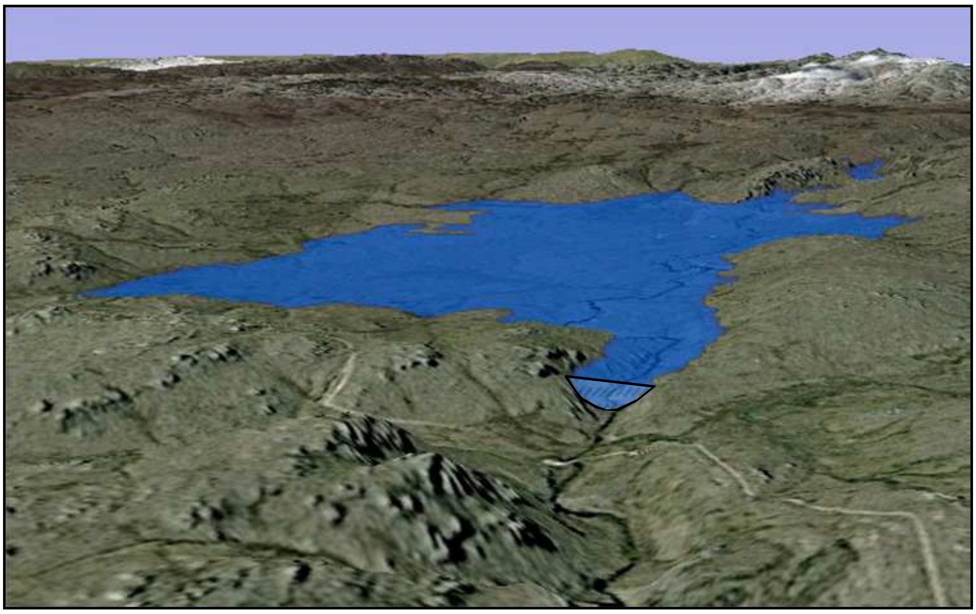
Figure 30: Little Valley Creek West dam – 3D visualisation

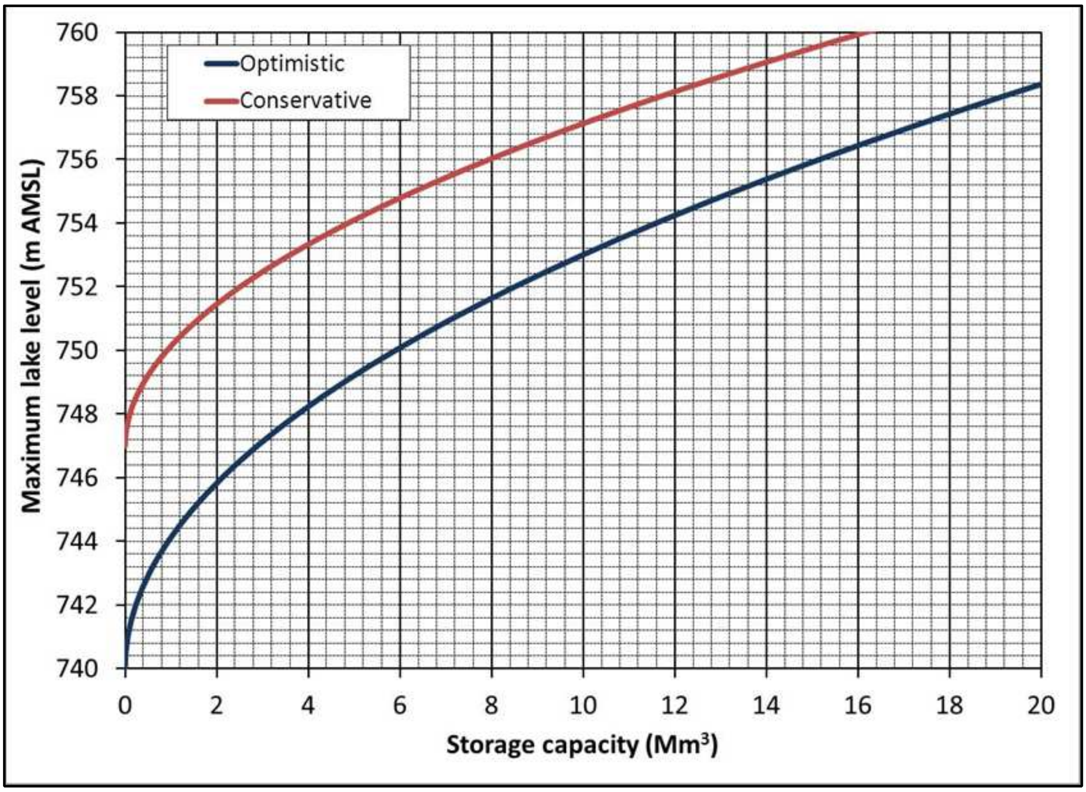

Figure 31: Little Valley Creek West dam – stage storage relationship

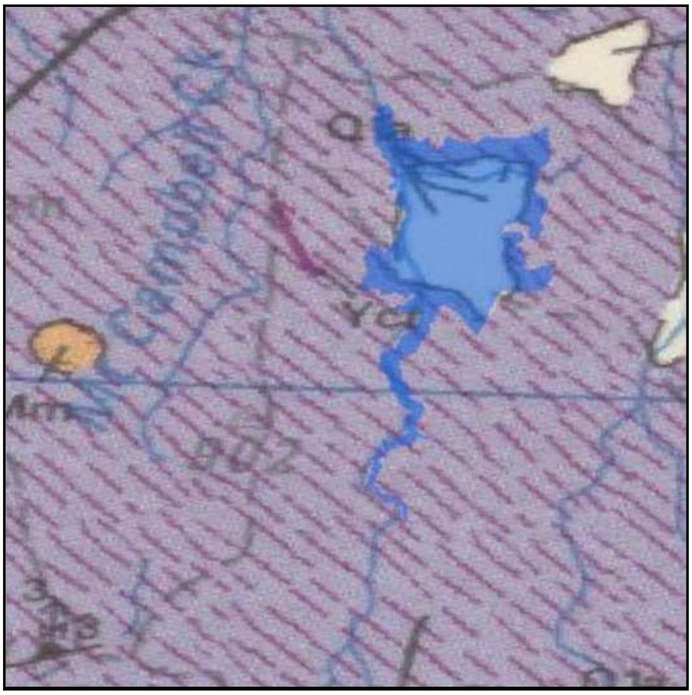

Figure 32: Little Valley Creek West dam – geology

4.4.5 Speargrass Creek dam

The Speargrass Creek dam is at the site of an existing masonry dam. This existing dam, originally known as Mr River's dam, was built in about 1901 for mining purposes (Offer 1997).

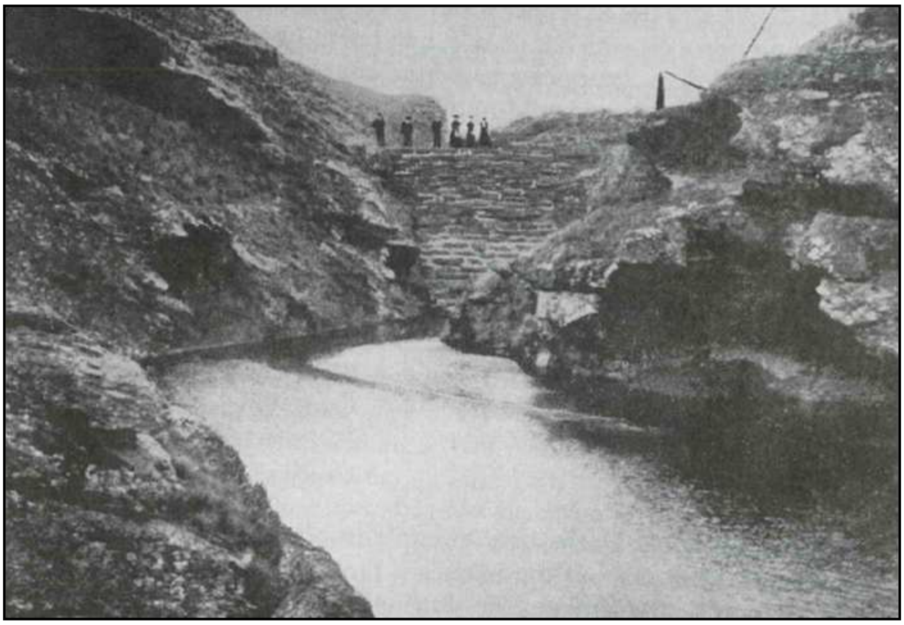

Figure 33: Existing Speargrass Creek masonry dam (Offer 1997)

The topography of a dam on Speargrass Creek is illustrated in Figure 34, Figure 35 and Figure 36.

The site's geology is illustrated in Figure 37. The abutments and foundation, and reservoir walls are all schist. Landslide debris on the east embankment would require investigation.

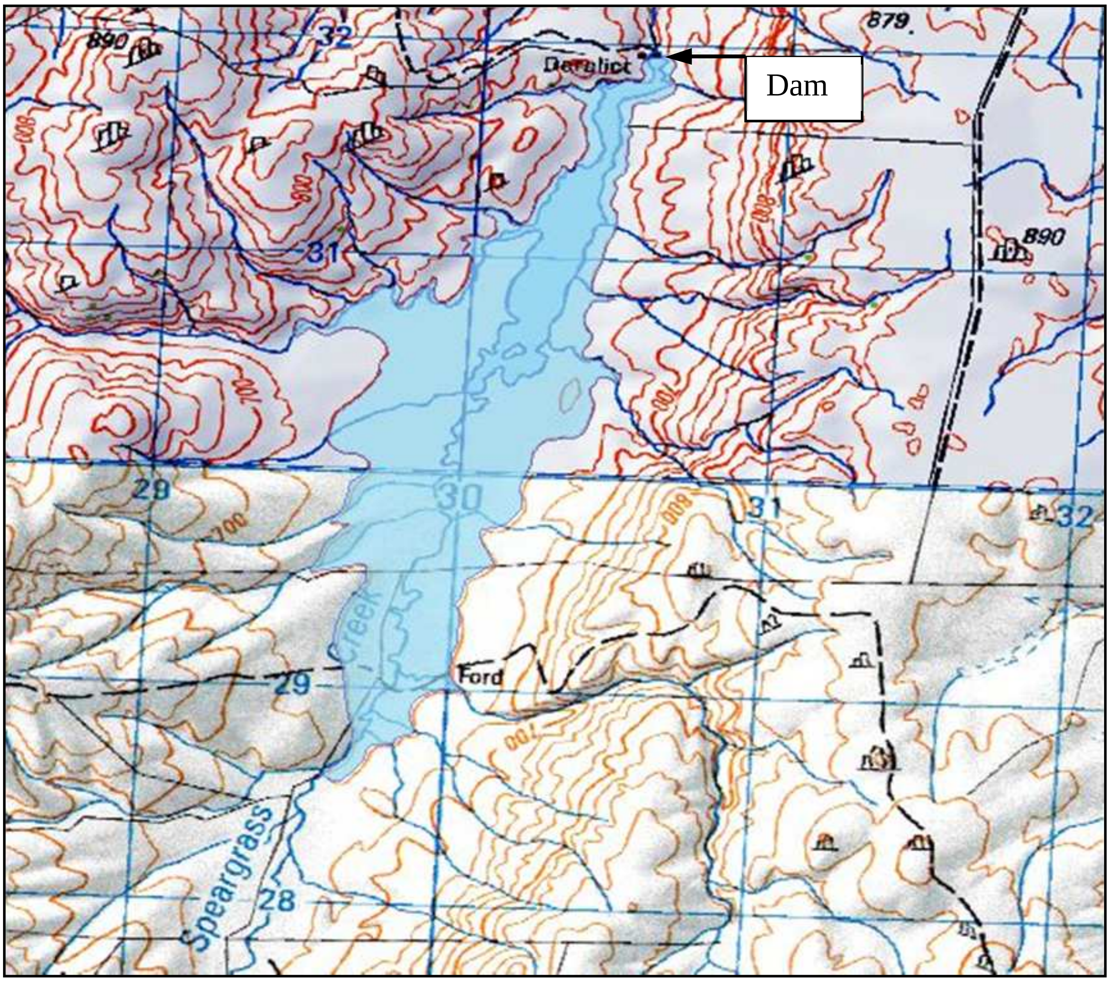

Figure 34: Speargrass Creek dam – topography

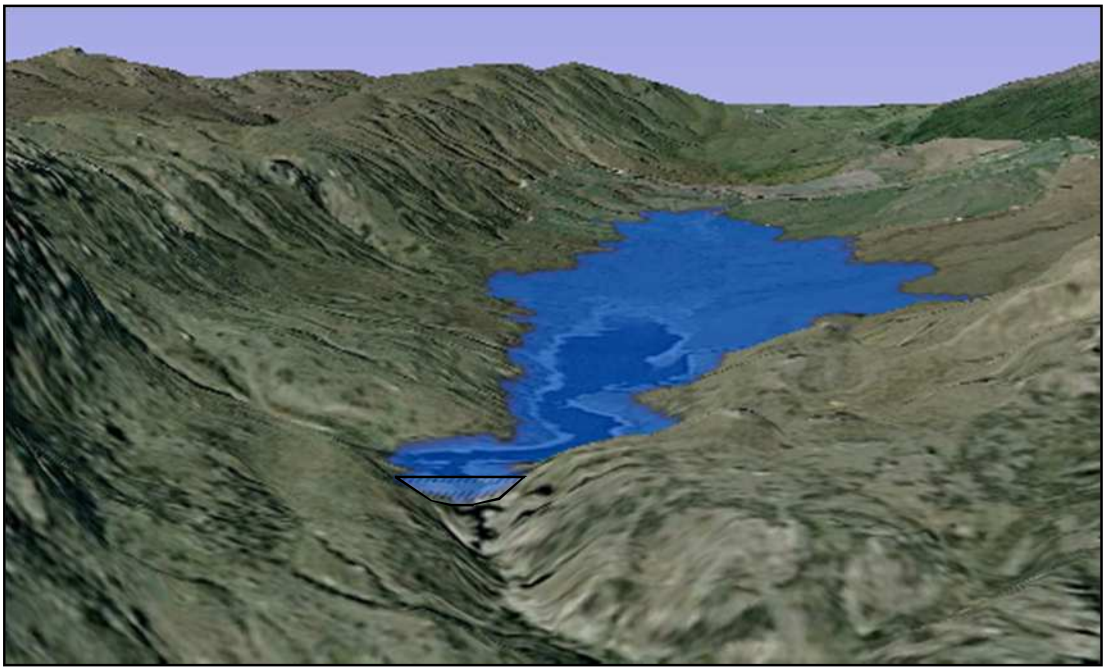
Figure 35: Speargrass Creek dam – 3D visualisation

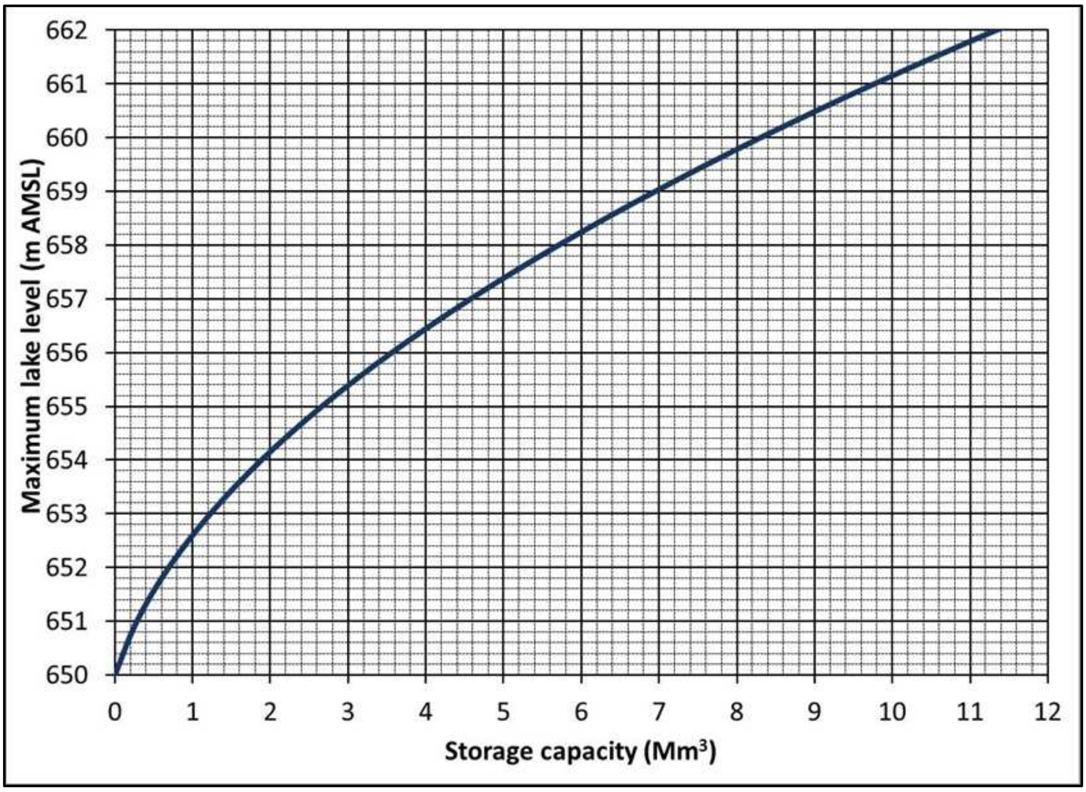

Figure 36: Speargrass Creek dam – stage storage relationship

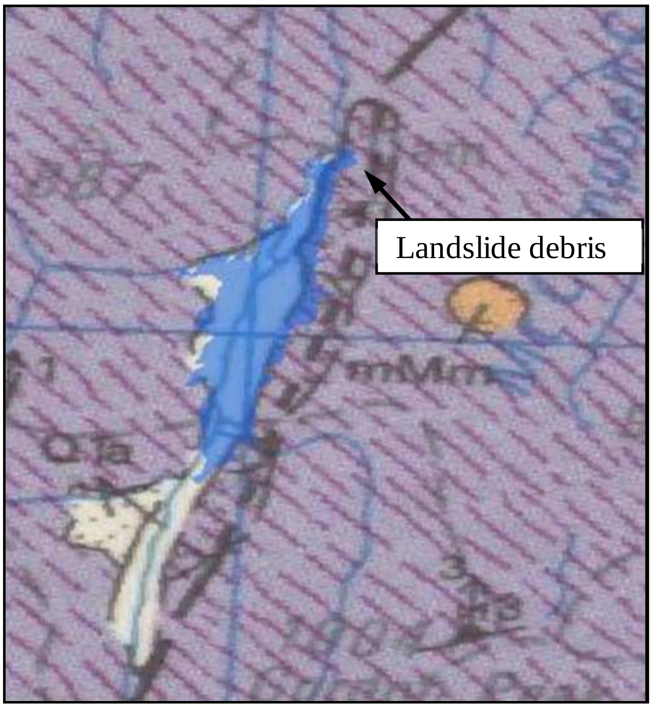

Figure 37: Speargrass Creek dam geology

4.4.6 Distribution

Galloway Irrigation's top race currently runs from north to south, towards the Lower Manor Burn reservoir. This race would need to be realigned to flow is the opposite direction. Other distribution costs should be minimal since distribution would be via the existing Galloway's distribution system.

4.4.7 Environmental

We expect environmental impacts of a dam supply to Galloway to be low. The reason is the catchment is very dry in summer. For Little Valley Creek West we suspect the river bed will naturally go dry in summer and autumn, however this requires confirmation. For the Speargrass Creek and Lower Manor Burn sites, dams already exists, therefore a new dam should not have a significant environmental impact.

4.4.8 Cost

Costs for this option are primarily associated with the construction of a new dam. We estimate a dam at the Lower Manor Burn site, with a crest height of 171 m, would indicatively cost about \$2.5 M[3]. Given a crest height of 171 m a new Lower Manor Burn dam would provide about 5.5 Mm^3 of usable storage, which should be sufficient to fully meet Galloway's current irrigation needs. Realigning the upper race could cost in the order of \$0.5M

Given a supply area of 530 ha, the per hectare cost would be about \$5,700/ha. If Galloway increased their supply area the per hectare cost would reduce. Capital costs would be off-set by the ability to reduce or eliminate scheme pumping costs. The moderate to high capital cost may create a financial challenge for existing irrigators. One possible solution may be to allow these irrigators to sell their Manuherikia water right to other irrigators further up the Manuherikia Catchment.

4.4.9 Conclusion

Our high level assessment of a dam supply to Galloway is summarised in Table 10. From this assessment we conclude a fully gravity dam supply is promising and recommend this option progress through to a more detailed Stage B pre-feasibility study.

[3] Based on an earth dam with 85,000 m^3 of fill, at a cost of \$15/m^3 (80,000 m^3×\$15/m^3 = \$1.3M). P&G, engineering, contingency, and spillway costs could add an additional \$1.2M. Alternative dam constructions may also be suitable options

Table 10: Dam supply to Galloway high level summary

Criteria	Value
Potential new water	Up to 16 Mm^3/y
Regional economic benefits	Low to medium
Cost risk	Medium to high
Uptake risk	Medium
Geological risk	Low to medium
Environmental risk	Low

4.4.10 Scope of future investigations

We recommend a Stage B pre-feasibility study on a dam supply to Galloway should cover the following topics:

- Engineering estimates of the cost of the dam on the Lower Manor Burn, Little Valley Creek West, and Speargrass Creek.
- Monthly time-step hydrological storage and demand modelling.
- An assessment of whether the Galloway command area can be increased.
- An assessment of whether there is an interest for additional irrigation water around Little Valley.
- An assessment of Galloway distribution losses, and recommendations on the costs and benefits of reducing these losses.
- Engineering costs for supplying the lower parts of Dipton Creek, currently supplied from the Upper Manor Burn dam.

The options of supplying the lower parts of Dipton Creek from Galloway rather than the Upper Manor Burn dam, and supplying additional water to Little Valley, both involve relatively small irrigated areas. These can be considered as part of a larger Galloway dam supply study.

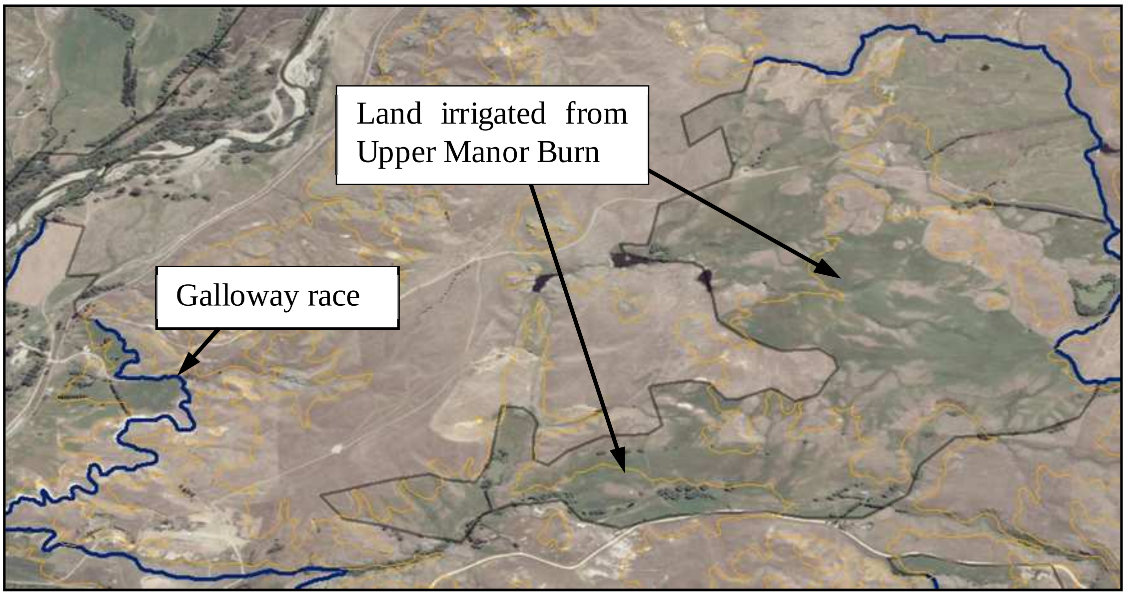

Figure 38: Option of supplying Lower Dipton Creek irrigators from Galloway rather than the Upper Manor Burn dam

Figure 39: Option of supplying additional irrigation water to Little Valley

4.5 Mt Ida dam

4.5.1 Overview

A dam near Seagull Hill on a tributary of the Ida Burn has been investigated at least twice historically. The most recent investigation was by Hamilton (2006). This dam site is generally referred to as Mt Ida dam. This option does not appear particularly promising due to high costs, water right issues associated with transferring water from the Manuherikia Valley, and geology challenges.

4.5.2 Hydrology

Hamilton (2006) estimated the dam has a storage capacity of about 15 Mm^3. Usable storage is primarily limited by inflows rather than storage capacity. Without out of catchment water we estimate the dam could optimistically provide 5 Mm^3 of usable storage in a dry year. Conservatively, reservoir leakage may mean much less water could be supplied.

The pre-feasibility study by Hamilton estimated that with Mt Ida Race water up to 2,000 ha of new irrigation could be supplied from this dam. We estimate this would indicatively require at least 10 Mm^3 of water from the Manuherikia catchment, via Mt Ida Race, in a dry year. Taking this water out of the Manuherikia catchment means less water would be available for irrigation use below Falls Dam.

4.5.3 Dam site

The topography of Mt Ida dam is illustrated in Figure 40 and Figure 41. The site's geology is illustrated in Figure 42. The geology is complex. The northern dam embankment is schist, while the southern embankment is alluvial gravel. The base of the dam is alluvial gravel. Alluvial gravel beneath, and on the southern and eastern reservoir walls means there is a significant risk of excessive reservoir leakage. Permeability testing of the gravel deposits would be required. The inactive fault near the north-west dam abutment would also require investigation.

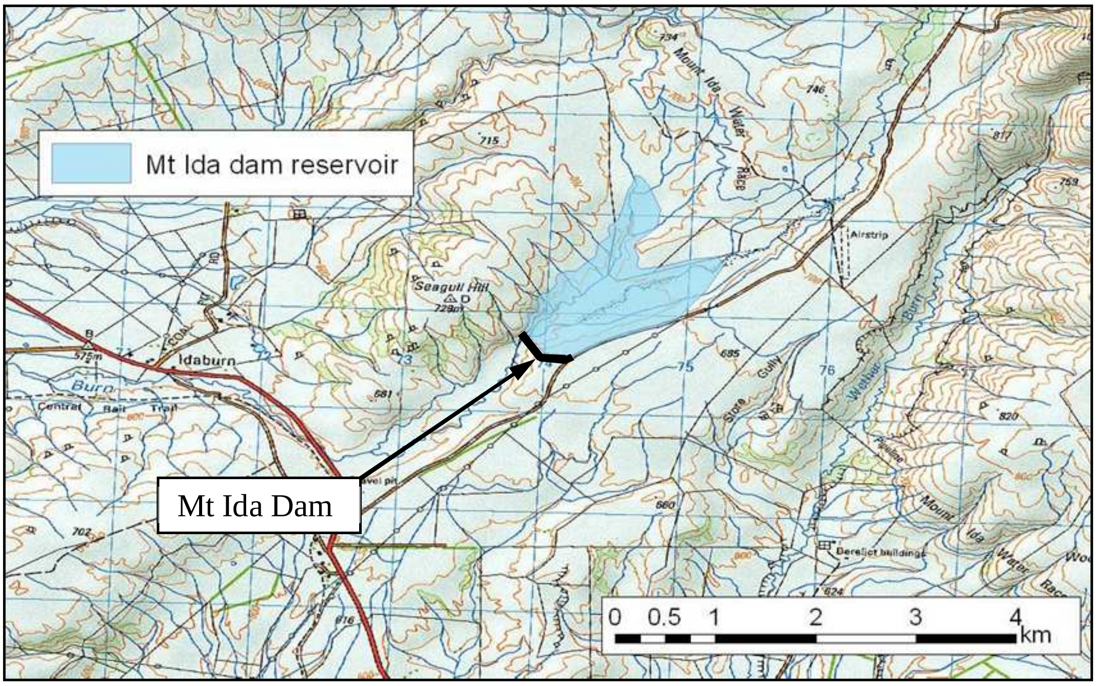

Figure 40: Mt Ida dam - topography

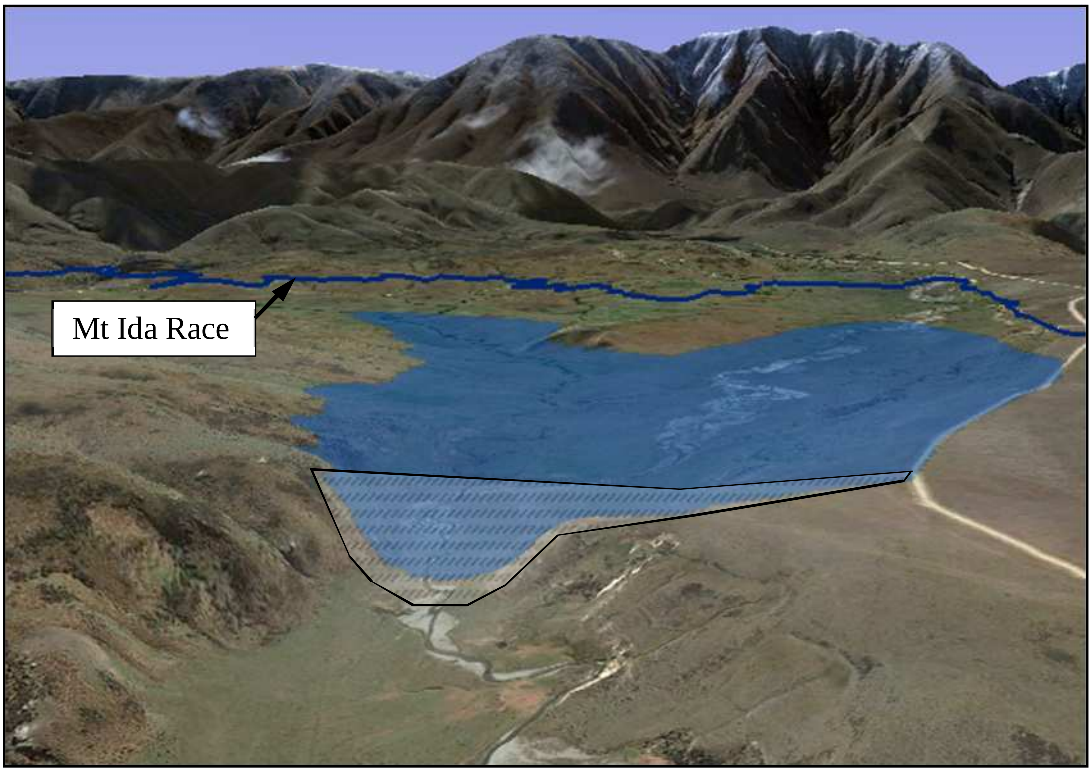

Figure 41: Mt Ida – 3D visualisation

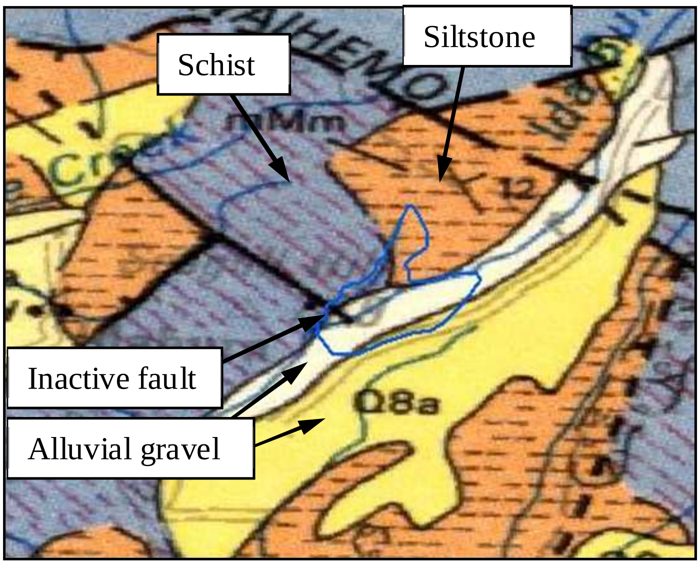

Figure 42: Mt Ida dam - geology

4.5.4 Distribution

Mt Ida dam is in the Ida Burn catchment. The previous study by Hamilton (2006) assumed water was transferred out of catchment to the Wether Burn catchment. We assumed the dam would supply the Ida Burn catchment since the scope of our study was limited to water use within the Manuherikia catchment.

4.5.5 Cost

Hamilton (2006) estimated the cost of Mt Ida dam and necessary upgrades to Mt Ida Race would cost about \$11M. In 2012 terms this is about \$13M.

We estimate the cost of gravity distribution by races within the Ida Burn catchment would be about \$4M or \$2,000/ha. We assumed some of the water would be used to fully irrigate areas that are currently only partially irrigated.

The per hectare cost of full irrigation, assuming Mt Ida Race water supplements the dam would optimistically be about \$8,500/ha. If the reservoir leaked, costs would be higher.

4.5.6 Conclusion

Our high level assessment of Mt Ida dam is summarised in Table 11. From this assessment we conclude this option is not particularly promising due to a combination of cost, water right issues associated with transferring water from the Manuherikia Valley, and geological challenges. Despite the challenges of this option, it is probably the most promising option for getting additional water to the Ida Burn catchment. We recommend the WCWSG make the final decision whether or not this option progress through to a more detailed Stage B pre-feasibility study.

Table 11: Mt Ida dam high level summary

Criteria	Value
Potential new water	15 Mm^3/y*
Regional economic benefits	High
Cost risk	High
Uptake risk	Medium
Geological risk	Medium to high
Environmental risk	Low
*10 Mm^3 of this water would need to come from the Manuherikia catchment, making less water available downstream of Falls Dam.	

4.6 On-farm storage

On-farm storage, in the absence of a natural dam site, typically costs \$3 - \$5/m^3. If the dam can only be filled in winter, the dam must have sufficient capacity to hold enough water for an entire season – typically 6,000 m^3/ha. The per hectare supply cost of full irrigation (excluding mainlines and irrigators) is therefore \$15,000 – \$30,000/ha. Consequently in most situations winter fill on-farm storage will be significantly more expensive than a supply from a community facility, if available.

Our high level assessment of winter fill on-farm storage is summarised in Table 12. We recommend this option not progress through to a more detailed Stage B pre-feasibility study.

Table 12: On-farm storage high level summary

Criteria	Value
Potential new water	Not assessed
Regional economic benefits	Low
Cost risk	Very high
Uptake risk	Low
Geological risk	Low
Environmental risk	Low

5 Efficiency improvements

5.1 Overview

In our Stage A (ii) study we concluded efficiency improvements above Ophir will not make more water available. The reason is because overall irrigation efficiency above Ophir at a catchment scale is already very high because any losses re-enter the Manuherikia River and are available for downstream use by Manuherikia and Galloway irrigation schemes.

Below Ophir we estimated irrigation efficiency is about 60% and improvements in efficiency will make additional water available for irrigation. Below Ophir, irrigation losses are from three main sources:

- Manuherikia Irrigation Scheme distribution losses.
- Galloway Irrigation Scheme distribution losses.
- On-farm losses.

5.2 Manuherikia Irrigation Scheme distribution losses

We suspect Manuherikia Irrigation scheme distribution losses are in the order of 30% of their take, which is typical for schemes of this age. This corresponds to a flow rate of about 760 l/s[4]. Through automatic flow control gates and lining leaky race sections some of this water could be saved, thereby allowing Manuherikia Irrigation scheme to increase their irrigated area. Assuming 80% of this water (600 l/s) could be saved; Manuherikia Irrigation could increase their irrigated area by about 1,200 ha.

Indicatively, efficiency improvements could cost in the order of \$1M - \$2M. This excludes costs associated with replacing assets that are already at the end of their economic life. The per hectare cost of new irrigation would therefore be about \$800/ha to \$1,700/ha.

Our high level assessment of this option is summarised in Table 13. From this assessment we conclude improving Manuherikia Irrigation Scheme distribution losses is promising and recommend this option progress through to a more detailed Stage B pre-feasibility study.

Table 13: Improving Manuherikia Scheme distribution losses high level summary

Criteria	Value
Potential new water	8 Mm^3/y
Regional economic benefits	Medium
Cost risk	Low
Uptake risk	Low
Geological risk	Low
Environmental risk	Low

[4] 2,550 l/s (90% reliable flow from Aqualinc (2012b))×30% = 760 l/s.

We recommend a Stage B pre-feasibility study on improving Manuherikia Irrigation Scheme distribution losses should cover the following topics:

- Mapping distribution systems
- A water audit for the scheme, including more accurately identifying the actual area of irrigation, leakage losses, bywash losses, and on-farm losses.
- Price estimate of upgrades.

5.3 Galloway Irrigation Scheme distribution losses

We recommend Galloway Irrigation Scheme distribution losses are best investigated as part of the Galloway dam supply option. If a new dam has sufficient water to fully meet Galloway's current and future needs, there may be fewer benefits in improving distribution efficiency. Conversely, some efficiency improvements may free up water at a relatively low cost, therefore even with a dam there may be benefits in making these improvements. Without a dam supply, the reasons why it is advantageous to improve Manuherikia Irrigation Scheme distribution efficiency will also apply to Galloway.

5.4 Lower Manuherikia on-farm losses

Reducing on-farm losses generally requires the installation of spray systems. The advantage to farmers can be increased production and an expanded area of irrigation. Farmers need to balance these benefits against the higher capital and on-going pumping cost of spray systems.

Improvements in on-farm efficiency may also have an impact on downstream water quality.

On-farm spray system technology is well established and does not in general involve complex engineering. Our view is that further Stage B engineering investigations on the topic of on-farm efficiency is not necessary.

6 Clutha River water

The Clutha River represents a potential run of river water source for supplying parts of the lower Manuherikia catchment. The Clutha has a mean flow of 490 m^3/s at the Clyde Dam, which is over 25 times greater than Manuherikia River flows. Only a fraction of the Clutha River water has been allocated for abstractive use and consequently there is currently little abstractive pressure on the Clutha River. The area that can be irrigated from the Clutha River is primarily limited by the area that can be feasibly, irrigated rather than water availability. Feasibility is constrained by elevation and conveyance costs.

Supplying parts of the Lower Manuherikia catchment using Clutha River water has been discussed for many years. A recent engineering pre-feasibility study by OPUS (2010) investigated a pumped pipe scheme supplied from Lake Dunstan through Dairy Creek, extending as far as Tiger Hill. This scheme had a design flow of 3.8 m^3/s[5], and an irrigated area of between 6,500 – 8,300 ha out of a potential command area of 10,900 ha.

An alternative to a pumped pipe scheme is a gravity pipe scheme supplied from Lake Dunstan. A gravity scheme could supply the flats between Clyde and Alexandra – a net irrigable area of about 900 ha.

A large portion of the water used by the Manuherikia and Galloway irrigation schemes is irrigation drainage water from irrigation upstream of Ophir. The existing synergy between upper and lower Manuherikia irrigators needs to be considered when assessing the amount of area to supply from the Clutha River.

6.1 Lake Dunstan pumped pipe scheme

OPUS (2010) proposed two irrigated area options. Option 1 had an irrigated area of 8,300 ha and would require existing Manuherikia and Galloway irrigation scheme irrigators to be supplied from the new pumped scheme. The financial challenge for existing irrigators is they would need to give up a gravity scheme with low water charges and reasonably good reliability in favour of a very expensive pumped scheme. Option 2 had an irrigated area of 6,500 ha and assumed existing Manuherikia and Galloway irrigation scheme irrigators, and a reduced area of new irrigable land, would be supplied from the new scheme.

The major challenge with a pumped pipe scheme is the cost; the cost risk is very high.

Our high level assessment of OPUS's 6,500 ha pumped pipe scheme is given in Table 14. This option has already been assessed to a pre-feasibility level. Results of this pre-feasibility assessment can be incorporated into a summary report once other Stage B pre-feasibility investigations have been completed.

[5] Averaged over a 24 hour period.

Table 14: Lake Dunstan pumped pipe scheme high level summary

Criteria	Value
Potential new water	45 Mm^3
Regional economic benefits	High
Cost risk	Very high
Uptake risk	High
Geological risk	Low
Environmental risk	Low

6.2 Lake Dunstan gravity pipe scheme

A gravity pipe scheme from Lake Dunstan could supply the flats between Clyde and Alexandra. This land is all below an elevation of 180 m amsl, whereas Lake Dunstan has a minimum water level of 193.5 m amsl. A potential command area and trunk main pipe alignment is shown in Figure 43. The gross irrigable area shown is 1,100 ha. Assuming 80% of this area is irrigated, the net supply area would be about 900 ha.

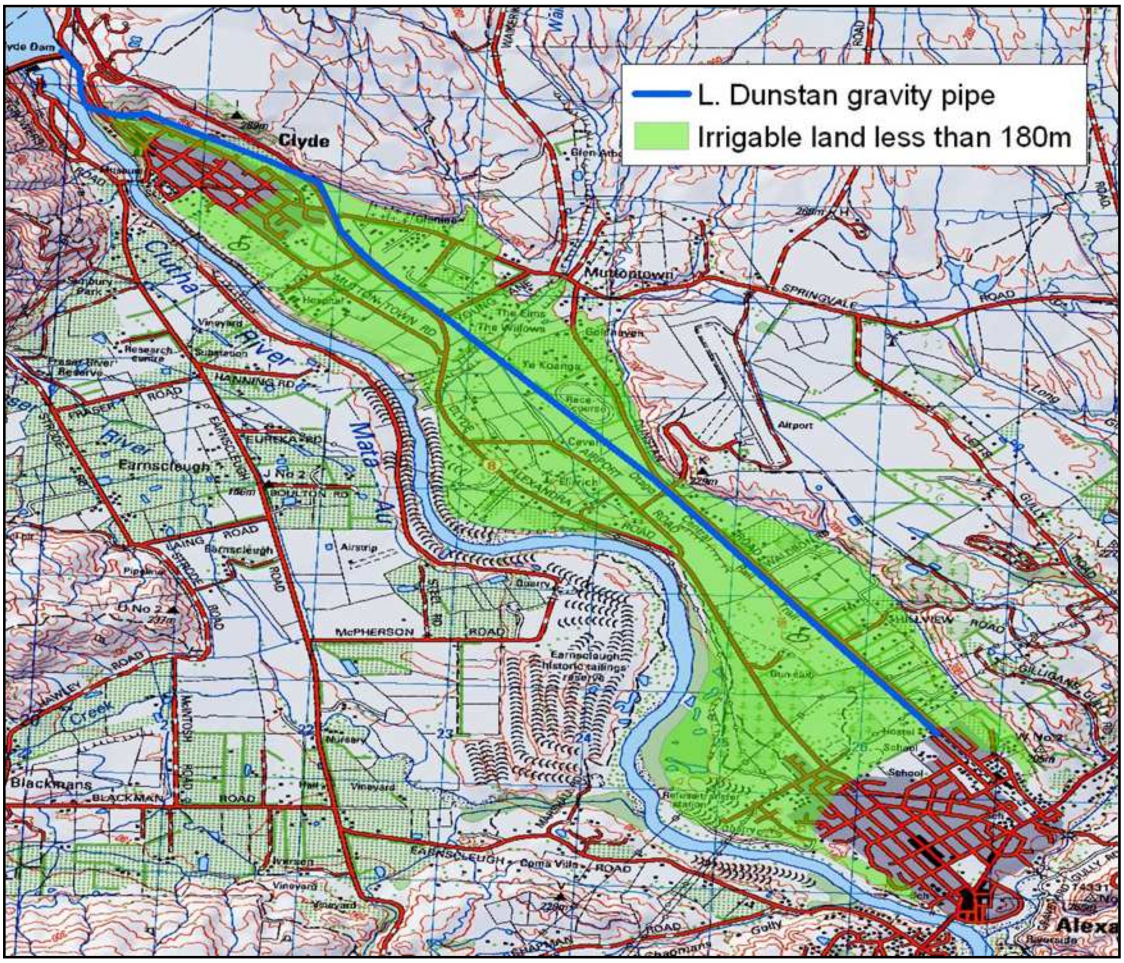

Figure 43: Lake Dunstan gravity pipe scheme

We estimate the scheme would cost \$4,000/ha - \$6,000/ha. This price estimate is based on recent gravity piped schemes either under construction or recently built in Canterbury.

Some of this area in Figure 43 is already supplied from the Manuherikia Irrigation Scheme. The moderate to high capital cost may create a financial challenge for existing irrigators. One possible solution may be to allow these irrigators to sell their existing water right to other irrigators within the Manuherikia Irrigation Scheme or further up the Manuherikia Catchment.

A gravity pipe scheme could also provide water to Alexandra. This is particularly attractive given the current water quality problems with Alexandra's existing water source.

Our high level assessment of this option is summarised in Table 15. From this assessment we conclude a gravity piped supply from Lake Dunstan is promising and recommend this option progress through to a more detailed Stage B pre-feasibility study.

Table 15: Lake Dunstan gravity pipe scheme high level summary

Criteria	Value
Potential new water	6 Mm^3
Regional economic benefits	Medium
Cost risk	Medium to high
Uptake risk	Medium
Geological risk	Low
Environmental risk	Low

We recommend a Stage B pre-feasibility study on a piped gravity scheme from Lake Dunstan cover the following topics:

- Pipe sizes, alignments and engineering cost estimates.
- Potential uptake risk given the mix of land use.
- An assessment of Alexandra's water needs, and whether or not Lake Dunstan water would offer improved water quality over the existing source.

7 Conclusion

In conclusion, we recommend the following Stage B pre-feasibility investigations:

Raise Falls Dam:

- Engineering estimates of raising the dam 6 m, 15 m, and 27 m.
- Daily time-step hydrological storage and demand modelling.
- Distribution alignments and costs. Command area options should at least consider an enlarged Omakau scheme (see Figure 6), an enlarged Blackstone scheme, water to Ida Valley, and additional water to the Lower Manuherikia catchment.
- An assessment of the environmental impacts (positive and negative) of lake inundation and a change in the flow regime downstream of the dam.
- An assessment of the environmental impacts of an expanded area of irrigation.
- Hydropower options, including modelling the option for a portion of the lake storage to be reserved for maximizing electricity revenue.
- Small dam(s) on Lauder and Thomsons Creek.
- Iwi consultation.

Lower Hope Creek dam supplying Ida Valley:

- Engineering estimates of the cost of the low dam (647 m crest with pumping) and high dam (654 m crest without pumping), and conveyance costs to the Bonanza Race.
- Monthly time-step hydrological storage and demand modelling.
- Review of Ida Valley Irrigation distribution system, and the capacity to accommodate the additional water.
- Engineering costs of reducing existing leakage in the Bonanza Race.
- An assessment of the environmental impacts of land use intensification.
- Iwi consultation.

Improve Manuherikia Irrigation Scheme distribution efficiency:

- Mapping distribution systems
- A water audit for the scheme, including more accurately identifying the actual area of irrigation, leakage losses, bywash losses, and on-farm losses.
- Price estimate of upgrades.

Lake Dunstan gravity piped supply:

- Pipe sizes, alignments and engineering cost estimates.
- Potential uptake risk given the mix of land use.
- An assessment of Alexandra's water needs, and whether or not Lake Dunstan water would offer improved water quality over the existing source.

Galloway dam supply:

- Engineering estimates of the cost of the dam on the Lower Manor Burn, Little Valley Creek West, and Speargrass Creek.
- Monthly time-step hydrological storage and demand modelling.
- An assessment of whether the Galloway command area can be increased.
- An assessment of whether there is an interest for irrigation water around Little Valley.
- An assessment of Galloway distribution losses, and recommendations on the costs and benefits of reducing these losses.
- Engineering costs for supplying the lower parts of Dipton Creek, currently supplied from the Upper Manor Burn dam.

8 References

Aqualinc (2012a). "Manuherikia Catchment Study: Stage 1". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12040/1. March 2012.

Aqualinc (2012b). "Manuherikia Catchment Study: Stage 2". Report prepared by Aqualinc Research Ltd for the Manuherikia Catchment Water Strategy Group. Report C12040/2. April 2012.

Ellis, D. (2009). "The small dams of Central Otago: A history of the small dams that were built to provide irrigation and electricity for the people of the area". ISBN 978-0-908960-53-8

Offer, R.E. (1997). "Walls for water: Pioneer dam building in New Zealand". Dunmore Press Ltd, Palmerston North. ISBN 0-86469-313-3

OPUS (2010). "Lower Manuherikia Valley Water Resources Study: Summary document for discussion brief." Report prepared for the Manuherikia Irrigation Co-operative Society Ltd by Opus International Consultants Ltd. August 2010.

Hamilton, D.J. (2006). "Mt Ida Dam investigation feasibility study report including simulation for water storage and piped irrigation reticulation." Report prepared for Hawkdun Ida Burn Irrigation Co. Ltd. by David Hamilton & Associates Ltd.