August 2015

REPORT

SUMMARY REPORT

Manuherikia Catchment Feasibility Study

Submitted to:
Manuherikia Catchment Water Strategy Group
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PO Box 302
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Report Number: 1378110270-2000-R-Rev0-224

Distribution:

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Executive Summary

Background

The Manuherikia Catchment Water Strategy Group (MCWSG) commissioned a Feasibility Study, (summarised in this report), to assess the technical, environmental, economic and financial feasibility of five water development options which are aimed at developing and implementing cost effective, efficient and sustainable options for water users within the Manuherikia River catchment. Three options involve raising the impoundment of Falls Dam by 5.4 m, 15.2 m, or 27 m, through either building a new dam or raising the existing dam. The fourth option considered improving the efficiency of irrigation within the Manuherikia Valley by developing efficient water distribution systems. The fifth option is the construction of a new dam (the Mount Ida Dam) on the upper Ida Burn. In addition to the five main options a preliminary assessment has been completed on the proposed Hopes Creek Dam which would supply water to the Ida Valley. Key locations and water management infrastructure within the study are shown in the figure on page ii.

The Feasibility Study was separated into five interconnected components based on discipline (Hydrology, Geotechnical and Engineering, Water Allocation and RMA Planning, Environmental and Economic and Commercial). The relationship between the components and various key documents that make up the overall feasibility study are shown in the figure on page iii.

Hydrological assessment

Hydrological models were used to assess various development scenarios, including the existing reservoir impounded by Falls Dam, but under increased minimum flow regimes, the various larger reservoirs impounded by larger dams at the site of Falls Dam and a proposed new reservoir on the Upper Ida Burn. The modelling indicates that annually it is not a lack of water within the Manuherikia Catchment, but rather the seasonality of flows and the lack of storage, that are the critical issues. The models were used to support a collaborative stakeholder process to assess potential flow regimes under the 27 m raise option for Falls Dam. The model predicts that the large reservoir associated with a 27 m raise of Falls Dam would reliably fill and together with run of river takes would allow reliable spray irrigation of 20,500 ha above Ophir (excluding the Ida Valley) and a further 4,500 ha below Ophir while also allowing for an increased minimum flow regime.

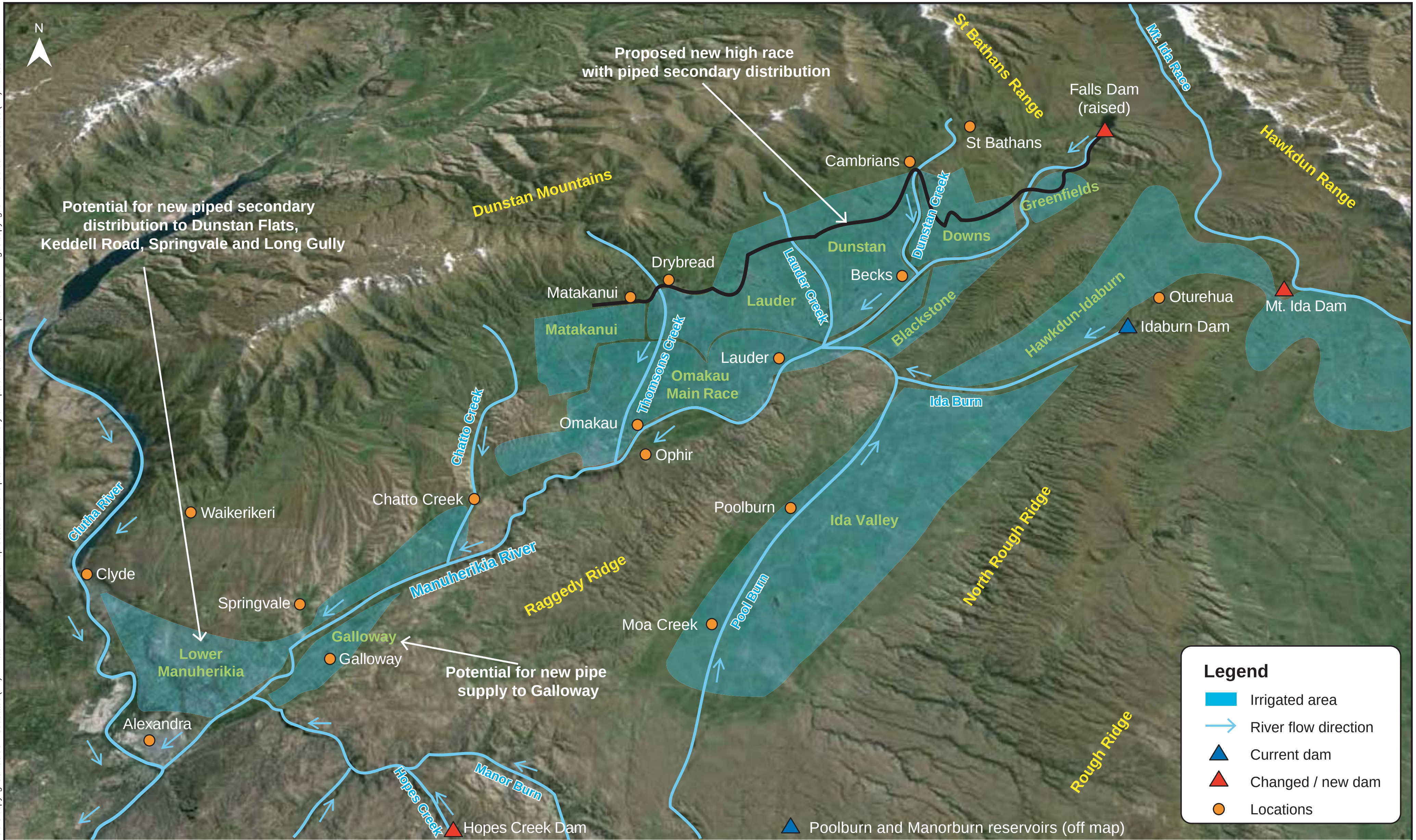
The models were also used to evaluate the efficiency of some preliminary scenarios incorporating an alternative, intermediate impoundment volume at Falls Dam that may be closer to optimal than the three original Falls Dam options. These preliminary scenarios suggest that if reduced supply reliability is acceptable, then substantially less water storage (in the order of 70 - 80 Mm^3 of live storage achieved by a 20 - 22 m impoundment raise) is required at Falls Dam. This would reduce total storage costs.

Storage options

Falls Dam:

Feasibility level designs and costs estimates were prepared for the three options for enlarging the impoundment at Falls Dam. Engineering assessment of both dam stability and construction methodology were focused on the large (27 m) raise option for Falls Dam and construction of a new Roller Compacted Concrete (RCC) dam located downstream of the current dam. The findings from the large (27 m) raise option were then applied to the mid (15.2 m) and low (5.4 m) raise options for Falls Dam which meant that the mid and low raise options were progressed as new RCC dams downstream of the existing dam. The cost estimates for the three RCC dam options (outlined in the table on page iv) are substantially more than proposed in the prefeasibility study.

An optimisation process was completed to review the dam designs with the goal of identifying potential cost savings and a potential optimised dam design and location. The optimised RCC dam is expected to have the following characteristics:



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TITLE MANUHERIKIA OVERVIEW MAP

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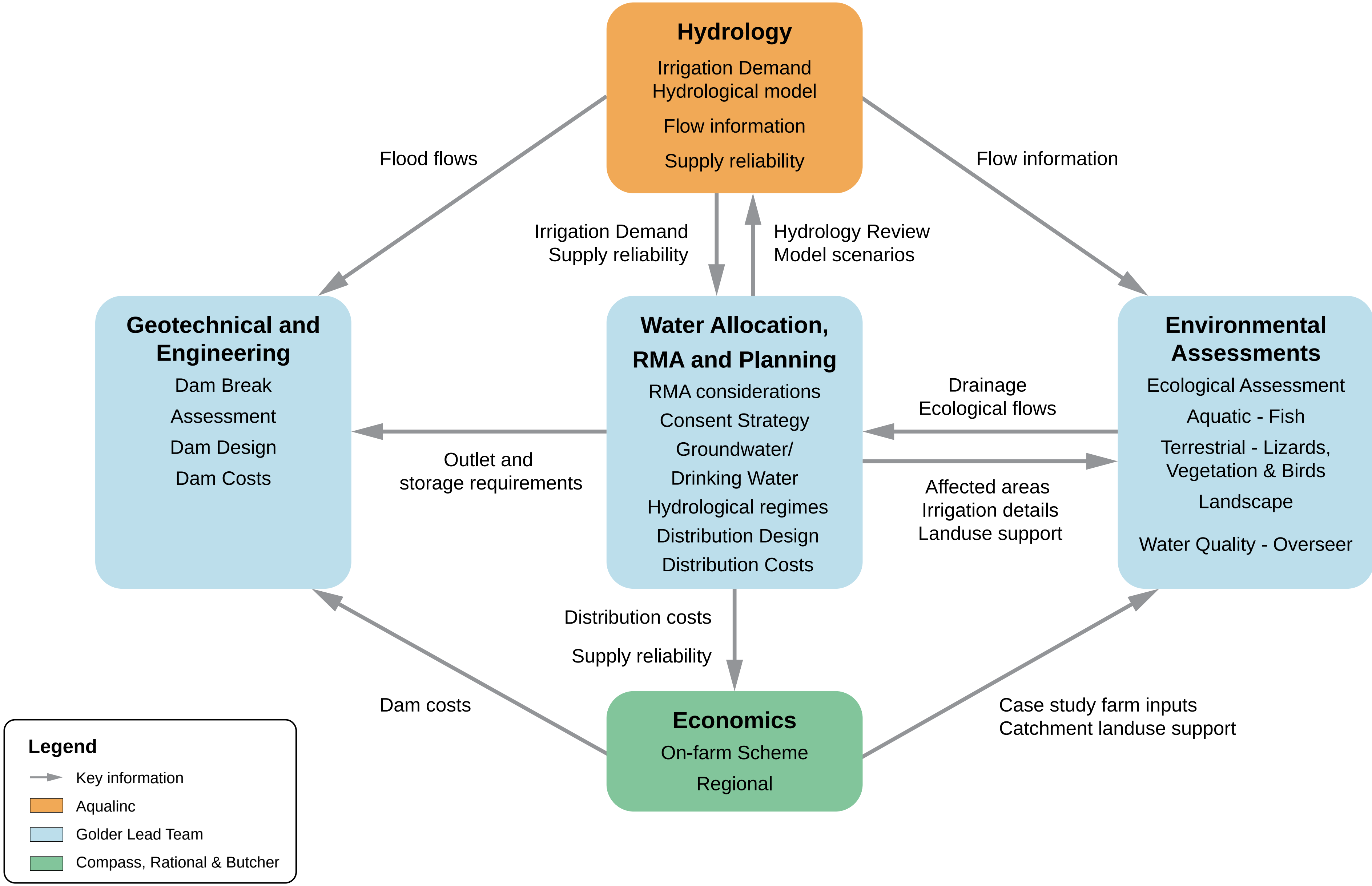

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Water development options details and costs.

Parameter		Falls Dam				Mt Ida Dam	Hopes Creek Dam
		Current	**5.4 m raise**	**15.2 m raise**	**27 m raise**		
Dam type		CRFD	RCC	RCC	RCC	Earth Embankment	CRFD or RCC
Location			Downstream of existing powerhouse	Downstream of existing powerhouse	Downstream of existing powerhouse	Seagull Hill Upgrade of Mount Ida Race required	Gorge below Stone Hut Flat
Usable Storage (Total storage) (Mm^3)		10.0 (10.3)	19.0 (20.6)	50 (51.6)	114.1 (119.0)	14.6 (15.6)	15 (19)
Storage costs ($M[1])	Base Construction Cost (BCS)		62.5	84.9	116.3	10.6	25.0 (33.6)
	Construction Management (7 % of BCS), Engineering and Design (10 % of BCS) Bonds and Insurance (5 % of BCS) Consenting (2 % of BCS)		14.6	20.4	27.9	3.9	6.5 (8.7)
	Direct Construction Cost (DCS)		77.1	105.3	144.2	14.5	31.5 (42.3)
	Uncosted Items (35 % of DCS[2])		27.0	36.8	50.5	5.1	11.0 (14.8)
	Total Estimated Preliminary Project Costs		104.1	142.1	194.7	19.6	42.5 (57.2)
Cost per m^3 usable storage ($/$m^3$)			5.5	2.8	1.7	1.3	2.8 (3.8)
Area Irrigated[3] (ha)		~11,500	~11,500	~16,000	~25,000	Additional ~2,000 in Hawkdun/Idaburn	Additional ~3,000 in Ida Valley
Storage Cost per hectare[4] ($/ha)			9,100	8,900	7,800	9,800	14,200 (19,100)
Reliability Comment		Poor	High	High	High	High	Significant improvement on current
Distribution comment		Existing network needs upgrading and maintenance	Uses existing network which needs upgrading and maintenance	New High Race to Lauder Creek plus upgrade of existing. Potential for some pressurised supply	New High Race to Matakanui Station plus upgrade of existing. Potential for significant pressurised supply	Distribution system required not included in assessment.	A pumped rising main and a new race to feed into upper Bonanza race required.

Notes: 1) Costs are rounded up to the nearest $100,000 and exclude GST.
2) The 35 % contingency for uncosted items is based on experience from similar large water projects at feasibility stage design.
3) Unless stated irrigated area is within the Manuherikia Valley only (i.e. excludes Ida Valley). The irrigated area is based on spray irrigation and is based on hydrological model results.
4) Assumes storage costs spread evenly over area irrigated. Estimated storage costs per hectare are rounded up to the nearest $100 and exclude GST.

- A full supply level of between 585.0 m (19.8 m raise with usable storage of ~70.5 Mm^3) and 587.4 m (22.2 m raise with usable storage of ~83.6 Mm^3).
- Be located between the toe of the current dam and the existing power station.
- A downstream slope for the RCC embankment of between 0.8H:1V and 1H:1V.
- Have an overtopping spillway down the centre left of the dam, thereby allowing for an offtake structure on the right abutment.

<u>Mount Ida Dam:</u>
The feasibility investigations have identified a number of issues with the proposed Mount Ida Dam including increased seismic risk, weak clay material below the terrace on the true left (eastern) bank of the dam site and estimated high construction costs.

<u>Hopes Creek Dam:</u>
Preliminarily assessments indicated that either a Concrete Faced Rockfill Dam (CFRD) or a RCC dam are potentially suitable options for the Hopes Creek Dam. Conceptual designs for both a 41 m high CFRD and a similar height RCC dam have been prepared. Design and overall feasibility of the proposed Hopes Creek Dam is strongly linked to the stage storage curve, the available inflows, and irrigation demand. Further work is required to confirm the hydrology of the proposed dam site and the potential supply reliability benefits to the Ida Valley Irrigation Scheme.

Distribution Options

A distribution assessment identified various potential distribution scenarios for each of the five irrigation development options on a scheme by scheme basis. In assessing the various irrigation development options, current and potential irrigators need to consider the development as a whole, including: storage, distribution, on-farm development, water management and scheme operation. The various distribution options identified provide differing levels of service, particularly in regard to the provision of pressurised versus non-pressurised water, which need to be considered when comparing options. The table on page vi summarises the distribution development options.

Environmental considerations

<u>Storage reservoirs:</u>
The upper Manuherikia River valley supports a significant array of indigenous plants, birds, lizards and fish. The braided river habitat in the upper Manuherikia River valley provides the only habitat for the Manuherikia alpine galaxias and habitat for a number of threatened braided river birds. Additionally, the Manuherikia River gorge immediately downstream of Falls Dam and gullies to the east of Falls Dam provide good habitat for threatened plants and lizard species. All options to raise Falls Dam will increase inundation of the braided river system. This habitat loss will have impacts on the Manuherikia alpine galaxias and the nesting area of the nationally critically threatened black-billed gull. A proportion of the nesting habitat of the nationally endangered black fronted tern will also be lost as will some threatened plants and a portion of high value lizard habitat around the reservoir edge.

The Mt Ida dam and reservoir site has been assessed as having relatively low environmental values and mitigation is considered limited or not necessary.

The preliminary assessment of the Hopes Creek Dam did not considered environmental issues.

<u>Irrigated area:</u>
The principal environmental concerns regarding the irrigated area are:

- Ensuring that remaining areas of indigenous vegetation and high biodiversity are suitably protected.
- Flow regimes are developed for the areas waterways which suitably consider instream values.
- That land use intensification is managed to ensure existing water quality is maintained or enhanced.

The highly modified valley floors of the Manuherikia and Ida valleys provide little indigenous species habitat. However, any remaining areas of indigenous vegetation and particularly saline wetlands are of high value.

Catchment summary of distribution scenarios.

Irrigation Scheme[1]	Distribution scenarios	Irrigated area (ha)	Capital Cost ($)	Annual Operational Cost[2] ($)	Reliant on increased storage	Relevant Irrigation development option	Comments[3]
Galloway (GIS)	Pumped Open Race (Status Quo unpressurised supply)	520	410,000 (800/ha)	210,000[4] (390/ha)	No	Status Quo	Current supply reliability is sufficient to support on-farm spray irrigation and distribution development. Given the existing power arrangement, a move to pumped piped supply from the Manuherikia River is supported. If Keddell Road pipe goes ahead as part of MIS developments then investigate the potential of gravity supply from MIS main race. If Hopes Creek Dam goes ahead investigate shifting supply to the Lower Manorburn Dam. Costs exclude consideration of the Lower Manorburn Dam.
	Pumped piped pressurised supply from Manuherikia	550 (potentially more)	1,930,000 (3,500/ha)	160,000[4] (290/ha)	No	4 (Efficient Distribution)	
Manuherikia (MIS)	Open Race (Status Quo excludes areas below)	3,600	3,620,000 (1,000/ha)	230,000 (70/ha)	No	Status Quo excludes Dunstan Flats etc.	Current supply reliability sufficient to support on-farm spray irrigation and distribution development. Development of a gravity piped supply to Dunstan Flats, Keddell Road, Springvale and Long Gully areas is supported. Investigate the potential to tie the Keddell Road pipeline in with a gravity supply to the GIS. Reduced use of the Borough Race and transfer of the take to the main intake from the Manuherikia River should be investigated as it will simplify scheme operation, reduce maintenance and maximise the area that can be supplied with gravity pressurised water.
	Gravity pipe Dunstan Flats	500	3,150,000 (6,300/ha)	70,000 (140/ha)	No	4 (Efficient Distribution)	
	Gravity pipe Keddell Road, Springvale etc.	600	1,420,000 (2,400/ha)	70,000 (120/ha)	No	4 (Efficient Distribution)	
Blackstone (BIS)	Open Race (Status Quo unpressurised supply)	660	410,000 (600/ha)	70,000 (110ha)	No	Status Quo & 2 (Falls Dam low raise)	Current supply reliability is relatively poor which will limit development of spray irrigation to the area with secure peak of season water supply. Falls Dam High, Mid and Low raises increase supply reliability allowing increased spray irrigation. A gravity piped supply is possible but expensive. Focus development on-farm initially then on improving supply reliability.
	Gravity pressurised pipe supply from new High Race	1,200 (potentially more)	6,480,000 (5,400/ha)	50,000 (40/ha)	Yes	1 and 3 (Falls Dam mid and high raise)	
Omakau (OIS)	Main Race status quo (unpressurised supply)	3,759	3,830,000 (1,000/ha)	160,000 (40/ha)	No	Status Quo & 2 (Falls Dam low raise)	Current supply reliability is relatively poor (particularly for the Lauder, Matakanui and County parts of the OIS) which will limit development of spray irrigation to the area with secure peak of season water supply. Development of spray irrigation on-farm only for areas with secure peak of season water supply. Falls Dam High, Mid and Low raises increase supply reliability allowing increased spray irrigation. A gravity piped supply to the Becks Flat area from the Blackstone Race is possible and should be investigated further. Focus development on-farm initially then on improving supply reliability. Investigate potential to supply Matakanui extension area from expanded OIS main race.
	Dunstan, Lauder, Matakanui and County status quo (unpressurised supply)	2,083	2,320,000 (1,100/ha)	280,000 (130/ha)	No	Status Quo	
	Main Race expanded capacity (unpressurised supply)	6,000[5]	10,670,000 (1,800/ha)	160,000 (30/ha)	Yes	1 and 3 (Falls Dam mid and high raise)	
	Gravity pipe to Becks Flats	600	2,790,000 (4,700/ha)	10,000 (20/ha)	No	Status Quo	
High Race	High Race to Matakanui Station Boundary piped secondary distribution.	14,100[5] (~ 8,000[5] pressurised supply)	63,880,000 (4,500/ha)	230,000 (20/ha)	Yes	1 (Falls Dam high raise)	High race associated with Falls Dam Mid and High raises, would increase supply reliability allowing increased spray irrigation. Falls Dam High raise allows High Race to replace all irrigation from Dunstan, Lauder, Thomsons Creeks and associated tributaries. Falls Dam Mid raise allows High Race to replace all irrigation from Dunstan Creek and suppliants current takes from Lauder Creek. There is a large potential for gravity pressurised supply and development should focus on these areas. Focusing development closer to Falls Dam will reduce distribution costs.
	High Race to Lauder Creek piped secondary distribution.	6,500[5] (~ 4,000[5] pressurised supply)	32,680,000 (5,000/ha)	230,000 (40/ha)	Yes	3 (Falls Dam mid raise)	
Hawkdun Idaburn (HIIC)	Upgrade Mt Ida Race, gravity unpressurised supply	3,585	1,260,000 (400/ha)	90,000 (30/ha)	No	Status Quo	Current supply reliability very poor. Development of spray irrigation on-farm only for areas with secure peak of season water supply. There is potential to increase water harvesting by the Mt Ida Race through reducing leakage, upgrading intakes and potentially harvesting from additional sub-catchments, all of which should be investigated further. The proposed Mt Ida Dam improves supply reliability allowing increased spray irrigation. With Falls Dam High Raise the potential to pump over Home Hills Saddle to suppliant R race should be investigated.
	Expand Mt Ida Race	2,000	2,2900,000 (1,200/ha)	Included in above	Yes	5 (Mt Ida Dam)	
Private irrigators	Development focused on-farm	Total area unknown	n/a	n/a	No	Status Quo	For irrigators who take from the Manuherikia River, current supply reliability is sufficient to support conversion to spray irrigation. For many of the irrigators who take from the tributaries current supply reliability is relatively poor and on-farm development of spray irrigation will be limited to those areas with secure water supply during the peak of the irrigation season.

Notes:
(1) The Ida Valley Irrigation Scheme (IVIS) was not assessed as it is not influenced by any of the 5 development options covered by the Feasibility Study.
(2) Unless stated annual operational costs exclude any scheme or on farm pumping.
(3) Supply reliability comments are based on hydrological model results (Aqualinc 2012f, 2013a and 2014).
(4) Operational costs for the Galloway scenarios include scheme pumping.
(5) Area is indicative only and based on assessment of current areas irrigated and potential increases suggested by the hydrological model results (Aqualinc 2012f, 2013a and 2014).

Shaded scenarios represent either full (dark grey) or partial (light grey) provision of pressurised (>30 m pressure) water to the farm gate. Unshaded scenarios require on-farm pumping for spray irrigation.

For each farm that becomes part of an irrigation scheme it is recommended that the Farm Management Plans (FMP) include a biodiversity assessment, especially for any areas where new irrigation development is occurring.

The water resources of the Manuherikia Catchment are very highly allocated and potentially over-allocated during summer. Increased water harvesting and storage of water is required to overcome the current allocation issues and potentially allow for environmental flows and increased irrigation. The larger the storage volume the more opportunity there is to address over-allocation issues and provide for improved environmental releases and minimum flows.

The current state of the Manuherikia River and its tributaries is varied. In general, the upper catchment has excellent water quality. However, in the lower reaches of the Manuherikia River the water quality has declined to ‘good’. In the tributaries, water quality declines downstream as each stream flows across the Manuherikia or Ida valley floor. Current irrigation in the catchment is dominated by flood irrigation practices. Large application depths are applied which cause saturation of the soil profile, runoff and significant drainage of water through the soil profile. Increased runoff leads to sediment and phosphorus being washed into the watercourses while increased drainage results in leaching of nitrogen. There is potential for algal blooms, although this is currently limited by low levels of nitrogen in the streams. Nutrient budget analysis undertaken using Overseer indicates that the Manuherikia catchment has a number of characteristics (e.g., a dry climate, deep soils with limited susceptibility to phosphorus loss and the ability to significantly reduce drainage and nitrogen loss from existing flood irrigated areas by converting to spray irrigation) that significantly reduce the risk of increased nutrient concentrations. At a catchment level the proposed irrigation development scenarios are expected to result in reduced nitrogen loss from the bottom of the root zone. A reduction in catchment scale nitrogen loss is expected to result in reduced nitrogen concentrations in the area’s waterways and potentially improved groundwater and surface water quality.

At a catchment level the proposed irrigation development scenarios are expected to result in increased phosphorus loss from the catchment’s farms. Phosphorus loss is principally associated with runoff, overland flow and active soil erosion. Measures such as appropriate cultivation techniques, vegetation management to limit erosion, riparian strips, controlling stream bank erosion and preventing stock access to waterways will be required to control phosphorus concentrations in the waterways that drain the irrigated areas.

Farm Management Plans which identify and address potential erosion “hotspots” and which require detailed on-farm nutrient budgeting will be an important mitigation measure to reduce the risk that future land use intensification poses to water quality.

Overall:
The environmental assessments of the five proposed water development options have identified a number of issues (particularly those associated with endangered species) which will require very careful management. However, it is anticipated that suitable management and mitigation options could be developed that would allow the proposed water development options to potentially progress.

Economic Assessment

The off-farm water supply cost estimates developed during the feasibility study were considerably higher than the earlier prefeasibility estimates and result in decreased on-farm economic viability. Due to the high off-farm water supply costs the economic assessment of the overall scheme was put on hold while an optimisation process was undertaken to assess options for reducing off-farm costs. This optimisation process is ongoing.

Future resource consent applications

It is anticipated that the completed Feasibility Study will form the technical ‘backbone’ for subsequent resource consent applications. As part of the Feasibility Study a consenting strategy was developed to guide any future consent applications. The strategy was developed via a collaborative working party process involving representation from MCWSG, Golder, ORC and CODC. The common goal of the process was to

“seek mutually acceptable outcomes in relation to water allocation and/or management and future resource consenting within the Manuherikia Catchment and project area”.

Conclusions and recommendations

Given the estimated high costs of the five irrigation development options there is need to look critically at water demand, hydrology, storage options, engineering design, costings and to a lesser extent distribution and environmental issues to determine an optimised solution which could progress to more detailed investigations. Of the environmental issues, the area of new inundation above Falls Dam is considered the issue most likely to affect selection of the optimum solution. Based on the investigations to date the optimum solution is expected to involve a smaller dam, lower supply reliability and possibly review of expected water demand to include consideration of land uses which are less water intensive.

To progress the project and to assist in the identification of the optimum water management and irrigation development solution for the Manuherikia Catchment the following investigations are recommended.

- The hydrological models prepared for the Manuherikia Catchment provide a means for quickly assessing potential development scenarios. Some refinement of the models is recommended to:
  - Better assess tributary contributions.
  - To include the production implications of water supply restrictions.
  - To provide more flexibility in terms of future water demand, so that different crops and climate change scenarios can be assessed.
  - To allow whole catchment water management options to be quickly assessed.
- That predicted future irrigation demand requirements be reviewed to assess if future water demand and hence storage requirements can be reduced.
- Optimisation of Falls Dam to identify the preferred dam design and location and then confirm estimated costs. Following selection of the preferred water storage option, potential flow regimes and water supply reliability needs to be confirmed through an open stakeholder process. Following confirmation of the flow regime and supply reliability further design work is required to optimise the distribution networks and confirm estimated distribution costs.
- Irrigator support for each of the development options should be assessed, in light of the results of this feasibility study.

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TABLES

FIGURES

APPENDICES

LIST OF ABBREVIATIONS

amsl	above mean sea level
Aqualinc	Aqualinc Research Limited
BCS	Base Construction Costs
BIC	Blackstone Irrigation Company
BIS	Blackstone Irrigation Scheme
CFRD	Concrete Faced Rockfill Dam
CODC	Central Otago District Council
DEM	Digital Elevation Model
EAP	Emergency Action Plan
FMP	Farm Management Plan
FSL	Full Supply Level
GIC	Galloway Irrigation Company
GIS	Galloway Irrigation Scheme
Golder	Golder Associates (NZ) Limited
ha	hectare
HIIC	Hawkdun/Idaburn Irrigation Company
HIIS	Hawkdun/Idaburn Irrigation Scheme
IVIC	Ida Valley Irrigation Company
IVIS	Ida Valley Irrigation Scheme
km	kilometre
LINZ	Land Information New Zealand
L/s	litre per second
M	Million
m	meters
7d MALF	7 day mean annual low flow
MCWSG	Manuherikia Catchment Water Strategy Group
mm	millimeters
MIC	Manuherikia Irrigation Company
MIS	Manuherikia Irrigation Scheme
MWD	Ministry of Works and Development
NPS	National Policy Statement
O&M	Operation & Maintenance
OCRT	Otago Central Rail Trail
OIC	Omakau Irrigation Company
OIS	Omakau Irrigation Scheme
ORC	Otago Regional Council
PE	polyethylene pipes
PIC	Potential Impact Category
RCC	Roller Compacted Concrete
RL	Reduced level
RMA	Resource Management Act
RPS	Regional Policy Statement
SH85	State Highway 85

1.0 INTRODUCTION

1.1 Background

The Manuherikia Catchment Water Strategy Group (MCWSG) was established with the aim of developing and implementing cost effective, efficient and sustainable irrigation options for water users within the Manuherikia catchment. The Manuherikia catchment consists of two valley systems separated by the Raggedy Range; the Manuherikia Valley to the west and the Ida Valley to the east Figure 1.

Approximately 25,000 ha are currently irrigated within the Manuherikia catchment, of which approximately 15,000 ha are consider fully irrigated with the remainder only partially irrigated (Aqualinc 2012b). Six main irrigation companies operate within this area as well as a number of private irrigators with rights to abstract water for irrigation purposes. The irrigation companies are: the Omakau Irrigation Company (OIC), Blackstone Irrigation Company (BIC), Hawkdun/Idaburn Irrigation Company (HIIC), Ida Valley Irrigation Company (IVIC), Manuherikia Irrigation Company (MIC) and the Galloway Irrigation Company (GIC). Irrigation is predominantly from run of river takes supplemented from various water storage reservoirs. There are four main water storage reservoirs (Falls Dam, Manorburn Reservoir, Greenland Reservoir and Poolburn Reservoir), two smaller reservoirs (the Lower Manorburn and Idaburn dam) and various on-farm reservoirs scattered throughout the catchment. The Omakau, Manuherikia, Galloway and Blackstone companies have shares in the Falls Dam Company Limited, which manages Falls Dam (MCWSG 2013). Falls Dam is also utilised for the generation of hydro-electricity by Pioneer Generation Limited. The IVIC operates the Manorburn, Greenland and Poolburn irrigation reservoirs which harvest winter runoff and snow melt for irrigation use in the southern section of the Ida Valley. The Lower Manorburn reservoir and the Idaburn dam are small reservoirs with limited live storage and are operated by the GIC and the HIIC, respectively. An extensive network of open water races is used to distribute irrigation water from various river intakes to the irrigated areas.

A staged assessment approach has been adopted in order to assess the viability of any future irrigation options. The first stage of assessment was a High Level Overview Study which assessed water availability and demand within the catchment (Aqualinc 2012a, 2012b and 2013c). This was followed by a Prefeasibility Study (Aqualinc 2012d[1]), which assessed potential development options for improved irrigation within the catchment. The conclusions arising from these studies were:

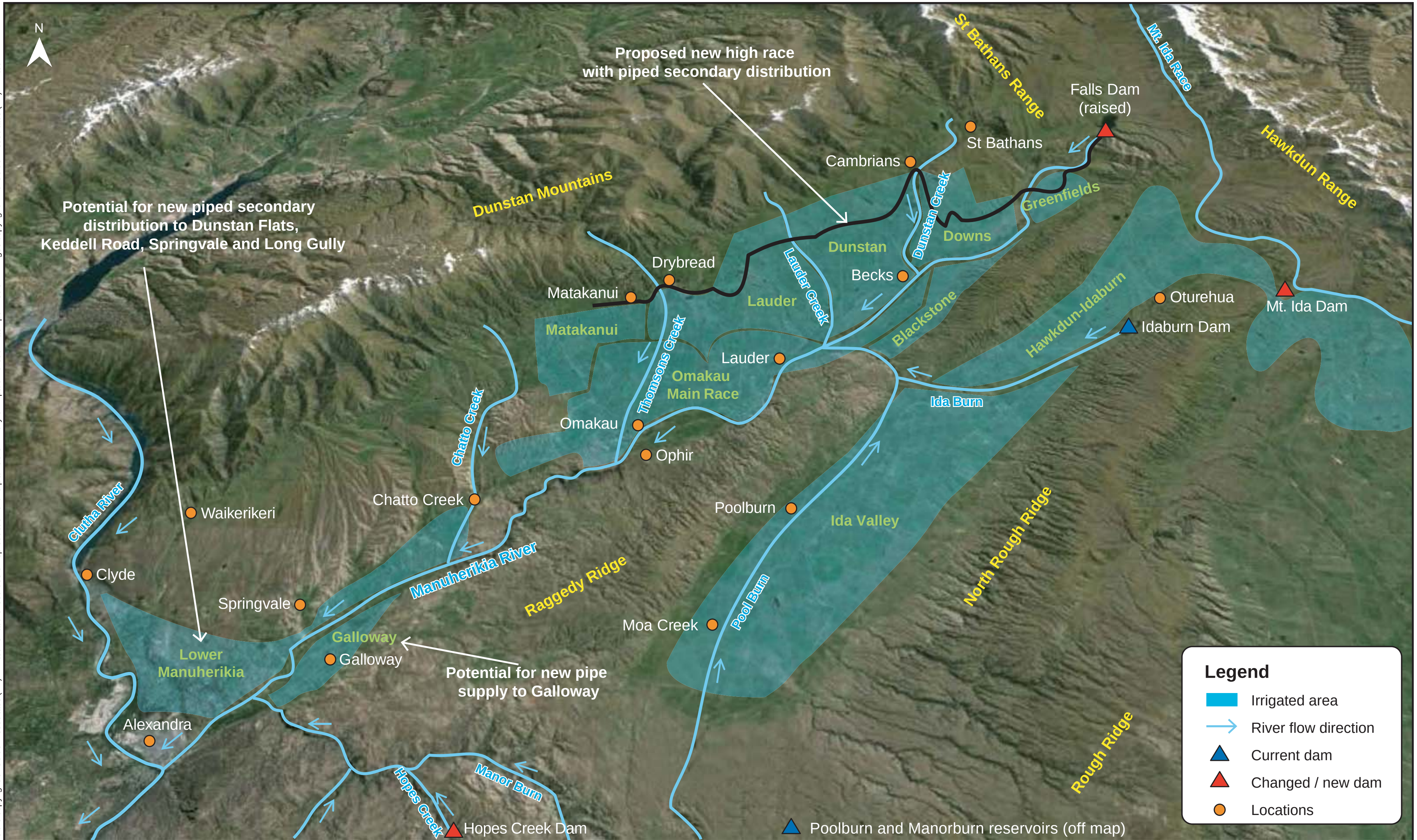
> *"… that the catchment was not water short and that there are promising options that could increase the reliability of the current irrigation area or potentially increase the total area of irrigated land from approximately 15,000 hectares to 35,000 hectares"* (MCWSG 2013).

MCWSG have now commissioned a feasibility study (which this report[2] summaries), to assess the technical, environmental, economic and financial feasibility of five irrigation development options. The aim of the feasibility study is to ensure that, at completion, the MCWSG has sufficient information to proceed to the next phase of the project (i.e., the development of a resource consent application(s)). The Feasibility Study has been separated into five interconnected components based on discipline (Hydrology, Geotechnical and Engineering, Water Allocation and RMA Planning, Environmental and Economic and Commercial). The relationship between the components and various key documents that make up the overall feasibility study are shown in Figure 2. A list of all the feasibility study reports and documents is provided in Appendix B.

The feasibility study is focused on five irrigation development options which were identified during the prefeasibility study (Aqualinc 2012d). The first three options involve raising the impoundment of Falls Dam by building a new dam or raising the existing dam. The fourth option is to improve the efficiency of irrigation within the Manuherikia Valley by developing efficient water distribution systems. The fifth option is the construction of a new dam (the Mount Ida Dam) on the upper Ida Burn. In addition to the five main options, a preliminary assessment has being completed on the proposed Hopes Creek Dam (Golder 2014a). A brief description of the five options is provided below and an overall map of the project site and key features is presented in Figure 1.

[1] The Prefeasibility Study generated a number of reports the key findings of which are outlined in a summary report Aqualinc 2012d.

[2] This report is provided subject to the limitations outlined in Appendix A.



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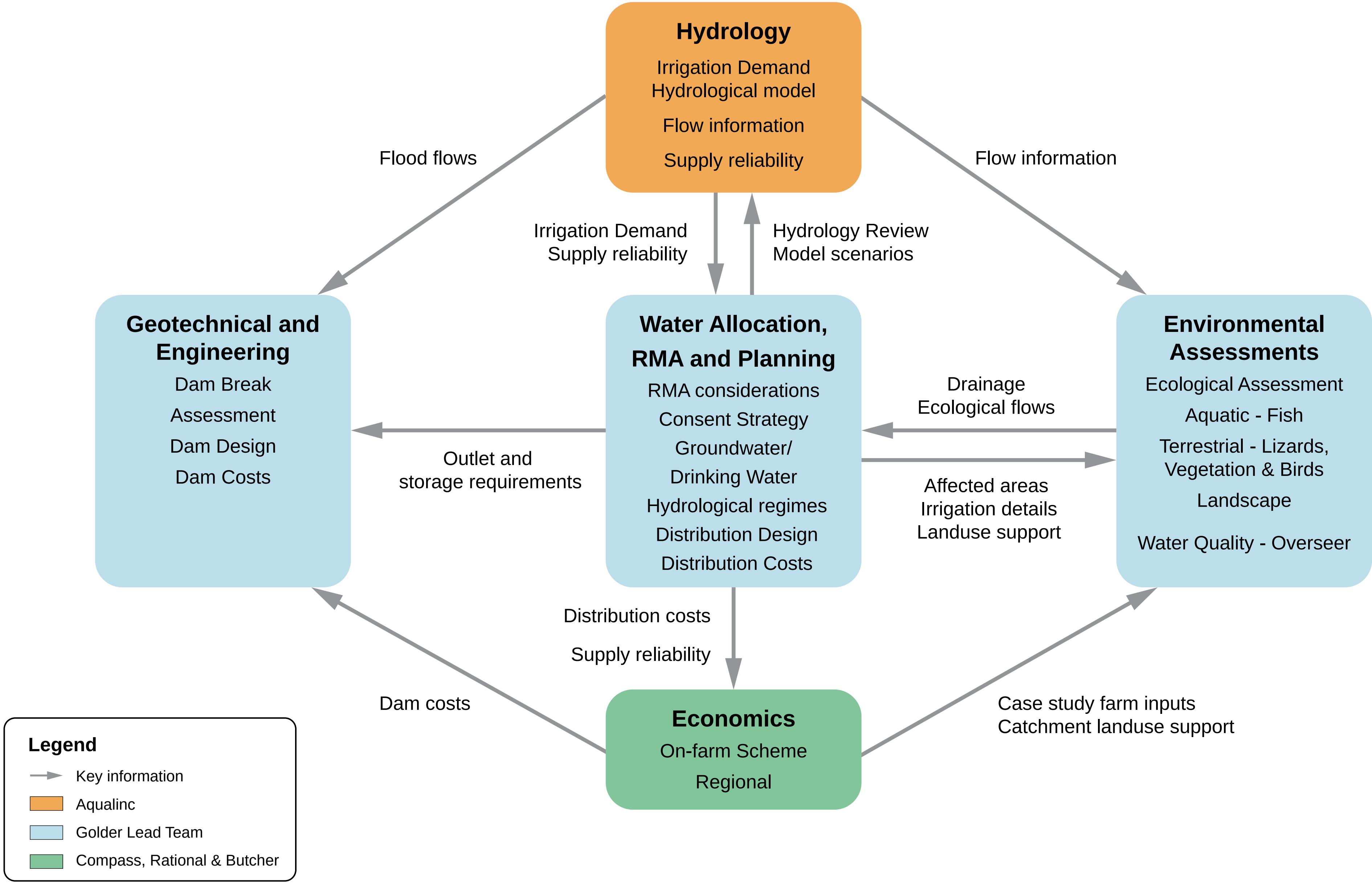

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1.1 The Five Development Options

The five irrigation development options that were defined by Aqualinc (2012d) and form the basis for the current feasibility study are briefly described in the following sections.

1.1.1 Option 1: Falls Dam High Raise

Raise the impoundment of Falls Dam by 27 m, to a full supply level of 592.2 m, by building a new dam or raising the existing dam. At a full supply level of 592.2 m Falls Dam is estimated to store approximately 119.0 Mm^3 of which approximately 114.1 Mm^3 is potentially useable. This option aims to maximise the amount of water that can be reliably harvested at the Falls Dam site and maximise the potential for downstream irrigation development. Water balance assessments indicated that 114.1 Mm^3 of usable storage, together with run of river takes, is sufficient to reliably irrigate approximately 25,000 ha of land within the Manuherikia Valley (Aqualinc 2014). To distribute the irrigation water a new high race is proposed, which extends to the Matakanui Station boundary, plus upgrading much of the existing distribution network.

1.1.2 Option 2: Falls Dam Low Raise

Raise the impoundment of Falls Dam by 5.4 m, to a full supply level of 570.6 m, by building a new dam or raising the existing dam. At a full supply level of 570.6 m Falls Dam is estimated to store approximately 20.6 Mm^3 of which approximately 19.0 Mm^3 would be potentially useable. This option was considered the "do nothing" scenario during the prefeasibility study and was associated with the potential need to construct a new spillway at Falls Dam and the conceptual option of using the excavated rock from the new spillway to raise the existing embankment by 5.4 m (Opus 2013). Water balance assessments indicated that 19.0 Mm^3 of usable storage, together with run of river takes, is sufficient to reliably irrigate about 11,500 ha of land within the Manuherikia Valley (Aqualinc 2013a). This option essentially provides reliable water to the existing irrigators who are able to access water from Falls Dam, namely: the Blackstone Irrigation Scheme (BIS), the main race part of the Omakau Irrigation Scheme (OIS), the Manuherikia Irrigation Scheme (MIS) and the Galloway Irrigation Scheme (GIS). This option utilises the existing distribution network with upgrading and maintenance required.

1.1.3 Option 3: Falls Dam Mid Raise

Raise the impoundment of Falls Dam by 15.2 m, to a full supply level of 580.4 m, by building a new dam or raising the existing dam. At a full supply level of 580.4 m Falls Dam is estimated to store approximately 51.6 Mm^3 of which approximately 50 Mm^3 would be potentially useable. This option represents an approximate mid-point between Options 1 and 2. It aims to provide reliable water to most existing irrigators, while allowing a small expansion of the irrigated area north of Lauder Creek. Water balance assessments indicated that 50.0 Mm^3 of usable storage, together with run of river takes, would be sufficient to reliably irrigate about 16,000 ha of land within the Manuherikia Valley (Aqualinc 2013a). To distribute the irrigation water a new high race was proposed, which extends to Lauder Creek, plus upgrading much of the existing distribution network.

1.1.4 Option 4: Improved Irrigation Efficiency

This option is based on the current storage situation, but with improved irrigation efficiency within the Manuherikia Valley, through development of efficient water distribution systems. The current distribution network is based on an extensive open race network that is operated on a roster system. Improving irrigation efficiency essentially represents a move from flood irrigation to spray irrigation. Historically all irrigation in the catchment was by flood. More recently, many individual irrigators have converted to spray irrigation. Conversion to spray provides production benefits but is expensive, ranging from $2,000/ha to $10,000/ha (Aqualinc 2012e). To justify the conversion costs a reliable, preferably continuous, water supply is preferred. Most of the spray conversions have occurred on properties which have one or more of the following: reliable high priority water rights; a large quota; access to water from Falls Dam and on-farm buffer storage. Many of the conversions have retained some areas of flood irrigation that are irrigated during the spring and wetter seasons when water is plentiful. During drier seasons when water is restricted, only those areas developed for spray are actually irrigated.

The Lower Manuherikia River and particularly the MIS and GIS are relatively water rich due to a combination of large quotas, access to water from Falls Dam, tributary inflows below Falls Dam and increased runoff and losses from upstream irrigation (Aqualinc 2012f and 2013a). Irrigators from both schemes have access to the reliable water that is required to justify conversion to spray. Option 4 is focused on the MIS and GIS and potential efficient distribution networks, which would facilitate increased spray irrigation.

1.1.5 Option 5: Mount Ida Dam

The HIIC have been investigating options for obtaining more reliable water for many years. Feasibility assessments (Hamilton 2006, Pickens 2005 and Raineffects 2006) proposed a new impoundment (Mount Ida Dam) with a 34 m high earth embankment on the upper Ida Burn near Seagull Hill. The Mount Ida Dam is estimated to store approximately 15.6 Mm^3 of which approximately 14.6 Mm^3 would be potentially useable (Hamilton 2006). The dam *"maximises the storage that can be achieved at the site"* (Hamilton 2006) and would harvest water from its upstream catchment with inflows supplemented by the Mount Ida Race. To improve the dam's ability to refill, enlargement of the current Mount Ida Race from the upper Ida Burn to Hills Creek was proposed. Water balance assessments indicated that 14.6 Mm^3 of usable storage is sufficient to reliably irrigate about 2,000 ha of land in the Oturehua, Wedderburn and White Sow areas (Hamilton 2006 and Aqualinc 2013b). To distribute the irrigation water, both a piped and an open race network are being considered as part of this option.

1.2 Ida Valley Irrigation Scheme

The five options above do not cover the approximately 14,000 ha command area of the Ida Valley Irrigation Scheme (IVIS) which covers the southern part of the Ida Valley. The IVIS is predominantly storage based and harvests winter runoff and snow melt in the existing Manorburn, Greenland and Poolburn irrigation reservoirs for irrigation use over summer. The scheme is considered very water short and operates with a low average allocation (Aqualinc 2012b). In addition to the five main options a preliminary assessment has being completed of the proposed Hopes Creek Dam (Golder 2014a), which would provide additional storage for the IVIS.

1.3 Study Area

The Feasibility Study covers the whole of the Manuherikia catchment plus a small section of the Tairi catchment near Wedderburn, which is within the potential command area of the proposed Mount Ida Dam.

1.4 Purpose of this Report

The purpose of this Summary Report is to briefly document the feasibility study process and the key results.

Following this introductory section the report is separated into five further sections as follows:

Section 2 – Feasibility Study Process: Describes the feasibility study assessment process and a number of key decisions that shaped the assessment.

Sections 3 to 7 – Key Findings: Discusses the key findings under each of the five disciplines.
Section 3 - Hydrology
Section 4 - Geotechnical and Engineering
Section 5 - Water Allocation and RMA Planning
Section 6 - Environmental
Section 7 - Economic and Commercial

Section 8 – Conclusions and Recommendations: The key overall conclusions from the feasibility study are briefly summarised along with recommendations for future work to advance the development of cost effective, efficient and sustainable irrigation options for the Manuherikia catchment.

The report concludes with a list of references and various appendices which contain pertinent supporting information.

2.0 FEASIBILITY STUDY PROCESS

A key objective of the feasibility study process was to build on and expand the earlier prefeasibility work. The earlier prefeasibility assessments considered a large number of potential water storage and irrigation development options and selected five to be progressed to feasibility study level. This feasibility study has focused on detailing the five options, identifying the key issues and risks associated with each and developing ways forward. The prefeasibility assessments identified relatively few issues with the five options and suggested estimated development costs which appeared to be economically favourable.

As highlighted in Figure 2 the feasibility assessment has involved collaboration between a number of organisations and has required considerable transfer of information. The timeline for the feasibility assessment called for the study to be completed by end of 2014 in order to rapidly progress the potential development and to build on the momentum generated by the favourable indications from the prefeasibility assessments. In order to meet this timeframe various work-streams were progressed in parallel. This was challenging, particularly for the environmental aspects of the project, which initially, had to progress with an incomplete understanding of the engineering details of the proposed options.

The feasibility assessment has identified a number of issues (documented in this report) that have slowed the progress. Principle among these has been that feasibility level cost estimates were substantially higher than those suggested during the prefeasibility assessments, in part due to the decision to proceed with designing a new dam rather than building on top of the existing. These issues have reduced momentum in the overall project and have resulted in considerable debate on the viability of the scheme. They have also resulted in some changes and modifications to the original brief for the feasibility study.

In addition to the need to progress the various work-streams in parallel the feasibility assessment was shaped by the following six key decisions:

1) Future irrigation demand is based on full grass irrigation, which represents a maximum water demand scenario. While this decision increases the water storage requirements, it does ensure there is sufficient water for all future land uses. This decision was influenced by the generally favourable indications from the prefeasibility assessments and was based on a desire to not limit future land uses and to ensure a conservative (high) estimate of water demand was used.

2) For the three options for raising the impoundment of Falls Dam, the assessment of both dam stability and construction methodology was focused on one of the three development options (Golder 2014a). Option 1 Fall Dam high (27 m) raise was selected, with a focus on a new Roller Compacted Concrete (RCC) dam downstream of the existing dam. The dam stability information and construction methodology determined for the high (27 m) raise was then applied to the mid and low raises. The principal reason for this was to focus the feasibility efforts to meet project timeframe and budget constraints. The result of this was that the mid (15.2 m) and low (5.4 m) raise options for Falls Dam were progressed as new RCC dams downstream of the existing dam.

3) To focus initial environmental assessment on the inundated areas associated with the proposed reservoirs and for Falls Dam to focus on the high (27 m) raise option. Given the need to progress the work-streams in parallel and that the inundation area associated with the various irrigation development options was reasonably well understood it was considered logical to commence the environmental assessment in the potentially inundated areas. This allowed time for the potentially irrigated areas, the distribution network and the potential changes in downstream flows to be determined. In undertaking the environmental assessments and developing mitigation options it was decided to focus of the potential maximum irrigation development, namely a high (27 m) raise of Falls Dam (Option 1), in combination with improved irrigation efficiencies (Option 4) and the proposed Mount Ida Dam (Option 5). This was considered conservative and based on the reasoning that if the environmental effects of the maximum potential development could be suitably mitigated then smaller development options should have reduced potential effects and be simpler to mitigate.

4) To focus distribution on maximising use of the current infrastructure and where new infrastructure is proposed, to focus on maximising the potential to supply gravity pressurised water. The decision to do this was based on trying to minimise distribution costs and to ensure any new distribution infrastructure

encouraged spray irrigation. For Option 1 Falls Dam high (27 m) raise the distribution network was to include a high race that extended to the Matakanui Station boundary.

5) That Option 3 Falls Dam (mid raise) to be based around an approximately 15.2 m raise of the impoundment to a full supply level of 580.4 m. The 15.2 m raise was higher than the 8-10 m suggested in MCWSG 2013, but was selected for the following reasons:

   a) It is an approximate mid-point between the high (27 m) and low (5.4 m) options.

   b) It results in a usable storage of approximately 50 Mm^3 for which both the potentially irrigated area and the change in downstream flows had been estimated using the hydrological model early in the feasibility process (Aqualinc 2013).

   c) It provides sufficient water to meet the desired outcomes of the landowners in the area, namely that flows in the Manuherikia River, Dunstan Creek and Lauder Creek are supplemented in order to improve the reliability of water supply to existing users and provides some additional water to allow increased irrigation of the areas known as the Downs, Greenfields and the area between Dunstan Creek and Lauder Creek.

6) In late 2014 the feasibility cost estimate for the Falls Dam component of Option 1 Falls Dam high (27 m) raise was presented to the MCWSG. The cost estimate was substantially higher than the cost proposed in the prefeasibility study and was considered unlikely to get irrigator support. It was decided to undertake an optimisation process which was completed in early 2015 to review the dam designs with the goal of identifying potential cost savings and a potential optimised dam design and location. At the same time as initiating the optimisation process for Falls Dam, it was also agreed to delay both the economic and social impact assessment of the overall scheme and the assessment of the hydropower potential until a more economically efficient storage option was developed.

3.0 HYDROLOGY

Water storage and irrigation scheme developments rely primarily on hydrological information; dam/spillway design, scheme/farm economics and the environmental effects are all strongly influenced by hydrological factors. The hydrology part of the feasibility study was completed by Aqualinc (Figure 2) and this built on their early prefeasibility investigations. A key component of the hydrological assessment involved hydrological modelling of the catchment to predict storage requirements and downstream flows. Details of the hydrological models and the key hydrological findings from the feasibility assessment are documented in two reports and three letters as shown in Table 1:

Table 1: Feasibility Assessment key hydrological documents

Title	Date	Author	Key topics
Report: Manuherikia Valley Hydrology: 2013 update	17 Sept 2013	Aqualinc	Contains a water balance model for the main stem of the Manuherikia River and Fall Dam.
Report: Mt Ida Dam hydrology	17 Sept 2013	Aqualinc	Contains a water balance model for the proposed Mt Ida Dam.
Letter: Manuherikia Hydrology Review	18 Mar 2014	Golder	Review of earlier reports on Manuherikia Valley hydrology
Letter: Mt Ida Dam Hydrology Review	18 Mar 2014	Golder	Review of earlier reports on Mt Ida Dam hydrology
Letter: Manuherikia Catchment feasibility Study: Flow Regimes	1 Dec 2014	Golder	Documents key discussion points and areas of general agreement relating to flow regimes for the Manuherikia catchment based on a large increase in storage of Falls Dam.

Aqualinc's Mt Ida Race and Dam (Aqualinc 2013b) and Manuherikia Valley (Aqualinc 2012d and 2013a) hydrological models use a daily time-step and cover the 39-year period June 1973 to May 2013 which is considered sufficiently long to address climate variability.

For the Manuherikia Valley and Falls Dam, Aqualinc (2014) have assessed the following four scenarios using the Manuherikia Valley hydrological model (Aqualinc 2013).

1) The current situation with 10 Mm^3 of usable storage in Falls Dam, 7,500 ha irrigated above Ophir (excluding the Ida Valley) and 4,500 ha irrigated below Ophir with a minimum flow at Ophir of 820 L/s.

2) The current situation with minimum flows on the main tributaries (Dunstan Creek, Lauder Creek and Thompsons Creek) and on the Manuherikia River at Campground (2 m^3/s). This scenario was run to assess the implications of higher minimum flows on existing users.

3) Irrigation development Option 1 Falls Dam high (27 m) raise with no change to minimum flows i.e., 114 Mm^3 of usable storage in Falls Dam, 20,500 ha irrigated above Ophir (excluding the Ida Valley) and 4,500 ha irrigated below Ophir with a minimum flow at Ophir of 820 L/s.

4) Irrigation development Option 1 Falls Dam high (27 m) raise with increased minimum flows i.e., 114 Mm^3 of usable storage in Falls Dam, 20,500 ha irrigated above Ophir (excluding the Ida Valley) and 4,500 ha irrigated below Ophir with minimum flows on the main tributaries (Dunstan Creek, Lauder Creek and Thompsons Creek) and on the Manuherikia River at Campground (2 m^3/s).

As part of developing the model scenarios a collaborative stakeholder process to assess potential flow regimes was undertaken. The process involved a simple interactive water balance model which allowed the storage requirements, irrigation potential, water supply reliability and downstream residual flow implications of various management decisions and flow regimes to be rapidly assessed. The key findings of the process were documented in a letter titled *Manuherikia Catchment Feasibility study: Flow Regimes* and dated 1 December 2014 (Golder 2014f). While the flow discussions were principally focused on irrigation development Option 1 Falls Dam high (27 m) raise the following areas of agreement are considered relevant to all development options:

- The surface water resources of the Manuherikia catchment are very highly allocated and potentially over-allocated during summer.
- Water harvesting and storage of water is seen as a way of overcoming some of the current allocation issues and potentially allowing for environmental flows and increased irrigation.
- Falls Dam is a good dam site with good potential inflows and storage attributes (i.e., size of dam versus size of reservoir) and is the logical place for water storage in the catchment.
- It is accepted that any development will be funded by those that benefit, in this case principally the irrigators in the catchment. To justify the economic cost a suitable level of water supply reliability is required. Irrigators would prefer 100 % supply reliability however it is usually uneconomic to achieve this. A common target is to limit irrigation water restrictions to approximately one year in ten.
- A larger storage volume is likely to provide more opportunity to address over-allocation issues, provide for improved environmental releases and minimum flows, allow increased irrigation, and provide the economic benefits necessary to ensure the dam is economically viable. The maximum area potentially irrigated in the in the Manuherikia Valley is expected to be in the order of 25,000 ha.
- Currently dead storage in Falls Dam is approximately 3.6 % of total storage. In assessing larger dams a dead storage of approximately 4 % of total storage is considered appropriate. For the proposed 27 m raise the 4 % dead storage equates to 4.5 Mm^3 (i.e., the current dam about half full). During dry seasons when the live storage of the dam had been used up the ability to access part (say up to 50 %) of the dead storage for environmental reasons (e.g., residual (minimum) flow releases or flushing flow releases) is considered advantageous.

- The concept of “shared pain” between irrigators and the environment is supported. During extreme dry periods when live storage in the dam gets low and irrigation restrictions are being considered, reductions in environmental flow releases (residual (minimum) flow releases or flushing flow releases) should also be considered. In assessing the options for increasing storage at Falls Dam the concept of “shared pain” above some environmental bottom lines is considered appropriate. An “Adaptive Management” approach which allows modifications and adjustments to the flow regime is considered more appropriate that an inflexible or fixed regime.
- Currently much of the main stem of the Manuherikia River below Falls Dam is used to transport irrigation water which results in elevated flows during the irrigation season. The Lower Manuherikia River below the irrigation abstractions (i.e. at the Campground flow monitoring site) is a critical location for the assessment of residual flows and the effects of upstream irrigation development.

The hydrological modelling showed that the Falls Dam reservoir regularly drains under current conditions and this would be drained more frequently if minimum flows are increased. The predicted frequent draining is consistent with the irrigation restrictions regularly imposed on current users. The modelling indicates that annually it is not a lack of water, but rather the seasonality of flows and the lack of storage, that are the critical issues. The model predicts that a large reservoir at Falls Dam can reliably fill, and that very high levels of supply reliability can be maintained. Figure 3 shows how water storage within the current Falls Dam is predicted to fluctuate under scenarios 1 and 2, while Figure 4 shows scenarios 3 and 4.

Flow exceedance curves, for flow in the Manuherikia River; immediately below Falls Dam, at Ophir and at Campground, under the four scenarios are shown in Figures 5, 6 and 7 respectively.

A large increase in storage at Falls Dam (27 m raise) would allow high minimum flows to be maintained. Flow in the Manuherikia River at Ophir is projected to exceed 3 m^3/s 98 % of the time. Flow in the Manuherikia River at Campground is projected to always exceed 2 m^3/s and exceed 3 m^3/s 79 % of the time. However, due to the increased water harvesting (i.e., the larger storage takes significantly longer to fill) flow in the Manuherikia River immediately below Falls Dam will be held at its minimum low flow level of 0.5 m^3/s for significantly longer periods of time, particularly during autumn and winter when the reservoir is refilling. Currently, flow in the Manuherikia River immediately below Falls Dam exceeds 0.5 m^3/s 94 % of the time. Under the large scale development option (27 m raise) flow in the Manuherikia River immediately below Falls Dam is projected to exceed 0.5 m^3/s 56 % of the time.

The model was also used to run some preliminary scenarios associated with the optimisation process for Falls Dams. These preliminary scenarios suggest that if reduced supply reliability is acceptable (i.e., irrigation restrictions late in the season (March and April) for 1 year in 5), then substantially less water storage is required at Falls Dam. This would reduce total storage costs.

The hydrological models provide a means for quickly assessing potential development scenarios. However some refinement of the models is recommended to:

- Better assess tributary contributions.
- To include the implications of water supply restrictions.
- To provide more flexibility in terms of future water demand, so that different crops and climate change can be assessed.
- To allow whole catchment water management to be assessed.

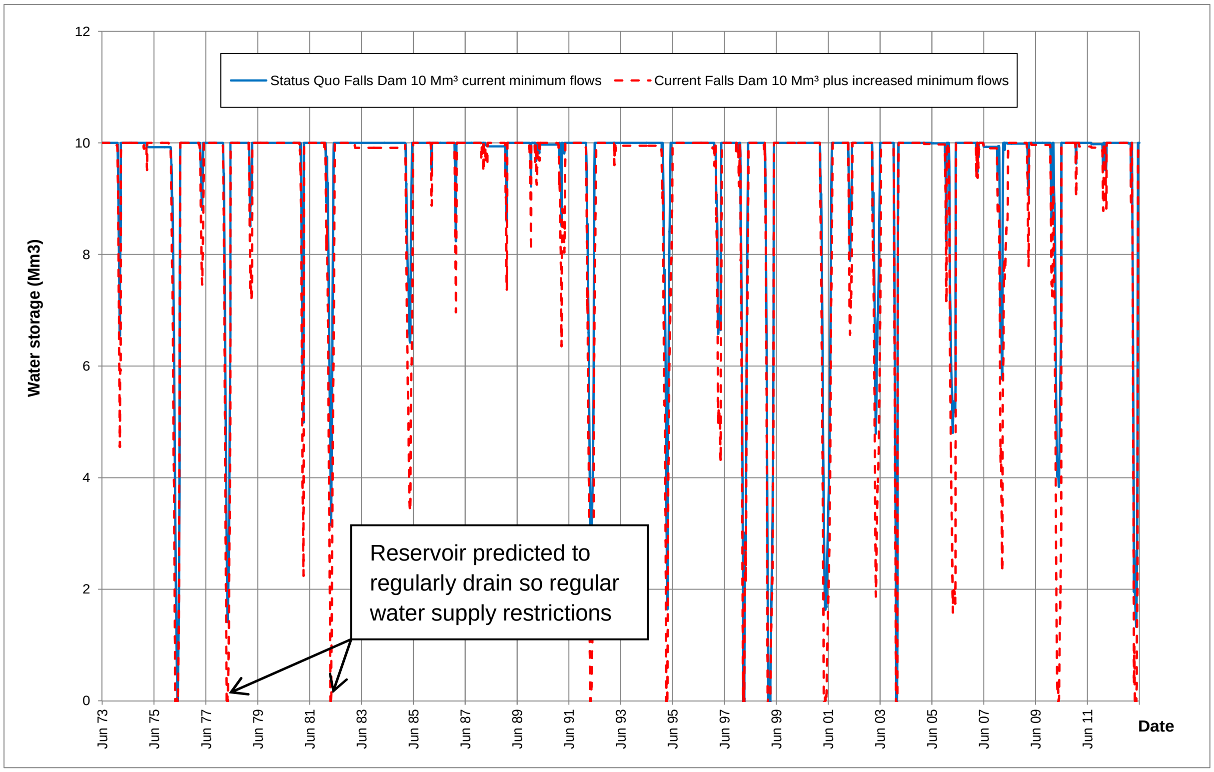


Figure 3: Current Falls Dam predicted storage under both the current and an increased minimum flow regime.

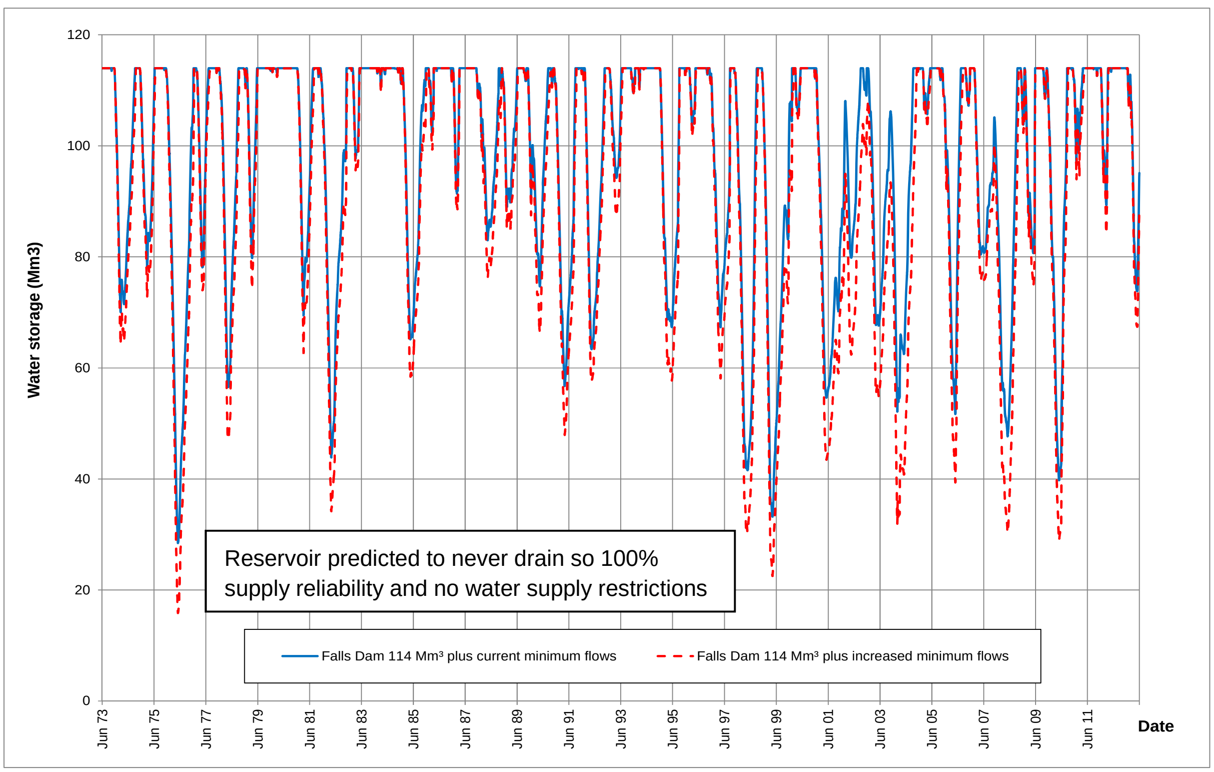
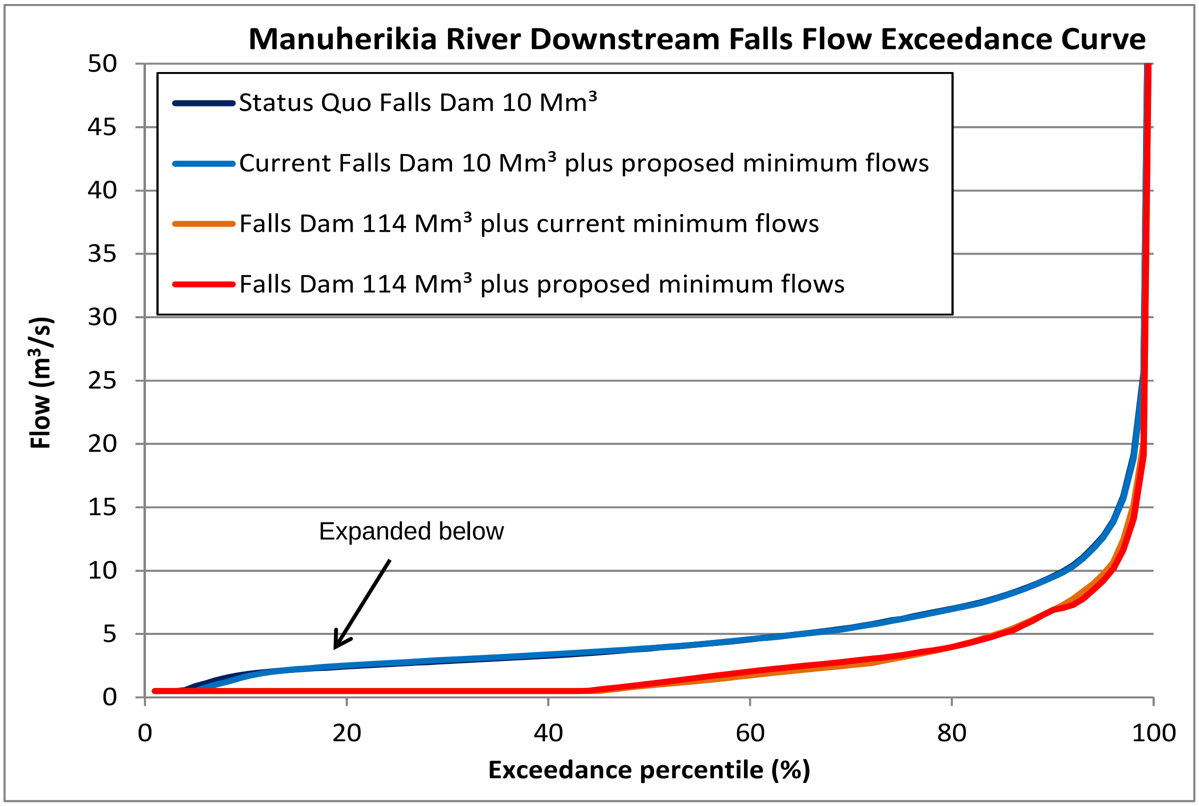


Figure 4: Falls Dam predicted storage under Irrigation development Option 1 Falls Dam high (27 m) raise under the current and an increased minimum flow regime.



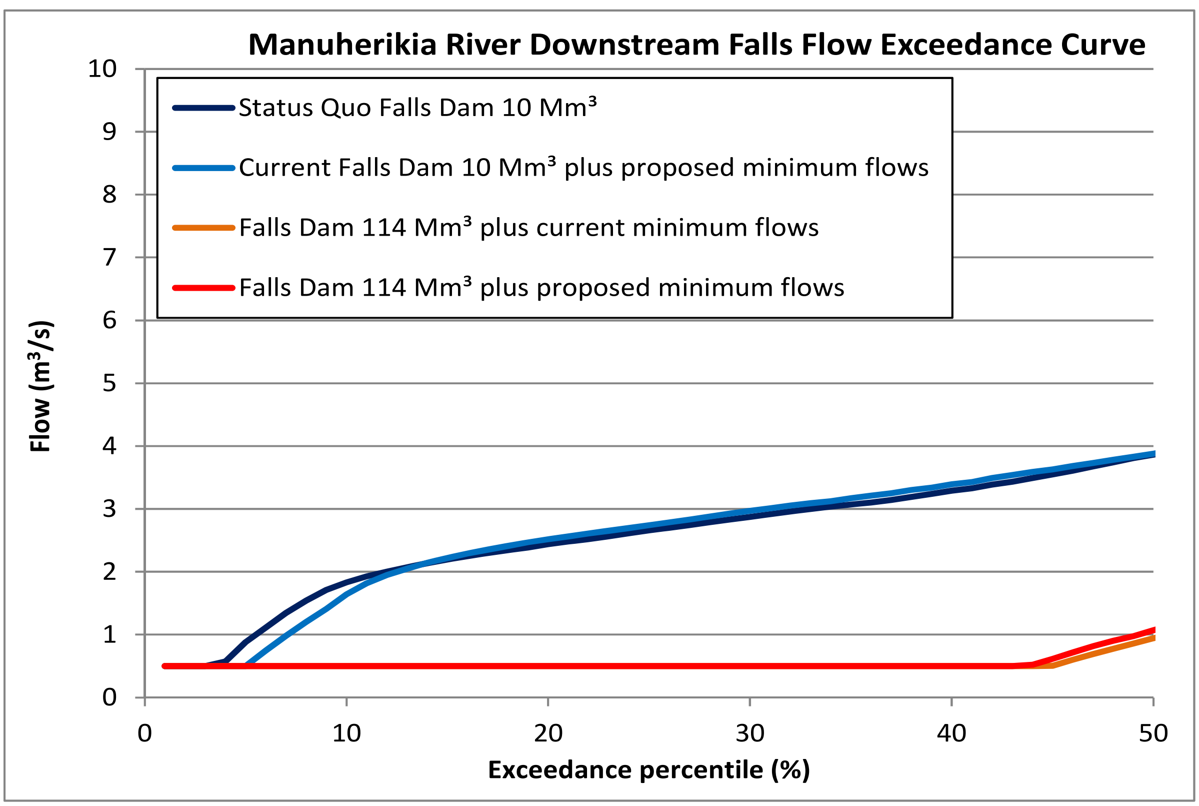


Figure 5: Flow Exceedance Curve for the Manuherikia River downstream of Falls Dam.

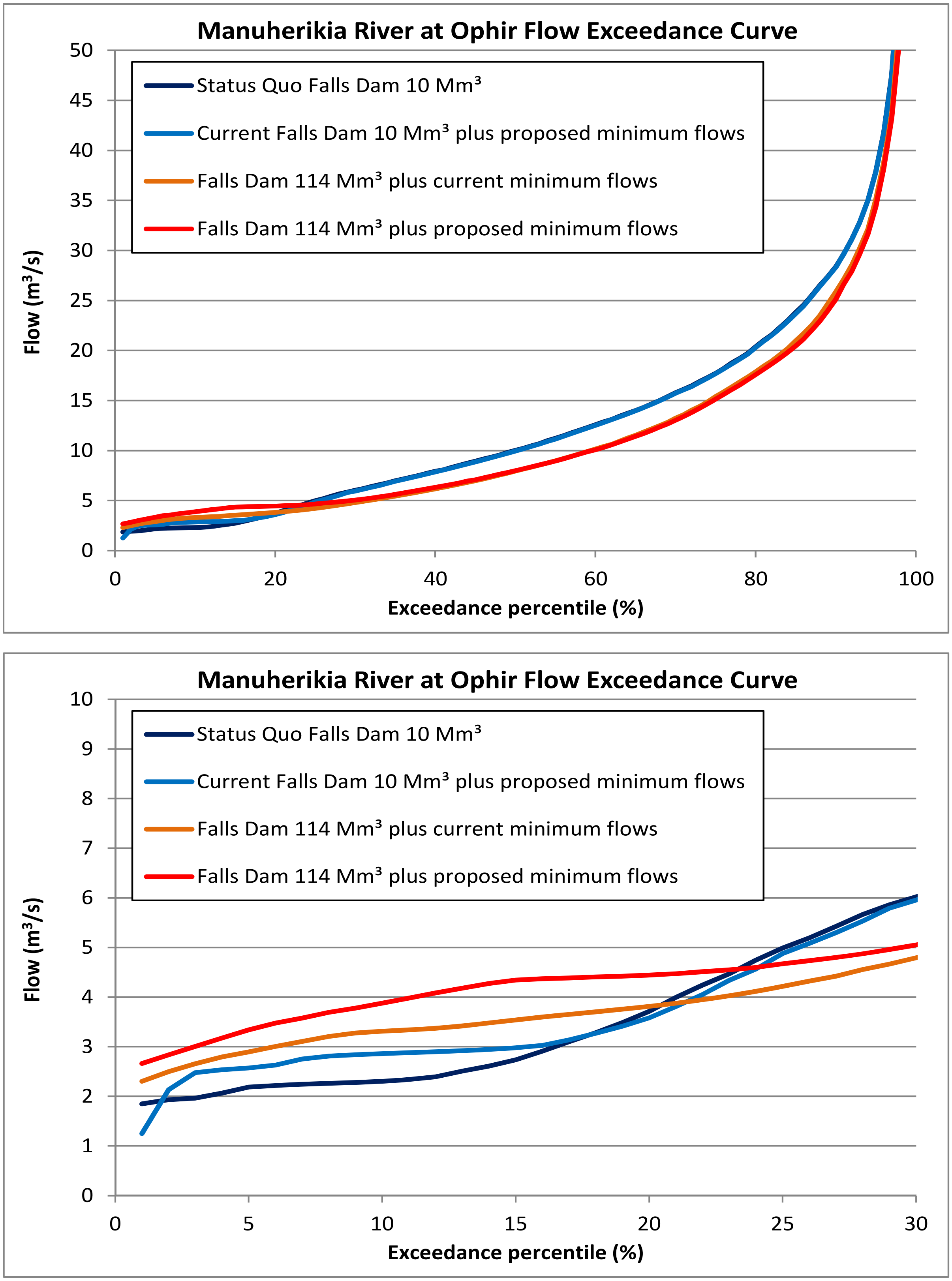
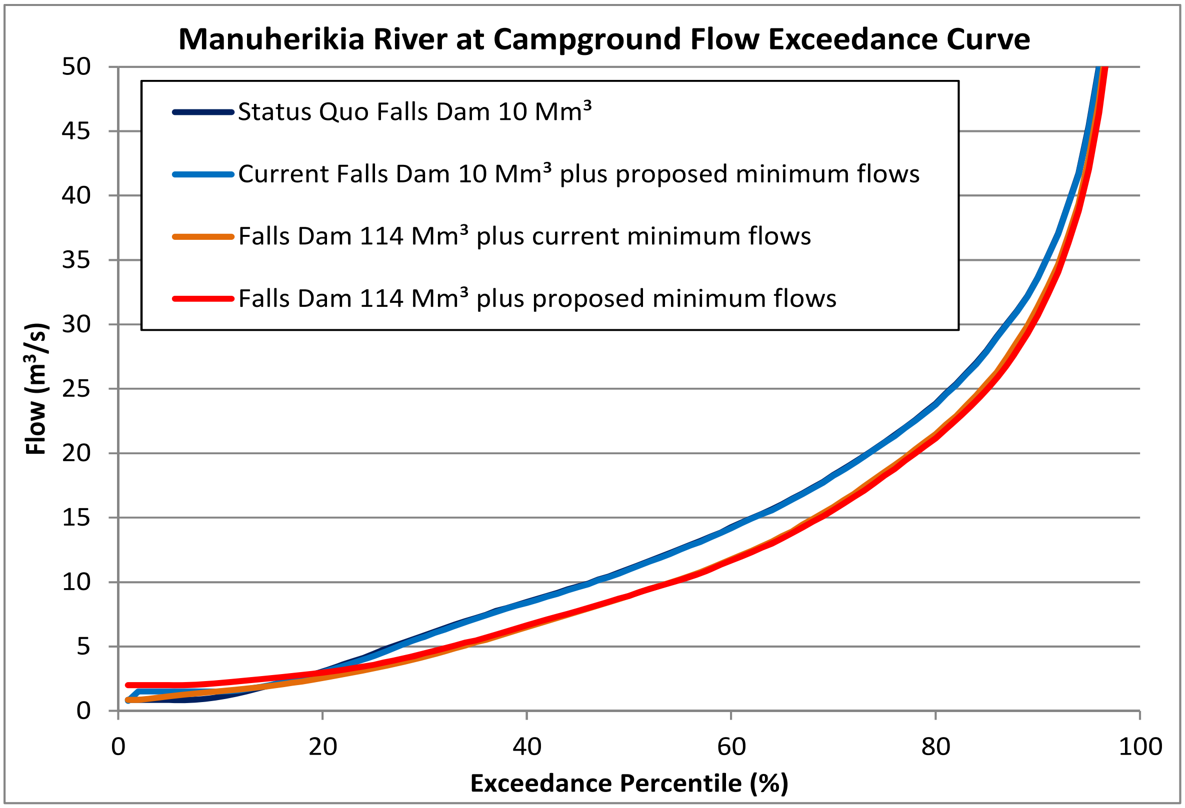


Figure 6: Flow Exceedance Curve for the Manuherikia River at Ophir.



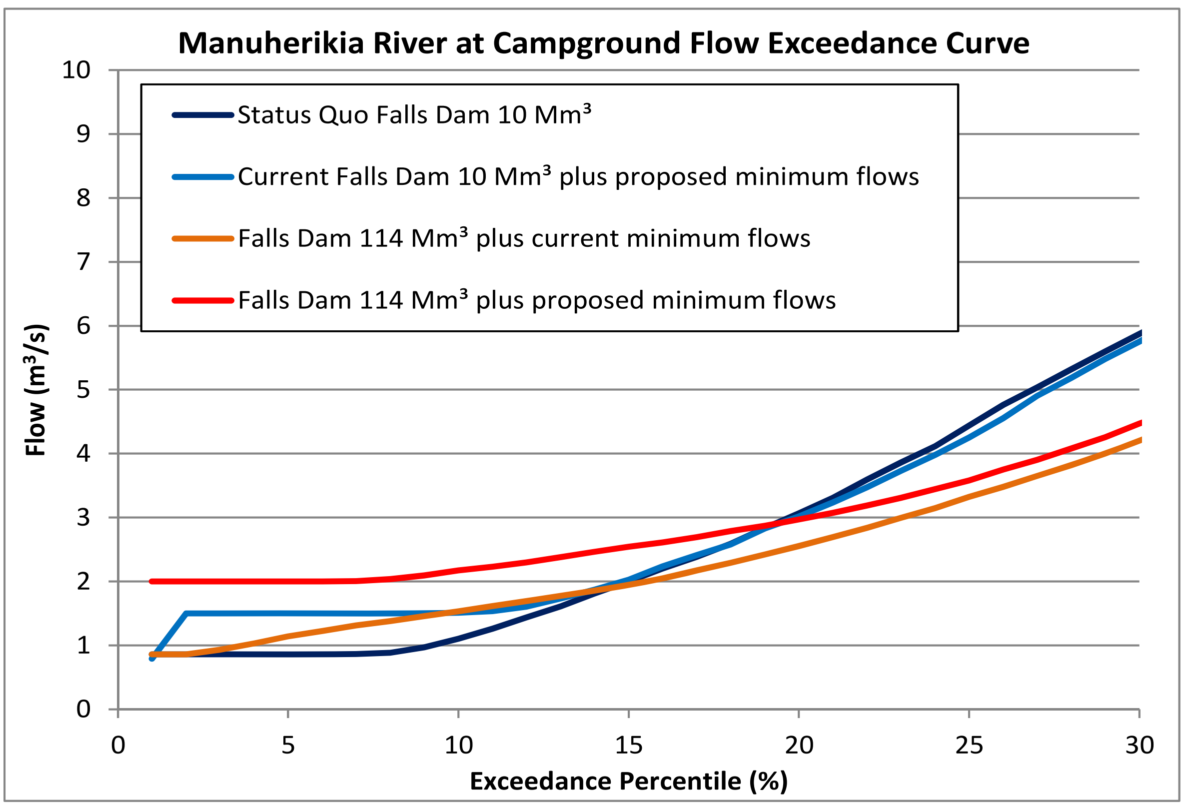


Figure 7: Flow Exceedance Curve for the Manuherikia River at Campground.

4.0 GEOTECHNICAL AND ENGINEERING

The geotechnical and engineering component of the feasibility study was separated into two parts: water storage and distribution. The findings of the water storage and distribution aspects of the feasibility study are documented in fourteen reports and letters as shown in Table 2.

Table 2: Feasibility Assessment key geotechnical and engineering documents.

Report Title	Date	Key topics
Memorandum: Proposed geotechnical investigations at Falls & Mt Ida Dam Sites	19 Dec 2013	A technical memorandum providing a list of proposed geotechnical investigations to be undertaken in early 2014 at the proposed Falls and Mt Ida Dam Sites.
Letter: Hopes Creek Stage 1 Engineering Assessment	24 April 2014	An initial engineering assessment of the proposed Hopes Creek Dam.
Letter: Water supply options for the Moutere Disputed Spur Road area	24 April 2014	Includes a preliminary assessment of water supply options for the Moutere Disputed Spur Road area. The report discusses four potential water supply options.
Geotechnical Stage 1 Report: Background Review and Investigations	May 2014	Provides a review of earlier investigations, contains the results of site investigations. Provides the background information and analysis used to support the Stage 3 Report.
Letter: Mt Ida Dam Site	23 May 2014	Provides a preliminary examination of the proposed Mount Ida dam site following completion of geotechnical background review, mapping, test pitting, field testing, and laboratory testing. Highlights a number of potential issues with the proposed Mount Ida Dam
Letter: Mt Ida Dam updated information June 2014	4 June 2014	Provides updated indicative cost information for the proposed Mount Ida Dam.
Letter: Manuherikia: Falls Dam Recommended Option	4 July 2014	Includes the rationale supporting the recommendation that a Roller Compacted Concrete (RCC) Dam capable of storing 50 M m^3 i.e., an approximately 15 m raise of the existing full storage level be the option that is progressed for Falls Dam.
Dam Break Assessment Report - raised Falls Dam full supply level of 588m	July 2014	Describes the findings of a dam break assessment of a roller compacted concrete dam with a full supply level of 588 m above mean sea level constructed in the vicinity of the existing Falls Dam.
Letter: Falls Dam Proposed Scope of Preliminary Design	4 Aug 2014	Confirms the scope of work for preliminary design of the raise options for Falls Dam.
Hopes Creek Dam Stage 2 Engineering Assessment Report	Aug 2014	A Stage 2 engineering assessment of the proposed Hopes Creek Dam including preliminary cost estimates for the anticipated 'high cost' items (i.e., those elements that the project cost is expected to be most sensitive to) for both a concrete faced rockfill dam (CFRD) and a roller compacted concrete (RCC) dam.
Letter: Mt Ida Dam updated information September 2014	22 Sept 2014	Provides updated cost estimates for the Pickens design (2005) of the proposed Mount Ida Dam.
Geotechnical Stage Three Report: Falls Dam Preliminary Design and Cost Estimate	Feb 2015	Documents the preliminary designs and cost estimates for a new roller compacted concrete (RCC) dam downstream of the existing power station at Falls Dam. Three options are discussed with full supply levels of 592.2 m (27 m raise), 580.4 m (15 m raise) and 570.6 m (5.4 m raise). The full supply level 592.2 m option is described in detail herein while the designs for the full supply levels 580.4 m and 570.6 m options are briefly summarized since they have the same design criteria as the full supply level 592.2 m option.

Report Title	Date	Key topics
Letter: Manuherikia: Falls Dam Optimisation	27 Feb 2015	Summarises the Falls Dam optimisation process and suggests a way forward.
Irrigation Distribution Report	June 2015	For each of the five irrigation development options various potential distribution scenarios are identified and discussed on a scheme by scheme basis. For each scheme a brief description and history is provided following by an assessment of the efficiency of the current distribution network. Proposed distribution networks under the various irrigation development options, including design schematics and costing information are provided for each of the schemes.
Letter: Mount Ida Dam and Water Supply Options	26 Aug 2015	Summarises the feasibility investigations related to the Mount Ida Dam and discusses water supply options for the Hawkdun/Idaburn Irrigation Scheme.

The key findings associated with each of the irrigation development options are briefly summarised below.

4.1 Falls Dam

Three options were investigated for Falls Dam, the pertinent data for each is summarised in Table 3. As part of the feasibility assessment additional survey information was collected by Landrpo, formerly BTW South and used to refine the stage storage curve for the Falls Dam reservoir.

Table 3: Pertinent Data for the three Falls Dam Options.

Dam Option	Crest Elevation(1) (m)	Full Supply Level(1) (m)	Approximate Dam Height(1) (m)	Estimated Total Storage (Mm^3)	Estimated Useable Storage (Mm^3)
Existing Falls Dam	RL568.5	RL565.2	33.5	10.3	10.0
5.4 m Raise	RL574.6	RL570.6	49.6	20.6	19.0
15.2 m Raise	RL584.4	RL580.4	59.4	51.6	50.0
27 m Raise	RL596.6	RL592.2	71.2	119.0	114.1

Notes: 1) Elevations are from survey provided by Landrpo, formerly BTW South, on 27 June 2014. Coordinate system, survey, and all elevations are in reference to LINZ listed Trig N No. 2 and Dunedin Vertical Datum 1958.

4.1.1 Falls Dam high raise

The construction of a new RCC dam downstream of the existing Falls Dam to a full supply level of 592.2 m (27 m raise) increases storage to 114.1 Mm^3. Summary drawings of the 27 m raise option are included in Appendix C and details of the design including full drawings are discussed in the *Geotechnical Stage Three Report: Falls Dam Preliminary Design and Cost Estimate* report (Golder 2014b). A brief summary of the 27 m dam raise option is described below.

Dam Design

The proposed RCC dam is a high potential impact category (PIC) dam and will need to withstand an estimated 1 in 10,000 year earthquake and inflow design flood. The High PIC classification for the proposed Falls Dam modifications requires the highest (i.e., most stringent) design requirements and results in a more conservative design than for a Low or Medium PIC dam.

The proposed layout consists of a 71.2 m high RCC gravity dam, with a crest length of 212 m, a crest width of 8 m and maximum crest elevation of 596.6 m. The upstream slope is vertical with 4 m tall vertical portion transitioning to an overall 1H:1V downstream slope. The full supply level of 592.2m allows for 4 m of freeboard, which is adequate to accommodate wave run up and setup during normal operations and during the design storm event. The dam crest contains a 35 m wide free overflow spillway located near the centre of the dam with an overflow spillway crest elevation of 592.2 m. Flows during the design flood event are estimated to be 3 m in depth resulting in one meter of freeboard. The stepped spillway chute discharges into an energy dissipator, which empties into the Manuherikia River downstream. The offtake structure consists of an intake tower with three intake elevations, which are gated and protected by a trashrack. A single gated 2 m diameter conduit running through the dam at an invert elevation of 545 m releases irrigation, flushing, and emergency drawdown flows downstream. The conduit discharges into the new powerhouse along the right side of the embankment. Release valves before and after the new powerhouse allow for offtake flows to enter the Manuherikia River or a proposed new high race distribution canal.

A saddle dam is required in Shamrock Gully to contain the full supply reservoir pool at elevation 592.2 m. The saddle dam will have a maximum height of approximately 5 m, a crest elevation of 596.6 m, and a crest width of 5 m to allow for vehicle traffic. The saddle dam will mostly act as a freeboard structure. Field explorations encountered sandy gravels to silty clays along the saddle dam alignment, so shallow excavation of foundation soils and a cutoff trench are anticipated (Golder 2014a). The saddle dam will be constructed with a low permeability core with a chimney drain extending up to the full supply level. The upstream slope will consist of a layer of riprap to reduce wave erosion.

Cost

Typically, preliminary designs are based on a partially optimized design from the limited field explorations, project information, and technical analyses. Further optimization is completed at the later, detailed design stage. Estimated construction costs are based on the preliminary design, which will likely change during detailed design and any design changes will impact the construction cost estimates. The cost estimates will also be sensitive to future escalation of key cost components such as labour rates, fuel prices, and material prices.

Fish passage has not been included in the preliminary design or cost estimate, but its need should be evaluated as part of the final design. Cost to develop documents and programmes such as emergency action plans (EAP), operation and maintenance (O&M) manual, dam safety assurance plans, and an inspection program have not been included.

The preliminary cost estimate for the 27 m raise RCC dam option with a full supply level of 592.2 m and associated distribution costs are presented in Table 4. Estimates of the cost for construction management, engineering and design, consenting, bonds and insurance, and a contingency for uncosted items have also been included as separate line items. The detailed cost estimate is presented in the *Geotechnical Stage Three Report: Falls Dam Preliminary Design and Cost Estimate* report (Golder 2014b).

Table 4: Falls Dam Cost Estimates – Full Supply Level 592.2 m.

Item	Description	Cost Estimate[1]
Site Establishment	Includes items such as site access and setup, quarry establishment, power supply, and demolition of existing dam and powerhouse.	$13,870,000
Foundation Treatment	Includes items such as foundation rock excavation, backfill / dental concrete and grout curtain.	$3,390,000
RCC and Spillway	Includes items such as producing and placing RCC and concrete for overtopping spillway, instrumentation, and drainage features.	$94,920,000
Offtake Structures	Includes items such as of concrete for intake tower, gates and control for gates.	$3,080,000
Saddle Dam	Includes items such as saddle dam foundation excavation and embankment placement.	$1,010,000
Base Construction Cost (BCS)		**$116,270,000**
Construction Management	7 % of BCS	$8,140,000
Engineering and Design	10 % of BCS	$11,630,000
Bonds and Insurance	5 % of BCS	$5,820,000
Consenting	2 % of BCS	$2,330,000
Direct Construction Cost (DCS)		**$144,190,000**
Uncosted Items	35 % of DCS[2]	$50,470,000
Total Estimated Preliminary Project Costs		**$194,660,000**

Notes 1) Costs are rounded up to the nearest $10,000 and exclude GST.
2) The 35% contingency for uncosted items is based on experience from similar large water projects at feasibility stage design.

4.1.2 Falls Dam intermediate raise

The construction of a new RCC dam downstream of the existing Falls Dam to a full supply level of 580.4 m (15 m raise) increases storage to 50 Mm^3. The design criteria and methodology for the 15.2 m option is the same as those for the 27 m option. The 15.2 m raise option is considered to be high PIC and needs to be designed for the 1 in 10,000 year earthquake and inflow design flood. The 15.2 m dam raise option has a similar layout at the 27 m option but the height is reduced to 59.4 m, the overflow spillway length is increased to 42 m wide as there is less attenuation within the reservoir, and the saddle dam is no longer required. Details of the design including drawings are discussed in the *Geotechnical Stage Three Report: Falls Dam Preliminary Design and Cost Estimate* report (Golder 2014b).

Typically, preliminary designs are based on a partially optimized design from the limited field explorations, project information, and technical analyses. Further optimization is completed at the later detailed design stage. Estimated construction costs are based on the preliminary design, which will likely change during detailed design and any design changes will impact the construction cost estimates. The cost estimates will also be sensitive to future escalation of key cost components such as labour rates, fuel prices, and material prices.

Fish passage has not been included in the preliminary design or cost estimate but its need should be evaluated as part of the final design. Cost to develop documents and programmes such as emergency action plans (EAP), operation and maintenance (O&M) manual, dam safety assurance plans, and an inspection program have not been included.

The preliminary cost estimate for the 15.2 m raise RCC dam option with a full supply level of 580.4 m and associated distribution costs is presented in Table 5. Estimates of the cost for construction management, engineering and design, consenting, bonds and insurance, and a contingency for uncosted items have also been included as separate line items. The unit rates estimated for the 27 m dam raise option were used and applied to the 15.2 m dam raise option. The detailed cost estimate is presented in the *Geotechnical Stage Three Report: Falls Dam Preliminary Design and Cost Estimate* report which is included in Appendix F (Golder 2014b).

Table 5: Falls Dam Cost Estimates – Full Supply Level 580.4 m.

Item	Description	Cost Estimate(1)
Site Establishment	Includes items such as site access and setup, quarry establishment, power supply, and demolition of existing dam and powerhouse.	$11,470,000
Foundation Treatment	Includes items such as foundation rock excavation, backfill/dental concrete and grout curtain.	$2,470,000
RCC and Spillway	Includes items such as producing and placing RCC and concrete for overtopping spillway, instrumentation, and drainage features.	$68,470,000
Offtake Structures	Includes items such as of concrete for intake tower, gates and control for gates.	$2,470,000
Base Construction Cost (BCS)		**$84,880,000**
Construction Management	7 % of BCS	$5,940,000
Engineering and Design	10 % of BCS	$8,490,000
Bonds and Insurance	5 % of BCS	$4,250,000
Consenting	2 % of BCS	$1,700,000
Direct Construction Cost (DCS)		**$105,260,000**
Uncosted Items	35 % of DCS(2)	$36,840,000
Total Estimated Preliminary Project Costs		**$142,100,000**

Notes: 1) Costs are rounded up to the nearest $10,000 and exclude GST.
2) The 35% contingency for uncosted items is based on experience from similar large water projects at feasibility stage design.

4.1.3 Falls Dam low raise

The construction of a new RCC dam downstream of the existing Falls Dam to a full supply level of 570.6 m (5.4 m raise) increases storage to 19 Mm^3. The design criteria and methodology for the 5.4 m option is the same as those for the 27 m option. The 5.4 m raise option is considered to be high PIC and needs to be designed for the 1 in 10,000 year earthquake and inflow design flood. The 5.4 m dam raise option has a similar layout at the 27 m option but the height is reduced to 49.6 m, the overflow spillway length is increased to 50 m wide as there is less attenuation within the reservoir, and the saddle dam is no longer required. Details of the design including drawings are discussed in the *Geotechnical Stage Three Report: Falls Dam Preliminary Design and Cost Estimate* report (Golder 2014b).

Typically, preliminary designs are based on a partially optimized design from the limited field explorations, project information, and technical analyses. Further optimization is completed at the later detailed design stage. Estimated construction costs are based on the preliminary design which will likely change during detailed design and any design changes will impact the construction cost estimates. The cost estimates will also be sensitive to future escalation of key cost components such as labour rates, fuel prices, and material prices.

Fish passage has not been included in the preliminary design or cost estimate but its need should be evaluated as part of the final design. Cost to develop documents and programmes such as emergency action plans (EAP), operation and maintenance (O&M) manual, dam safety assurance plans, and an inspection program have not been included.

The preliminary cost estimate for the 5.4 m raise RCC dam option with a full supply level of 570.6 m and associated distribution costs is presented in Table 6. Estimates of the cost for construction management, engineering and design, consenting, bonds and insurance, and a contingency for uncosted items have also been included as separate line items. The unit rates estimated for the 27 m dam raise option were used and applied to the 5.4 m dam raise option. The detailed cost estimate is presented in the *Geotechnical Stage Three Report: Falls Dam Preliminary Design and Cost Estimate* report (Golder 2014b).

Table 6: Falls Dam Cost Estimates – Full Supply Level 570.6 m.

Item	Description	Cost Estimate(1)
Site Establishment	Includes items such as site access and setup, quarry establishment, power supply, and demolition of existing dam and powerhouse.	$10,270,000
Foundation Treatment	Includes items such as foundation rock excavation, backfill / dental concrete and grout curtain.	$2,330,000
RCC and Spillway	Includes items such as producing and placing RCC and concrete for overtopping spillway, instrumentation, and drainage features.	$47,270,000
Offtake Structures	Includes items such as of concrete for intake tower, gates and control for gates.	$2,280,000
Base Construction Cost (BCS)		**$62,150,000**
Construction Management	7 % of BCS	$4,350,000
Engineering and Design	10 % of BCS	$6,220,000
Bonds and Insurance	5 % of BCS	$3,110,000
Consenting	2 % of BCS	$1,240,000
Direct Construction Cost (DCS)		**$77,070,000**
Uncosted	35 % of DCS(2)	$26,980,000
Total Estimated Preliminary Project Costs		**$104,050,000**

Notes: 1) Costs are rounded up to the nearest $10,000 and exclude GST.
2) The 35% contingency for uncosted items is based on experience from similar large water projects at feasibility stage design.

4.1.4 Falls Dam design optimisation

The above cost estimates were presented to the MCWSG in late 2014. The cost estimates are substantially more than the cost proposed in the prefeasibility study and was considered unlikely to get irrigator support. It was decided to undertake an optimisation process involving both Opus and Golder which was completed in early 2015 to review the dam designs with the goal of identifying potential cost savings and a potential optimised dam design and location. A meeting was held between Golder, MCWSG and OPUS on 19 January 2015 to discuss ways to optimise the dam location and cost. The results from the meeting and possible dam optimisation locations were documented in a letter dated 27 February 2015 and are briefly summarised below.

The three dam options presented above do not represent the only water storage options at the site, but provide indicative construction costs and design solutions meeting current standards and guidelines for the selected heights at the selected locations. Adjustments to the height, alignment, appurtenant structures, configuration and dam type will impact construction cost and an optimised solution will likely provide the most cost effective option.

In determining the most cost effective option, an understanding of how design changes impact construction costs should be evaluated. There are some relatively fixed costs associated with building a dam at the site that are independent of the dam configuration, including site preparation, bridge and road construction, demolition of the existing dam and upgrades to existing offtake structure/spillway for use as stream diversion during construction. Other costs are directly related to the dam size and location. Reducing the required storage volume, effectively lowering the dam height, will not only decrease dam volume but will eliminate the need for a saddle dam, while also decreasing the size of the quarry, the grouting depths, construction duration and required instrumentation.

When optimising the dam alignment and height, more than dam volume must be considered. The prefeasibility level study proposed a dam alignment located closer to the toe of the existing dam, which may provide for a lesser dam volume but cost increases due to increased foundation preparation and treatment, excavation, grouting, and reduced construction access are anticipated. As the dam height decreases to less than an 8 to 10 m raise, it may be more cost effective to raise the existing dam rather than construct a new dam. However, this option would likely require draining the reservoir for at least an irrigation season and there is increased risk and uncertainty associated with this option, as discussed in "Manuherikia: Falls Dam Recommended Option" report (Golder 2014b).

A detailed risk assessment may also be beneficial in future design stages as potential risks associated with static, seismic and hydrologic loadings may be better understood, resulting in more focused design efforts. There are also additional design and construction features that have not been discussed in detail during this feasibility level design that could potentially have a large impact on the total cost, including RCC mix design, design seismic loadings, deformation analysis and the inflow design flood.

The dam optimisation meeting on 19 January 2015 discussed survey differences, preferred dam type and location, the stream diversion, location of appurtenant structures, upstream and downstream slopes, costing methodology and future reporting. During the meeting the following was agreed:

- The RCC quantities do not appear to be overly sensitive to which digital terrain model is used. The survey supplied to Golder by BTWSouth (now Landpro) is appropriate for the current feasibility study.
- The optimised option will likely need to reduce dam volumes and the length of the stream diversion to reduce costs.
- The final downstream slope for the RCC embankment is likely to be between 0.8H:1V and 1H:1V. Additional stabilization works such as anchoring may be required for steeper downstream slopes such as 0.8H:1V but may not be required for shallower slopes (1H:1V). The cost difference between the additional stabilisation methods that may be required for steeper downstream slopes (0.8H:1V) and the increased RCC required for shallower slopes may not have a large impact on the overall cost estimates.
- Detailed dynamic analysis is required to confirm RCC embankment stability and the downstream slope required to maintain acceptable performance during the design earthquake scenarios. Such detailed analysis is usually undertaken during detailed design.
- The costing methodology and unit rates used by Golder are generally appropriate, although the fixed cost items should be pulled out of the uncosted items category in future cost estimates.
- In preparation for the meeting, Golder prepared 6 conceptual dam scenarios as potential 'optimised' dam configurations. Design criteria such as height, location and downstream slopes were altered and RCC volumes were estimated for each scenario. A summary of each scenario is presented in Table 7 below (the RCC volume estimates are preliminary and do not include all excavation or shaping volumes). During the meeting it was agreed that the preferred option will likely be located somewhere between Scenario 4 and Scenario 5 (see figures in Appendix C).

Benefits of these dam options, in comparison to the 592.2 m full supply level option (i.e., the 27 m dam raise) presented in Golder 2015, include:

- Reduced RCC volume.
- Stable downstream slopes based on preliminary analysis. Detailed dynamic analysis (usually undertaken as part of detailed design) is required to determine if steeper downstream slopes are possible.
- Reduced stream diversion length.
- Allowance for an overtopping spillway down the centre left of the embankment, thereby allowing for an offtake structure on the right abutment, simplifying distribution.

Table 7: Falls Dam Scenarios for optimisation process.

	Golder 27m Raise	Golder 15m Raise	Golder 6m Raise	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Location	D/S of plunge pool	D/S of plunge pool	D/S of plunge pool	U/S of plunge pool	U/S of plunge pool	Approx. Opus align. in Golder Survey	U/S of PH[1]	D/S toe in plunge pool	D/S of plunge pool
Crest Width (m)	8	8	8	8	8	6	8	8	8
Upstream Slope	Vertical	Vertical	Vertical	Vertical	Vertical	Vertical	Vertical	Vertical	Vertical
Downstream Slope	1H:1V	1H:1V	1H:1V	1H:1V	0.8H:1V	0.8H:1V	1H:1V	1H:1V	1H:1V
Offset from existing dam	85	85	85	10	10	20	5	25	85
Freeboard	4	4	4	4	4	5	4	4	4
Full Supply Level (m)	592.2	580.4	570.6	582.5	591.0	591.8	585.0	585.0	585.0
Total Storage Volume (Mm^3)	119.0	51.6	20.6	60.9	110.5	116.1	73.5	73.5	73.5
Usable Storage Volume (Mm^3)	114.1	50.0	19.0	59.0	106.0	111.5	70.5	70.5	70.5
Crest El. (m)	596.2	584.4	574.6	586.5	595.0	596.8	589.0	589.0	589.0
Est. RCC Volume (m^3)	235,000	155,600	101,150	142,774	128,136	172,941	161,324	169,159	187,856
Est. Facing Concrete (m^3) (15 % of RCC volume)	30,800	22,150	17,000	20,604	17,960	24,806	23,526	24,618	28,425

Notes: 1. PH = powerhouse

- Provided the full supply level of the reservoir is kept below approximately 587.4 m (a 22.2 m raise), a saddle dam is not required at Shamrock Gully.
- A full supply level in the order of 585.0 m (a 19.8 m raise) is expected to be possible provided constructability concerns can be addressed.

A full supply level of 585.0 m equates to a total storage volume of approximately 73.5 Mm^3 of which approximately 70.5 Mm^3 would be usable. A full supply level of 587.4 m (i.e., the maximum reservoir height before a saddle dam is required at Shamrock Gully) equates to a total storage volume of approximately 87.1 Mm^3 of which approximately 83.6 Mm^3 would be.

The distribution system does not greatly impact the selected dam location or height but does require a minimum offtake elevation that can feed into a proposed high level race. The proposed race would run approximately down the existing Fiddler Flat Road on the left bank terrace of the Manuherikia River. Because of the very steep topography on the left abutment of the dam site, it is logical for the outlet to be on the right abutment. Immediately downstream of the dam the race would be piped across the Manuherikia River to Fiddler Flat Road using the access bridge built during construction.

The anticipated dam optimisation option will likely fall between Scenarios 4 and 5 with possibly a slightly higher full supply level (between 585.0 m and 587.4 m). For a full supply level of 585 m (19.8 m raise) there is a decrease in the RCC volume on the order of 25 to 30 percent from the 592.2 m full supply level option (i.e., the 27 m dam raise) presented in Golder 2015 due to the lower height (which comes at a cost of reduced water storage) and its location above the existing power house.

The decrease in RCC volume will also decrease efforts of additional works such as rock quarrying, possibly construction duration, grouting, etc., along with stream diversion length, but may increase or complicate other portions of work such as constructability, foundation treatment, and shaping. The cost estimates presented in Golder 2015 assume that the RCC will be placed via a truck system, but an RCC dam of this size with limited upstream construction space may require a conveyor placement system to meet the tight time demands of lift placement and compaction requirements. A contractor with knowledge of RCC placement may need to be consulted to confirm the applicability of a truck versus conveyor system and estimated placement costs for the project.

By removing the saddle dam and reducing the cost of the RCC and Spillway by 25 percent (from the previous estimate for the 27 m dam raise option (Golder 2015)), a rough estimate of the optimised dam cost may be in the order of $150 M (excluding GST). This cost assumes that the dam is constructed with a truck system and does not take into account any additional work that may be required, as noted above, due to the change in the dam location. Overall, the cost of the dam is expected to decrease due to a smaller dam height and RCC volume; but the specific amount of decrease requires a constructability and costing evaluation. The dam cost will have an element of fixed costs, which will not vary significantly with dam size (i.e., outlet works, spillway energy dissipation structure etc.) and costs which will be directly related to dam size (i.e., RCC and facing concrete volumes, foundation stripping, quarry volumes etc.). Because of the fixed costs, large dams at the site will usually have a lower unit cost per hectare irrigated.

When considering overall project costs both dam and distribution cost estimates need to be considered. There is considerable flexibility in the distribution options ranging from essentially using the existing infrastructure for small increases in the usable storage at Falls Dam, to the development of a new high race and associated piped secondary distribution network, which would be required for large increases in usable storage. As such, optimising the overall project needs to include optimisation of both the dam and the distribution network.

The optimised dam is conceptual at this point and additional work is required to confirm the location, size and design criteria. Additional assessments such as constructability and hydraulic analyses along with quantities and cost estimates are required to finalise the dam location and cost. In parallel with assessments to finalise the dam location and cost, we recommend that Aqualinc's hydrological model (Aqualinc, 2013[3]) be

[3] Aqualinc 2013. Manuherikia Valley Hydrology: 2013 update. Report numbered C14000/1 prepared by Aqualinc for the MCWSG, dated 17 September 2013.

run to assess the irrigation potential of the optimised dam and the implications of any water supply restrictions. Based on initial hydrological model runs completed in December 2014, it is expected that 70.5 Mm^3 of usable storage, together with run of river takes, will be sufficient to irrigate approximately 25,000 ha in the Manuherikia Valley with restrictions 8 years out of the 40 years modelled (1973 - 2013). The restrictions would mainly occur late in the irrigation season (i.e., after 1 March) but on two occasions the model predicted there would be restrictions before March. Increasing the usable storage to 83.6 Mm^3 would delay and reduce the frequency of any restrictions.

4.2 Mount Ida Dam

Irrigation development Option 5 involves a proposed a new impoundment (Mount Ida Dam) with a 34 m high earth embankment on the upper Ida Burn near Seagull Hill and irrigation of approximately 2,000 ha of land within the command area of the HIIC. The reservoir would be filled from a combination of runoff from the catchment above the dam and inflow from a proposed enlargement of the Mount Ida Race. Hamilton (2006) completed a feasibility assessment of the scheme which included a feasibility level dam design prepared by Pickens (2005) and a hydrological assessment undertaken by Raineffects (2006). Plan views and typical sections of the embankment and spillways are available in Pickens (2005). The overall plan includes a main embankment section through the valley with a left embankment saddle dam that curves upstream to tie into the existing ground. A piped distribution network supplying pressurised water to approximately 2,000 ha in the Oturehua, Wedderburn and White Sow areas was proposed (Hamilton, 2006). Costs were estimated at approximately $10M for the dam (Pickens, 2005) and approximately $12M for the distribution system (Hamilton, 2006). The total costs of approximately $22M equate to an average of $11,000/ha.

Golder reviewed this earlier work and undertook additional field investigations, which are summarised in Golder 2014b. The site investigations and review indicated several geological challenges (including potential foundation faulting, high seismic hazard and soft clay foundation conditions) that will likely require robust and extensive design mitigation measures, resulting in higher construction costs and possibly more difficult consenting. Following presentation of this information it was agreed to update the cost estimate for the dam based on the Pickens (2005) design. The undated cost estimate for the dam is approximately $20M (Golder 2014c), giving a total costs of approximately $32M (assuming no increase in distribution costs) which equates to an average of $16,000/ha. Given these high costs the dam engineering part of the feasibility assessment of the Mount Ida Dam is currently on hold while the HIIC undertake strength testing of the soft clay foundation material to better determine the design and cost implications.

An assessment of the existing Mount Ida Race as part of the overall distribution assessment (Golder 2015) found that there is potential to increase water harvesting by the Mount Ida Race through reducing leakage, upgrading intakes and potentially harvesting from additional sub-catchments, all of which are recommended for further investigation. Similarly under irrigation development Option 1 (Falls Dam high (27 m) raise), the option to pump over Home Hills Saddle to supplement the HIIC's R race should be investigated.

4.3 Hopes Creek

Either a Concrete Faced Rockfill Dam (CFRD) or a Roller Compacted Concrete (RCC) dam are potentially suitable options for the Hopes Creek Dam. A conceptual design for a 41 m high CFRD and RCC dam have been prepared based on typical cross sections suggested by published references (USBR 1987) and summarised in Hopes Creek Stage 2 Engineering Assessment Report by Golder (2014a). Further analysis will be required to determine an optimized geometry that will meet the anticipated demands of static, hydrologic and seismic loading conditions. The cost estimates are based on quantities derived from the typical cross section for larger cost items, such as site access, rock excavation and sourcing and placement of rockfill, filters, traditional concrete and/or RCC, spillway and outlet construction and power supply to the site. The preliminary project cost estimate based on pricing the high cost items for the CFRD option is $42,530,000, which is lower than the RCC estimate of $57,160,000. Both cost estimates are considerably more than the $3.0 M estimated in the High Level Overview Study (Aqualinc 2012c).

Design and overall feasibility of the proposed Hopes Creek Dam is strongly linked to the stage storage curve, the available inflows, and irrigation demand. Further work is required to confirm the hydrology of the proposed dam site and the potential supply reliability benefits to the Ida Valley Irrigation Scheme.

4.4 Distribution

For each of the five irrigation development options various potential distribution scenarios were identified and assessed on a scheme by scheme basis in Golder 2015. For each scheme a brief description and history is provided following by an assessment of the efficiency of the current distribution network. Proposed distribution networks under the various irrigation development options, including design schematics and costing information are provided for each of the schemes.

Irrigation in the catchment is currently characterised by an extensive open race distribution network which is operated on a roster system that supplies water to predominantly on-farm flood irrigation. Six main irrigation schemes operate in the catchment (Omakau, Blackstone, Hawkdun/Idaburn, Ida Valley, Manuherikia and Galloway) in addition to numerous private irrigators with rights to abstract water for irrigation purposes. On a catchment level the irrigation is very efficient in terms of both scheme distribution efficiency and catchment water use. Inspection and monitoring of the open race network indicates that race leakage is limited and within the 10 % which is considered acceptable for open race based distribution networks. Irrigation water is spread very thinly and often recaptured and reused down gradient. While water use efficiency is high at a catchment level, on an individual paddock or farm basis it is often poor. Improving water use efficiency at a farm or paddock level essentially represents a move from flood irrigation, which currently dominates, to spray irrigation. Spray irrigation requires a constant, on demand water supply and the irrigation schemes would need to shift away from rostered supplies.

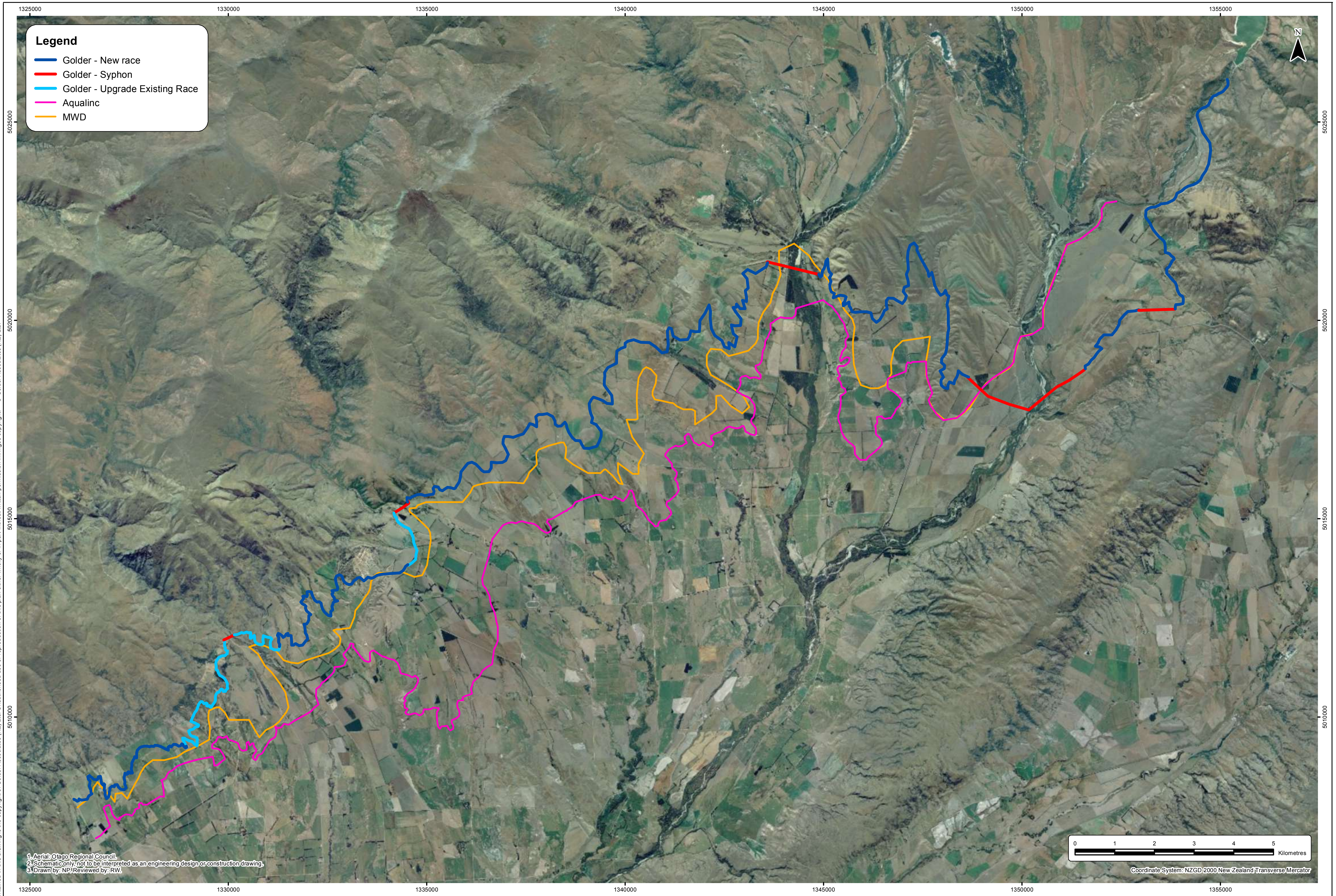
Conversion to spray provides production benefits but is expensive ranging from $2,000/ha to $10,000/ha (Aqualinc 2012). To justify the conversion costs a reliable water supply is required. The spray conversions that have occurred within the catchment are on properties with one or more of the following: reliable high priority water rights; a large quota; access to water from scheme storage reservoirs (i.e., Falls Dam) and on-farm buffer storage. Hydrological model results (Aqualinc 2013 and 2014) indicate that in the lower Manuherikia Valley below Ophir, irrigation water supply is sufficiently reliable to justify upgrades or improvements to the distribution network and on-farm conversion to spray irrigation. Most of the rest of the catchment (Manuherikia Valley above Ophir and the Ida Valley) suffers from reduced water supply reliability. Future irrigation development in this area needs to focus on improving water supply reliability and on-farm performance, prior to considering extensive upgrades or improvements to the distribution network. Improving supply reliability relies on increased water harvesting and storage, namely raising Falls Dam or constructing the proposed Mount Ida and Hopes Creek dams.

There is considerable existing distribution infrastructure throughout the catchment, parts of which are not fully utilised during the peak of the irrigation season due to insufficient water supply. Upgrading and improvement of the distribution networks should initially focus on activities which reduce bywash, assist management and operation, and encourage on-farm conversion to spray irrigation. Longer term distribution upgrades should focus on providing gravity pressurised piped water supply where possible.

The size, location and complexity of an irrigation distribution network are dependent on the irrigators who join the scheme and where the water is required. Limited information regarding potential irrigator demand or commitment is available. Conceptual distribution networks have been developed which provide an indication of the potential, size, extent and location of the networks to assist with preliminary cost estimation.

The benefits of gravity pressurised water supplies are significant. The key design principle used to develop the conceptual distribution networks was to provide gravity pressurised piped water supply wherever possible in order to; simplify scheme operation and management, facilitate the conversion to spray irrigation and eliminate or reduce scheme or on-farm pumping. An alignment for a new High Race has been developed (Figure 8) which maximises the area that can potentially be supplied with pressurised water. The new high race alignment is higher than the alignment suggested in the prefeasibility assessment and has the following characteristics relative to the prefeasibility alignment.

- The race feeds directly from Falls Dam. This eliminates the need for a downstream intake but slightly reduces the hydroelectric generation potential at Falls Dam. The topography of the Falls Dam site favours a spillway on the centre right and an off-take structure on left (western side). A race below Falls Dam would preferably be on the river terraces on the right (eastern) side of river (i.e., essentially follow Fiddler Flat Road). To feed the race, water from the outlet would need to be piped across Manuherikia River, immediately below Falls Dam. Construction of a large new Falls Dam is likely to require an access bridge over the Manuherikia River near the dam site (Golder 2015a). Following construction the access bridge, or part of it, could be used to support a pipe or formed channel over the river. Supplying the race directly from the dam will reduce flow in the Manuherikia River from the dam to approximately Loop Road as this section of the river will not be used to transfer High Race irrigation water as was proposed in the prefeasibility alignment.
- The preferred High Race alignment is higher than both the prefeasibility alignment (Aqualinc 2012h) and the MWD 1984 alignment. There are approximately 12,000 ha of irrigable land which is greater than 40 m below the proposed higher alignment and which could potentially be supplied with pressurised water. There is also significant, less irrigable land, above the higher alignment, which would reduce the need for pumping up from the race. Reducing future pumping costs is a significant benefit of the higher alignment and is expected to exceed the higher construction costs.
- The higher alignment uses the Matakanui Race, which simplifies the alignment through the Tinkers Diggings and allows the existing Thomsons Gorge intake and the numerous existing small storages off the Matakanui Race, to be simply incorporated into the expanded scheme.
- The preferred High Race alignment has an average slope of approximately 1.5 m/km (the same as the prefeasibility), which is considered a reasonable balance between maintaining elevation and minimising race cross sectional area.
- The elevation of the end of the race coincides roughly with the MWD 1984 alignment, which is preferred by landowners in the Matakanui area and would facilitate any potential extension of the race past the Matakanui Station Boundary.
- The preferred alignment is longer and therefore more expensive: approximately 72.1 km compared with approximately 59.9 km for the prefeasibility alignment and approximately 56.8 km for the MWD 1984 alignment. The 72.1 km preferred alignment consists of 56.2 km of new race, 9.3 km of upgraded race and 6.6 km of siphons. The siphon lengths required to cross Thomsons and Lauder Creeks are less than that required for the prefeasibility alignment, but the siphon lengths required to cross Dunstan Creek and the Manuherikia River are significantly longer and a new low pressure siphon is required at Greenfields.
- The alignment traverses through, rather than around, the Drybread Diggings, thereby reducing the length of race between Lauder and Thomsons Creeks. Race construction is expected to be difficult through this area and some piping maybe required and has been allowed for in the cost estimates. Site inspection and further design is required to confirm the alignment through the Drybread Diggings.
- The alignment is slightly above the OIS intake on Lauder Creek and the OIS and Downs intakes on Dunstan Creek. Allowing the High Race to supply water to those schemes is needed, although it is more difficult to feed water (particularly from Dunstan Creek) into the High Race.
- The preferred alignment traverses through the Beattie Road saddle, which is consistent with the alignment preferred by local farmers and significantly increases the irrigation potential in the Downs area.
- The higher alignment potentially allows water to be supplied (without excessive pumping) up Hawkdun Run Road and to the Johnson's property, thereby providing the landowners most affected by the raising of Falls Dam with some irrigation water.



Golder Associates

TITLE MANUHERIKIA VALLEY PROPOSED HIGH RACE ALIGNMENT

AUGUST 2015

PROJECT 1378110270

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Following selection of the preferred scheme, particularly the water storage option, further design work is required to optimise the distribution networks and confirm estimated distribution costs. This work would include: confirmation of supply areas and design flows, hydraulic design of key infrastructure (particularly the siphons and intakes) and alignment walkovers (particularly for the proposed High Race alignment through the Drybread Diggings).

The irrigation schemes and the numerous private irrigators in the catchment tend to operate in a somewhat independent and isolated manner. The Falls Dam Company and the priority associated with the various abstraction consents ensure a degree of co-operation. Irrigation development within the catchment will require a high level of co-operation and interactive management to ensure the optimum water supply and distribution solutions are identified and progressed. Similarly re-consenting of the existing irrigation activities when the deemed permits expire in 2021 is likely to be facilitated if a catchment wide approach is adopted. Through a working group of the MCWSG, some work has been undertaken to try to identify how private water rights will form part of the catchment wide approach.

In assessing the various irrigation development options current and potential irrigators need to consider the development as a whole, including: storage, distribution, on-farm development, water management and scheme operation. The various conceptual distribution options outlined in this report provide differing levels of service, particularly in regard to the provision of pressurised versus non-pressurised water. In comparing the various distribution development options we recommend the full life of asset costs be the principal means of comparison.

Table 8 summarises the distribution development options.

4.5 Hydropower

The original brief of the feasibility study included an assessment of the hydropower potential associated with the irrigation development options. However, as the estimated costs developed during this feasibility study were substantially more than those suggested in the prefeasibility study, it was decided to delay the hydropower assessment until a more optimised and economic option was developed.

Table 8: Catchment summary of distribution scenarios.

Irrigation Scheme[1]	Distribution scenarios	Irrigated area (ha)	Capital Cost ($)	Annual Operational Cost[2] ($)	Reliant on increased storage	Relevant Irrigation development option	Comments[3]
Galloway (GIS)	Pumped Open Race (Status Quo unpressurised supply)	520	410,000 (800/ha)	210,000[4] (390/ha)	No	Status Quo	Current supply reliability is sufficient to support on-farm spray irrigation and distribution development. Given the existing power arrangement, a move to pumped piped supply from the Manuherikia River is supported. If Keddell Road pipe goes ahead as part of MIS developments then investigate the potential of gravity supply from MIS main race. If Hopes Creek Dam goes ahead investigate shifting supply to the Lower Manorburn Dam. Costs exclude consideration of the Lower Manorburn Dam.
	Pumped piped pressurised supply from Manuherikia	550 (potentially more)	1,930,000 (3,500/ha)	160,000[4] (290/ha)	No	4 (Efficient Distribution)	
Manuherikia (MIS)	Open Race (Status Quo excludes areas below)	3,600	3,620,000 (1,000/ha)	230,000 (70/ha)	No	Status Quo excludes Dunstan Flats etc.	Current supply reliability sufficient to support on-farm spray irrigation and distribution development. Development of a gravity piped supply to Dunstan Flats, Keddell Road, Springvale and Long Gully areas is supported. Investigate the potential to tie the Keddell Road pipeline in with a gravity supply to the GIS. Reduced use of the Borough Race and transfer of the take to the main intake from the Manuherikia River should be investigated as it will simplify scheme operation, reduce maintenance and maximise the area that can be supplied with gravity pressurised water.
	Gravity pipe Dunstan Flats	500	3,150,000 (6,300/ha)	70,000 (140/ha)	No	4 (Efficient Distribution)	
	Gravity pipe Keddell Road, Springvale etc.	600	1,420,000 (2,400/ha)	70,000 (120/ha)	No	4 (Efficient Distribution)	
Blackstone (BIS)	Open Race (Status Quo unpressurised supply)	660	410,000 (600/ha)	70,000 (110ha)	No	Status Quo & 2 (Falls Dam low raise)	Current supply reliability is relatively poor which will limit development of spray irrigation to the area with secure peak of season water supply. Falls Dam High, Mid and Low raises increase supply reliability allowing increased spray irrigation. A gravity piped supply is possible but expensive. Focus development on-farm initially then on improving supply reliability.
	Gravity pressurised pipe supply from new High Race	1,200 (potentially more)	6,480,000 (5,400/ha)	50,000 (40/ha)	Yes	1 and 3 (Falls Dam mid and high raise)	
Omakau (OIS)	Main Race status quo (unpressurised supply)	3,759	3,830,000 (1,000/ha)	160,000 (40/ha)	No	Status Quo & 2 (Falls Dam low raise)	Current supply reliability is relatively poor (particularly for the Lauder, Matakanui and County parts of the OIS) which will limit development of spray irrigation to the area with secure peak of season water supply. Development of spray irrigation on-farm only for areas with secure peak of season water supply. Falls Dam High, Mid and Low raises increase supply reliability allowing increased spray irrigation. A gravity piped supply to the Becks Flat area from the Blackstone Race is possible and should be investigated further. Focus development on-farm initially then on improving supply reliability. Investigate potential to supply Matakanui extension area from expanded OIS main race.
	Dunstan, Lauder, Matakanui and County status quo (unpressurised supply)	2,083	2,320,000 (1,100/ha)	280,000 (130/ha)	No	Status Quo	
	Main Race expanded capacity (unpressurised supply)	6,000[5]	10,670,000 (1,800/ha)	160,000 (30/ha)	Yes	1 and 3 (Falls Dam mid and high raise)	
	Gravity pipe to Becks Flats	600	2,790,000 (4,700/ha)	10,000 (20/ha)	No	Status Quo	
High Race	High Race to Matakanui Station Boundary piped secondary distribution.	14,100[5] (~ 8,000[5] pressurised supply)	63,880,000 (4,500/ha)	230,000 (20/ha)	Yes	1 (Falls Dam high raise)	High race associated with Falls Dam Mid and High raises, would increase supply reliability allowing increased spray irrigation. Falls Dam High raise allows High Race to replace all irrigation from Dunstan, Lauder, Thomsons Creeks and associated tributaries. Falls Dam Mid raise allows High Race to replace all irrigation from Dunstan Creek and suppliants current takes from Lauder Creek. There is a large potential for gravity pressurised supply and development should focus on these areas. Focusing development closer to Falls Dam will reduce distribution costs.
	High Race to Lauder Creek piped secondary distribution.	6,500[5] (~ 4,000[5] pressurised supply)	32,680,000 (5,000/ha)	230,000 (40/ha)	Yes	3 (Falls Dam mid raise)	
Hawkdun Idaburn (HIIC)	Upgrade Mt Ida Race, gravity unpressurised supply	3,585	1,260,000 (400/ha)	90,000 (30/ha)	No	Status Quo	Current supply reliability very poor. Development of spray irrigation on-farm only for areas with secure peak of season water supply. There is potential to increase water harvesting by the Mt Ida Race through reducing leakage, upgrading intakes and potentially harvesting from additional sub-catchments, all of which should be investigated further. The proposed Mt Ida Dam improves supply reliability allowing increased spray irrigation. With Falls Dam High Raise the potential to pump over Home Hills Saddle to suppliant R race should be investigated.
	Expand Mt Ida Race	2,000	2,2900,000 (1,200/ha)	Included in above	Yes	5 (Mt Ida Dam)	
Private irrigators	Development focused on-farm	Total area unknown	n/a	n/a	No	Status Quo	For irrigators who take from the Manuherikia River, current supply reliability is sufficient to support conversion to spray irrigation. For many of the irrigators who take from the tributaries current supply reliability is relatively poor and on-farm development of spray irrigation will be limited to those areas with secure water supply during the peak of the irrigation season.

Notes:
(1) The Ida Valley Irrigation Scheme (IVIS) was not assessed as it is not influenced by any of the 5 development options covered by the Feasibility Study.
(2) Unless stated annual operational costs exclude any scheme or on farm pumping.
(3) Supply reliability comments are based on hydrological model results (Aqualinc 2012f, 2013a and 2014).
(4) Operational costs for the Galloway scenarios include scheme pumping.
(5) Area is indicative only and based on assessment of current areas irrigated and potential increases suggested by the hydrological model results (Aqualinc 2012f, 2013a and 2014).
Shaded scenarios represent either full (dark grey) or partial (light grey) provision of pressurised (>30 m pressure) water to the farm gate. Unshaded scenarios require on-farm pumping for spray irrigation.

5.0 WATER ALLOCATION AND PLANNING

The water allocation and planning part of the feasibility study covered a variety of issues including refinement of the potentially irrigable area, review of the current statutory regulations, review of current allocation levels, an assessment of groundwater use and drinking water supplies. The key findings associated with this part of the feasibility study are documented in six key reports and letters as shown in Table 9.

Table 9: Feasibility Assessment key water allocation and planning documents.

Report Title	Date	Key topics
Resource Management Act 1991 and Statutory Planning Considerations report	March 2014	Identifies the RMA and associated statutory planning considerations and allocation limits that have the potential, from both a technical and environmental perspective, to influence the assessment of the various irrigation developments options being considered as part of the Feasibility Study.
Letter: Consent review – Current Resource Consents	2 April 2014	Contains a review of the current resource consents (including deemed permits), that authorise the take and use of water in the Manuherikia Catchment. The report summaries current use and allocation throughout the catchment.
Consent Strategy report	May 2014	Outlines a proposed strategy for the future resource consent approach for the construction and operation of irrigation option(s) in the catchment.
Letter: Groundwater and Drinking Water Supply Reviews	27 May 2014	Contains a review of the groundwater environment in the Manuherikia Catchment and its current utilisation. The consequences for drinking water supplies and groundwater (quantity and quality) generally of proposed irrigation developments are also assessed.
Report: Issues and Options for Private Water Right Holders' consents on tributaries of the Manuherikia River.	22 Dec 2014	Provides a description of the issues facing private water right holders' in relation to how their water take and use activities might be consented and managed in the future. The report uses Lauder Creek as a model and provides practical advice on how issues such as allocation, water supply priority, integration into a larger irrigation scheme and consenting may be addressed at a local level.
Irrigation Distribution Report	June 2015	In addition to describing potential distribution scenarios the report includes a review of the irrigable land within the Manuherikia catchment.
Letter: Manuherikia Catchment feasibility Study: Water Quality and groundwater Recharge Addendum	July 2014	Uses the nutrient loss and drainage estimates from the Overseer modelling (AgResearch, 2015) to discuss the implications at a catchment level of: ■ Land use intensification on water quality, and ■ Changing from flood irrigation to spray irrigation on groundwater recharge.

The key findings associated with each of the irrigation development options are briefly summarised below.

5.1 Regulatory and Planning

The existing irrigation schemes, and any amended or new irrigation scheme, utilises the water, river and land resources within the catchment. Given this resource use, the fact that the catchment's mining privileges expire in 2021 and that MCSWG aim to implement a cost effective, efficient and sustainable irrigation option, approvals under the Resource Management Act 1991 (RMA) will need to be sought for both the construction and operation of the irrigation scheme. Details of the regulatory and planning requirements are provided in the *Feasiblity Study – Resource Management Act 1991 and Statutory Planning Considerations* report (Golder, 2014).

The RMA, and associated statutory planning documents, establish the thresholds within which resource utilisation activities must be undertaken and, subject to threshold requirements, the circumstances where approvals under the RMA are required. In the context of this project, the approvals include resource consents and / or a designation. A designation would replace the need to seek land use consents from the Central Otago District Council (i.e., for construction activities and for land-based irrigation infrastructure).

Part 2 of the RMA sets out the purpose and principles of the Act. The preferred option/s for irrigation within the catchment will need to ensure that the purpose and principles of the RMA are achieved as outlined in sections 5 to 8. This includes ensuring that the project promotes *"the sustainable management of natural and physical resources"* which means enabling resources to be used provided they are sustained for future generations, their life-supporting capacity is safe-guarded and any adverse effects of an activity are avoided, remedied or mitigated (section 5). Matters of national importance (section 6) that will need to be accommodated by the project, provided these values are present, include, preserving natural character of water bodies and protecting outstand natural features and outstanding natural landscapes and historic heritage from inappropriate development, protecting areas of significant indigenous vegetation and habitats of indigenous fauna, maintaining and enhancing public access along water bodies and recognising Maori connection to resources. Section 7 of the RMA identifies a range of other matters to which regard will also need to be given. In addition, the principles of Treaty of Waitangi need to be taken into account (section 8).

The statutory planning documents which are relevant to any proposed irrigation scheme include national, regional and district level provisions as well as other matters, namely the Kai Tahu ki Otago's Natural Resource Management Plan, under section 104(1)(c) of the RMA. The national statutory planning documents include the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010, the Electricity National Policy Statement (NPS) and Freshwater NPS as well as specific national environmental standards. The key regional planning documents are the Regional Policy Statement for Otago and the Regional Plan: Water for Otago, including Proposed Plan Change 6A, while the Central Otago District Plan is the relevant district level statutory planning document. These statutory planning documents have been developed to give effect to the RMA, and also to higher level planning documents.

There are a number of key implications for the proposed irrigation option/s from the national statutory plan provisions. They are:

- Under the Resource Management (Measurement and Reporting of Water Takes) Regulations 2010, all water takes greater than 10 L/s associated with the scheme will need to be accurately measured, recorded and the amount of water taken documented.
- Under the Freshwater NPS:
  - the need to utilise water is recognised and provided for, but any such use must ensure that outstanding values of water are protected, the life-supporting capacity of freshwater is safe-guarded and water quality is at least maintained (or improved, if considered degraded)
  - as an over-allocated catchment, the over-allocation of water is to be phased out, while also ensuring that water is used and allocated efficiently.
- Under the Electricity NPS, there is an aim to increase renewable electricity generation.

The RPS contains objectives and policies in relation to manawhenua perspective, land, water, air, the built environment, biota and energy that will be relevant to assessing the irrigation option/s and any future application for approvals under the RMA. These objectives and policies reflect the sustainable resource management approach outlined in Part 2 of the RMA.

The Water Plan, and Proposed PC6A[4], identifies a range of values associated with the region's water bodies, including the Manuherikia catchment. Values of relevance to this project include natural values, resident native freshwater fish, water supply values, registered historic values, values of significance to Kai Tahu and Regionally Significant Wetlands and Wetland Management Areas. The objectives and policies that relate to these values generally reflect the resource management approach outlined in Part 2 of the RMA, that is outstanding or significant values are to be protected from inappropriate development while other values are to be maintained or enhanced. This often means that avoiding adverse effects from activities is preferred over remedying or mitigating adverse effects.

The Water Plan schedules and maps also identify limits or criteria that apply to the Manuherikia catchment. These include a primary allocation minimum flow at Ophir of 820 L/s and a primary allocation limit for the whole catchment of 3,200 L/s (Schedule 2). It is noted that current allocation within the Manuherikia catchment is significantly above the primary allocation limit. Also, good quality water characteristics and numerical standards (Schedule 15 of Proposed PC6A), that are in effect receiving water standards, have potential implications in relation to the potential intensification of farming activities that may occur as a result of the use of any irrigation water.

Key considerations for any proposed irrigation option/s arising out of the Water Plan's objectives and policies principally relate to water quantity management. The mining privileges and the majority of other water takes in the catchment are considered to be primary allocation (Policy 6.4.2), and this water can potentially continue to be taken when new resource consents are issued. As an already over-allocated catchment, there is a strong driver to reduce the amount of water taken. New primary allocation water takes will therefore only be granted for the volume of water that has actually been taken, over the past five years, under the existing approval (Policy 6.4.2A). Given the current lack of measurement of the water takes, this could be a matter for discussion. In addition, the quantity of water taken cannot exceed the amount required for the purpose while also ensuring that water is taken and used in an efficient manner (Policies 6.4.0A and 6.6.1). Also, under the Water Plan rules, in effect resource consents for primary allocation water can only be granted to the people who hold the existing resource consent (Rule 12.0.1.1). Policy 6.4.17 (and section 136 of the RMA) enables a consent holder's interest in water take to be transferred to a new location while retaining primary allocation status, provided the matters identified above are met, and adverse effects on other takes or natural and human use values are no more than minor.

The KTKO Plan objectives and policies of relevance to this project cover matters such as wai Maori (across the region and within the Clutha / Mata-au catchments), wahi tapu, mahika kai and biodiversity. Many of the principles reflected in the RMA and statutory planning documents are contained within these objectives and policies. Specific additional matters relevant to assessing the proposed irrigation options include: cross-mixing of water will be opposed; generally 35 year resource consent terms will be opposed; efficient irrigation systems are encouraged; where appropriate dry land farming practices are also encouraged; fish passage past structures is to be provided; fish screens are to be fitted to pumps and intakes; and, in the Clutha / Mata-au catchment the creation of new dams will be opposed. Policy 5.3.4.19 identifies that Kai Tahu will require a Cultural Impact Assessment to be completed for any aspects of the proposal that requires damming and diversion of water. This requirement, and the proposal as a whole, should be discussed with Kai Tahu.

The District Plan's schedules and planning maps also identifies a range of values of land uses associated with the catchment. These include designations, scheduled activities, various heritage sites, notable tress, areas of significant indigenous vegetation and habitats of indigenous fauna, wetlands, areas with outstanding and significant landscape values, and flood prone land. As with the Water Plan, the objectives and policies generally reflect the resource management approach outlined in Part 2 of the RMA. Of specific relevance to this project is the objectives and policies in Section 13 (Infrastructure, Energy and Utilities), which except for specific landscape and public access objectives and policies from other sections of the District Plan, are a 'complete code' for such activities (i.e., other provisions of the plan do not apply). The Section 13 objectives

[4] PC6A of the Water Plan became operative on 1 April 2015. The feasibility study planning review (Golder, 2014) was undertaken prior to PC6A becoming operative.

and policies aim to provide for and support existing and new utilities and energy resource generation activities, given that they are essential, and contribute positively to the well-being of society.

Finally, the construction and operation of the irrigation option/s will require a number of resource consents principally in accordance the rules in the Water Plan and District Plan. If MCWSG decide to become a requiring authority, a designation will need to be sought for district level land use activities, namely construction activities and establishment of land-based irrigation infrastructure. Other RMA statutory planning documents may also trigger the need to seek additional resource consents. In addition to approvals under the RMA, the construction and operation of the preferred irrigation option/s is likely to require a range of other approvals either under other legislation and associated regulations, and /or from the manager of Crown or Council land.

The current over allocation of the Manuherikia Catchment, the requirement to use water efficiently, the expiry in 2021 of the catchments numerous mining privileges, the water quality requirements of Plan Change 6A, the potential need to undertake activities on crown land and the potential for irrigation development activities to effect endangered species are consider the main statutory challenges to any large scale irrigation development in the Manuherikia Catchment.

5.2 Consent Review and Current Allocation

In association with the Otago Regional Council (ORC) current water permits in the Manuherikia catchment were reviewed to develop a common data set of existing resource consents in the catchment and to determine current water allocation within the catchment. The findings of the review are documented in a letter titled *Consent review – Current Resource Consents* and dated 2 April 2014 (Golder, 2014a).

Table 10 summarises the volume and number of consented takes in the Manuherikia catchment on a sub-catchment basis. There are 279 current resource consents to take water within the Manuherikia Catchment of which 236 are for surface water and 43 are for groundwater. Of the 236 current resource consents to take surface water, 220 have information on the maximum rate of take and together authorise a combined maximum abstraction of approximately 41.7 m^3/s. Of which 24.3 m^3/s is assessed as being consumptive and is predominantly for the purpose of irrigation. The 43 current resource consents to take groundwater are predominantly clustered around Alexandra. Of the 43 resource consents, 21 have information on the maximum rate of take and together authorise a combined maximum abstraction of 663.5 L/s, although 600 L/s of this is associated with the flood protection scheme around Alexandra and is not considered a consumptive use. Total consented groundwater abstraction for consumptive uses in the Manuherikia catchment is expected to be in the order of 100 L/s.

Expiry of the approvals to take water was also assessed. Of the 279 current resource consents to take water within the Manuherikia Catchment:

- 38 resource consents authorising at total maximum take of approximately 0.9 m^3/s are due to expire prior to 2021.
- 162 resource consents (58 % by number) authorising at total maximum take of approximately 27.0 m^3/s (65 % by volume) are due to expire in 2021 (predominantly mining privileges / deemed permits which expire on 1 October 2021).
- The remaining 79 resource consents authorising at total maximum take of approximately 13.8 m^3/s are due to expire after 2021, with the latest resource consent expiry in 2047.

Table 11 summarises the volume and number of consented water takes in the Manuherikia catchment on a consent holder basis. The six irrigation companies hold 68 %, by volume (16.5 m^3/s), of the estimated total consumptive surface water take from the Manuherikia catchment. Of the 24.3 m^3/s estimated total consented consumptive surface water takes, 19.3 m^3/s (79 %) is authorised by deemed permits which expire in 2021.

Table 10: Existing surface water and groundwater takes in the Manuherikia catchment; per sub-catchment.

Sub-catchment	Total		Irrigation				Community/Domestic Supply				Industry			
			Primary		Secondary[1]		Primary		Secondary[1]		Primary		Secondary[1]	
	No.	L/s	No.	L/s	No.	L/s	No.	L/s	No.	L/s	No.	L/s	No.	L/s
Above Falls Dam	1	4,000[2]									1	4,000[2]		
Dunstan Creek	16	1,654	15	1,654	(1)	(-)								
Ida Burn[3]	25	4,053[4]	20	3,916[5]	(3)	(127[6])	1	5			1	5		
Pool Burn[7]	49	11,547[8]	41	11,425[8]	3 (1)	112 (-)					1	10	(3)	(-)
Upper tributaries	32	3,588[9]	21	3,359[10]	1 (5)	40 (84)	3[11]	105			1[12]	-	(1)	(-)
Lauder Creek	17	1,503	16	1,447			1	56						
Thomsons Creek	25	1,618[13]	25	1,618[13]										
Lower tributaries	72	8,344[14]	58	7,686[15]	(8)	(645[16])	5	12	(1)	(-)				
Below Campground	42	5388[17]	4	41	(26)	(4,735[18])			(7)	(11)			(5)	(601[19])
Total	**279**	**41,694**	**200**	**31,146**	**48**	**5,743**	**10**	**178**	**8**	**11**	**4**	**4,015**	**9**	**601**
Total consumptive takes	**242**	**24,357**	**174**	**23,306**	**43**	**888**	**9**	**136**	**8**	**11**	**2**	**15**	**6**	**1**

Notes: 'No.' refers to the total number of resource consents within the sub-catchment.
'L/s' refers to the total maximum allocated flow in L/s, rounded to nearest L/s. Some takes do not have volume information; these will be investigated further during Stage 2 of the consent review.
[1] Includes takes classified as "supplementary allocation" or are unclassified. The unclassified takes are shown in brackets and will be investigated further during Stage 2 of the consent review.
[2] Represents the non-consumptive hydro-electric take from Falls Dam. During the irrigation season most of this water is reused for downstream irrigation and not included in the consumptive total.
[3] The Ida Burn sub-catchment includes the Mt Ida Race.
[4] Includes 1,119 L/s (9 resource consents) which is considered a re-take and not included in the consumptive total.
[5] Includes 1,105 L/s (8 resource consents) which is considered a re-take and not included in the consumptive total.
[6] Includes 14 L/s (1 resource consent) which is considered a re-take and not included in the consumptive total.
[7] The Pool Burn sub-catchment includes the Ida Valley Irrigation Scheme takes from the Manorburn Reservoir and Manor Burn.
[8] Includes 5,236 L/s (9 resource consents) which is considered a re-take and not included in the consumptive total.
[9] Includes 70 L/s (3 resource consents) which is considered a re-take and not included in the consumptive total.
[10] Includes 28 L/s (1 resource consent) which is considered a re-take and not included in the consumptive total.
[11] Includes 42 L/s (1 resource consent) which is considered a re-take and not included in the consumptive total.
[12] The resource consent has no maximum rate and considered a re-take and not included in the consumptive total.
[13] Includes 56 L/s (1 resource consent) which is considered a re-take and not included in the consumptive total.
[14] Includes 1,726 L/s (10 resource consents) which is considered a re-take and not included in the consumptive total.
[15] Includes 1,415 L/s (7 resource consents) which is considered a re-take and not included in the consumptive total.
[16] Includes 311 L/s (3 resource consents) which is considered a re-take and not included in the consumptive total.
[17] Includes 600 L/s (3 resource consents) of groundwater which is associated with the flood protection scheme around Alexandra and 4,530 L/s (1 consent) from Lake Dunstan which has not been exercised none of which are included in the consumptive total.
[18] Includes 4,530 L/s (1 consent) from Lake Dunstan which has not been exercised and is not included in the consumptive total.
[19] Includes 600 L/s (3 resource consents) of groundwater which is associated with the flood protection scheme around Alexandra and is not included in the consumptive total.

Table 11: Existing surface water and groundwater takes in the Manuherikia catchment; per consent holder.

Holder	Total		Deemed Permits[1]		Main sub-catchment(s)
	No.	L/s	No.	L/s	
Private	203[2]	12,585[3]	89	5,543[4]	-
Blackstone Irrigation Scheme	3	536	2	508	Upper Tributaries
Galloway Irrigation Scheme	3	730	3	730	Lower Tributaries
Hawkdun Idaburn Irrigation Scheme	17[5]	3,714[6]	-	-	Ida Burn
Ida Valley Irrigation Scheme	21	10,570[7]	21	10,570[7]	Pool Burn
Manuherikia Irrigation Scheme	17	9,708[8]	16	5,178[8]	Lower Tributaries
Omakau Irrigation Scheme	15	3,850[9]	15	3,850[9]	Upper Tributaries, Dunstan Creek, Lauder Creek, Thomsons Creek
Total	**279**	**41,694**	**146**	**26,379**	
Total consumptive takes	**242**	**24,357**	**124**	**19,334**	

Notes: [1] Assumed to be all resource consents that expire on 10 January 2021.

[2] An additional 13 takes are located in Taieri catchment within the potential command area of the proposed Mt Ida Dam.

[3] Includes the 4,000 L/s non-consumptive hydro- electric take from Falls Dam, 600 L/s (3 consents) of groundwater which is associated with the flood protection scheme around Alexandra and 154 L/s (4 resource consents) which is considered a re-take, all of which are not included in the consumptive total.

[4] Includes 112 L/s (3 resource consents) which is considered a re-take and not included in the consumptive total.

[5] An additional 11 takes are located in Taieri catchment within the potential command area of the proposed Mt Ida Dam.

[6] Includes 1,119 L/s (9 resource consents) which is considered a re-take and not included in the consumptive total.

[7] Includes 5,236 L/s (9 resource consents) which is considered a re-take and not included in the total. Most of which is associated with operation of the Poolburn and Manorburn reservoirs.

[8] Includes 6,228 L/s (9 resource consents) which is considered a re-take or a take from Lake Dunstan which has not been exercised neither of which are included in the consumptive total.

[9] Includes two resource consents with no maximum rate attached which are considered re-takes and are not included in the consumptive total.

5.3 Consenting Strategy

It is anticipated that the completed Feasibility Study will form the technical 'backbone' for subsequent resource consent applications under the Resource Management Act 1991 (RMA) and an irrigation prospectus document for landowners. To help shape and guide the Feasibility Study a consenting strategy (Golder 2014) was developed via a collaborative working party process involving representation from MCWSG, Golder, ORC and CODC with input from other stakeholder as required. The common goal of the process was to *"seek mutually acceptable outcomes in relation to water allocation and/or management and future resource consenting within the Manuherikia Catchment and project area".* The strategy is a living document which will need to be refined as the project progresses and needs to be closely aligned to the MCWSG's "Community Proposition". Key aspects of the consenting strategy include:

- That technical work will give near-equal weighting (time and cost) for the two main parts of the investigation:

  1) Investigate (literature review, fieldwork, mapping etc.).

  2) Assess and report (assess effects, significance, Avoid-Remedy-Mitigate, reporting).

  This approach ensures the technical reports answer the question "*How significant is it and what should we do about it?*"

- For potentially adverse effects, the principles of avoid, remedy and mitigate will be applied as a hierarchy (i.e., avoidance will be the first goal of the project, then remediation and mitigation as appropriate).

- While the Feasibility Study has a scope to investigate several potential irrigation options within the catchment, the Consent Strategy is to only seek resource consents for those schemes that the MCSWG (as the agents for landowners) intend to build. The strategy is not to consent several options and allow the consenting process to refine the 'blueprints'. Multiple options add complexity and risk to the consenting process and will therefore be avoided.

- MCWSG's strategic intent is to establish an irrigation company (sometimes abbreviated to a working name of 'NewCo') that will hold all the resource consents for the construction and operation of the selected irrigation option for all of the sub-catchments associated with the scheme. This will include all of the irrigation related water permits in the sub-catchment associated with the scheme as a whole, not just those associated with the command area. MCSWG's aim is to achieve 100% uptake for all the resource consents in the relevant sub-catchment i.e., both the existing irrigation schemes and existing private water uses. If this is achieved then the irrigation company will be in a position to ensure full allocation of irrigation water within the command area for the selected option. Under this consenting holding approach, the irrigation company will not be responsible for: water related resource consents outside of the named sub-catchments (i.e., that is, the sub-catchments not included in the irrigation scheme) or, for any private water uses within the named sub-catchments where the water user has opted-out of joining the irrigation company.

- Communications associated with the project and any future consenting are to be underpinned by the expression early, open and honest. Stakeholders will therefore have access to reports and information as soon as practical i.e., early.

5.4 Issues and Options for Private Water Right Holders

As highlighted in the consenting strategy (Golder 2014) MCWSG's strategic intent is to establish an irrigation company that will hold all the resource consents for the construction and operation of the selected irrigation option for all of the sub-catchments associated with the scheme. Private water right holders in the sub-catchments associated with the scheme will need to decide to what degree they wish to join the scheme (i.e. not at all, partially or fully) which will determine the extent to which they need to transfer their private water rights to the new irrigation company. To assists private water right holders with this decision a report titled

Issues and Options for Private Water Right Holders' consents on tributaries of the Manuherikia River was prepared by the MCWSG's Farmer/Irrigator Advisory Group. The report summaries the issues facing private water right holders' in relation to how their water take and use activities might be consented and managed in the future. The report uses Lauder Creek as an example and provides practical advice on how issues such as allocation, water supply priority, rationing, integration into a larger irrigation scheme and consenting may be addressed at a local level. The key message from the report is that a voluntary process where water users within a sub-catchment work together to developed workable local solutions is likely to be preferred to a decision being imposed by an outside party namely the ORC/Environment Court.

5.5 Groundwater Use and Drinking Water Supplies

As part of the feasibility study, available information on the groundwater environment in the Manuherikia Catchment and its current utilisation was reviewed. The consequences for drinking water supplies and groundwater (quantity and quality) generally, of proposed irrigation developments was also assessed. The findings of the review are documented in a letter titled *Groundwater and drinking water supply reviews* and dated 27 May 2014 (Golder, 2014c).

The Manuherikia River Catchment has a modest groundwater resource when compared with the rest of the Clutha / Mata Au catchment. Small, scattered and geographically restricted pockets of high yield aquifers may be found, particularly in association with the Manuherikia River flood plain. The groundwater resources generally have good water quality, but show clear indications of being exposed to the residues characteristic of grazing agriculture (i.e., nitrate, phosphorus, potassium and chloride). Outside of the outwash and alluvial materials that form a thin veneer over the valley floors, the Tertiary sediments are not prospective for groundwater, although re-working of the top of the Tertiary and schist has lain down lenses of sand that contain useful but modest yields of groundwater. At the base of all of the geological materials discussed, the basement rock holds minor reserves of groundwater within the rocks' fracture network.

The groundwater resources of the Manuherikia River Catchment are not a large contributor to overall water use in the catchment. However, in certain locations (Dunstan Flats, Lower Manuherikia River alluvial gravels and potentially the Thompsons Creek area and parts of Ida Valley) they will provide a potential water source for small-scale irrigation. Throughout the catchment groundwater is a significant source of drinking water and stockwater.

Irrigation directly effects groundwater recharge and land use intensification associated with irrigation can influence groundwater quality. The five irrigation development options all involve increased spray irrigation which is often associated with land use intensification. As such, all five options have the potential to effect groundwater quantity and quality.

AgResearch completed OVERSEER® Nutrient Budget (Overseer) analysis and interpretation for the Manuherikia River catchment (AgResearch, 2015). The Overseer modelling provided catchment nutrient loadings and drainage rates under modelled current and future land use/water resource options. The results indicated that the Manuherikia catchment has a number of characteristics (e.g., a dry climate, deep soils with limited susceptibility to phosphorus loss and the ability to significantly reduce drainage and nitrogen loss from existing flood irrigated areas by converting to spray irrigation) which significantly reduce the risk of increased nutrient concentrations. At a catchment level the potential maximum irrigation development scenario associated with a large increase in water storage by raising Falls Dam by 27 m and constructing the proposed Mount Ida is expected to result in reduced nitrogen loss from the bottom of the root zone. A reduction in catchment scale nitrogen loss is expected to result in reduced nitrogen concentrations in the area's waterways and potentially improved groundwater and surface water quality. Catchment drainage under the potential maximum irrigation development scenario is expected to reduce due principally to the reduction in drainage associated with converting areas currently flood irrigated to spray irrigation. While the catchment level change is expected to be limited widespread conversion from flood irrigation to spray is expected to have a significant impact on local groundwater recharge. The Galloway and the Dunstan Flats areas are most at risk for reduced groundwater recharge Golder 2015d).

Drinking water supplies in the Manuherikia River Catchment have been shaped by the pattern of population and land settlement. Public water supplies under council management are restricted to the two main concentrations of population at Alexandra and Omakau – Ophir. Both the Alexandra and Omakau – Ophir water supply sources have significant issues with their water quality and compliance with the MoH drinking water standards. In both instances, replacement water source infrastructure is under investigation by CODC. Private water supplies are found in a dozen, or so, settlements throughout the catchment. Individual household domestic water supplies are also known to be obtained from wells, bores, springs (i.e., groundwater), roof catchments and water races according to the household's water resources and means. Little is known about these individual drinking water supplies and they generally only come to CODC scrutiny when a new dwelling is being consented.

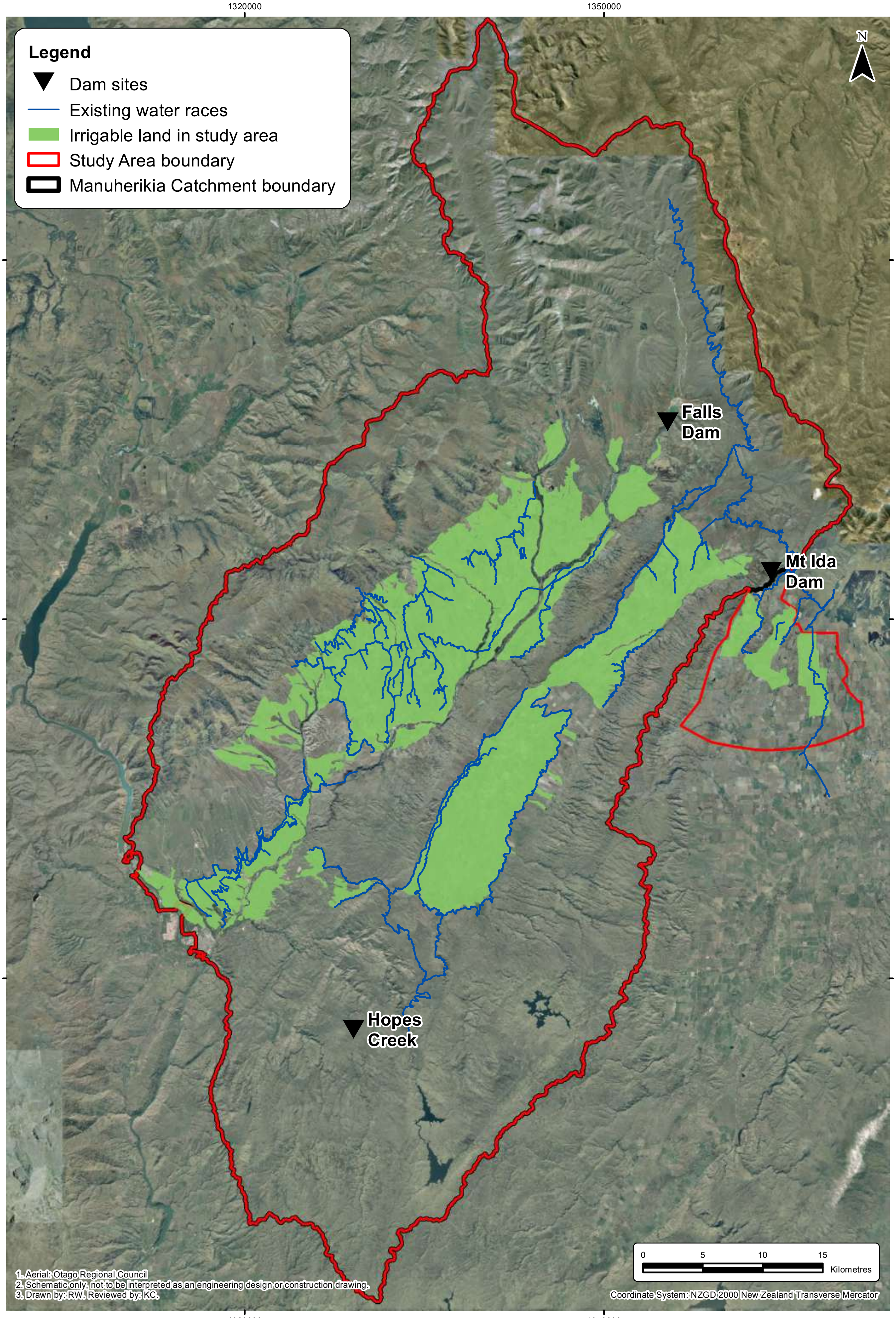
5.6 Irrigable Area

Using the irrigation area identified during the prefeasibility assessments as a guide, aerial photographs were assessed to confirm the potential irrigable area for the feasibility study. Urban areas, obvious wetlands and riverbeds, heavily vegetated riparian strips, steep broken topography and small disconnected irrigable areas, remote from water sources, which would require extensive distribution networks, were removed. The assessment identified a total of approximately 36,100 ha within the Manuherikia Valley (excluding Crawford Hills) which is considered irrigable (Table 12 and Figure 9). This is similar to, but approximately 350 ha more than, the 35,744 ha identified in the prefeasibility assessment (Aqualinc 2012e). The increase is due to a proposed higher elevation High Race alignment than used in the prefeasibility assessment.

Table 12: Irrigable land within the Manuherikia Catchment.

<table>
<tr><th colspan="4">Location</th><th>Area (ha)</th><th>Comment</th></tr>
<tr><td rowspan="11">Manuherikia Valley</td><td rowspan="4">Above Ophir</td><td rowspan="3">BIS, OIS & various private irrigators</td><td>Above races or pump from river</td><td>2,450</td><td>Blacks Flat included in pump from river.</td></tr>
<tr><td>< 40 below races</td><td>14,650</td><td>Includes ~ 7,600 ha below Omakau Irrigation Scheme Main Race which could receive pressurised supply from the proposed High Race. Also includes some private irrigators who take from various waterways who could be supplied from the High Race.</td></tr>
<tr><td>> 40 m below races, potential pressurised supply</td><td>12,400</td><td>Includes Blackstone Irrigation Scheme and Becks Flat part of OIS Omakau Irrigation Scheme.</td></tr>
<tr><td colspan="2">Sub-total</td><td>29,500</td><td></td></tr>
<tr><td rowspan="5">Below Ophir</td><td rowspan="3">MIS & private irrigators</td><td>Above Race</td><td>200</td><td>McArthur Ridge</td></tr>
<tr><td>< 40 below races</td><td>2,350</td><td>Includes some private irrigators who take from the Manuherikia River.</td></tr>
<tr><td>> 40 m below races, potential pressurised supply</td><td>1,500</td><td>~ 700 ha on Dunstan Flats and ~800 ha in the Keddell Road, Springvale and Long Gully areas</td></tr>
<tr><td>GIS</td><td>Pump from river</td><td>950</td><td></td></tr>
<tr><td colspan="2">Sub-total</td><td>5,000</td><td></td></tr>
<tr><td colspan="3">Matakanui Extension</td><td>1,600</td><td></td></tr>
<tr><td colspan="3">Manuherikia Valley Total(1)</td><td>36,100</td><td>Prefeasibility study estimate 35,744 ha</td></tr>
<tr><td colspan="4">Ida Valley (including Crawford Hills)</td><td>19,200</td><td></td></tr>
<tr><td colspan="4">Manuherikia Catchment Total</td><td>55,300</td><td></td></tr>
<tr><td colspan="4">Wedderburn area from proposed Mt Ida Dam</td><td>550</td><td></td></tr>
<tr><td colspan="4">Study Area Total</td><td>55,850</td><td></td></tr>
</table>

Notes: (1) Excludes the Dairy Flat command area.



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TITLE MANUHERIKIA CATCHMENT IRRIGABLE AREAS

AUGUST 2015

PROJECT 1378110270

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Approximately 29,500 ha of the irrigable area is located above Ophir, a further approximately 5,000 ha is below Ophir with the remaining approximately 1,600 ha within the Matakanui extension. The Matakanui Extension represents an area of irrigable land predominantly in the Chatto Creek and Yong Hill Creek sub-catchments in the vicinity of the Moutree Disputed Spur Road. This area is beyond the end of the proposed high race associated with Option 1 (Falls Dam High Raise) and is difficult for water distribution. This area is excluded from the five irrigation development options (Section 1.1) but was the subject of a separate assessment (Golder 2014b).

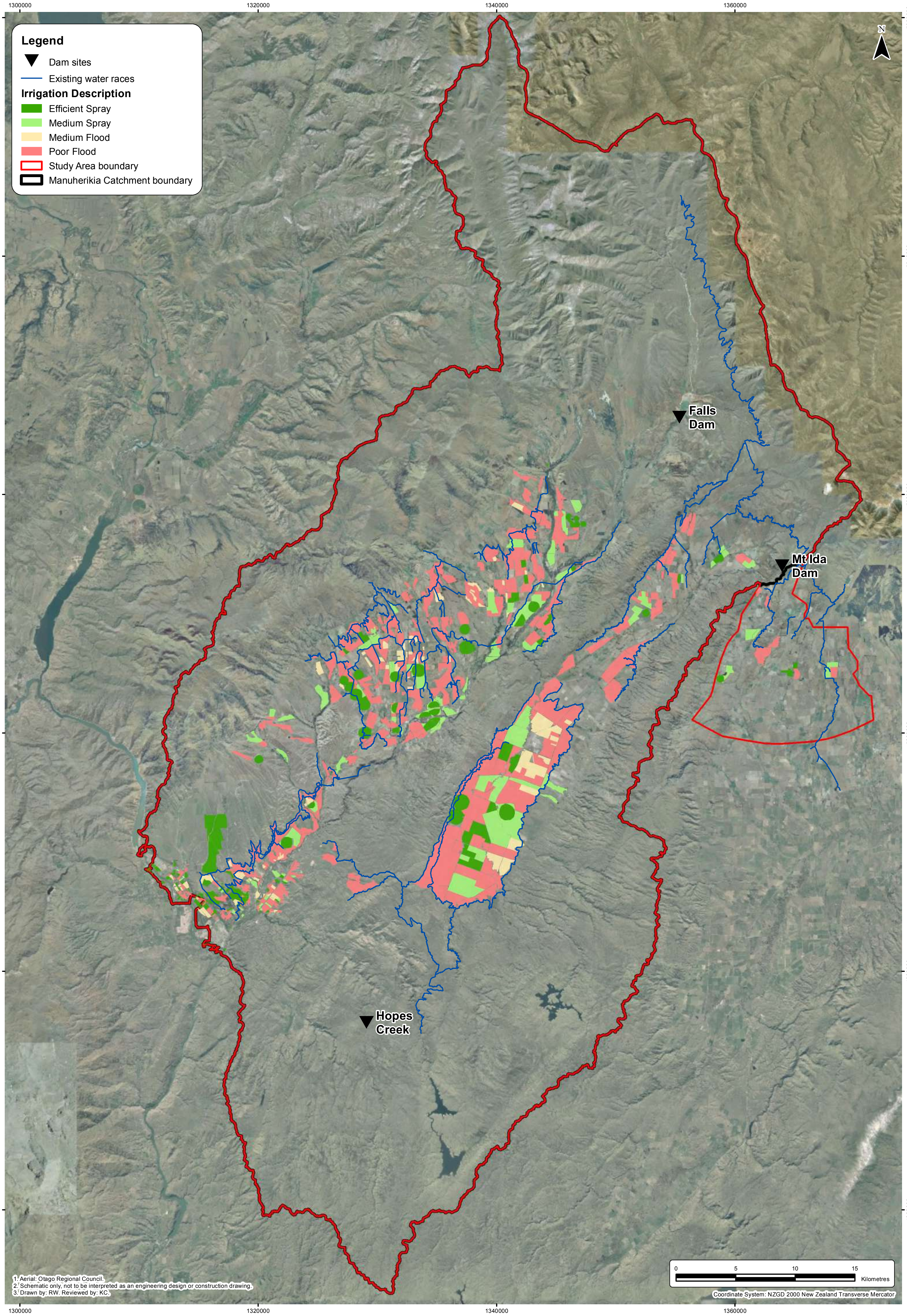
Of the 29,500 ha of irrigable land above Ophir approximately 2,450 ha is above the proposed distribution races (namely the proposed High Race) and would require piping and pumping up from the races. Approximately 12,400 ha is greater than 40 m below the proposed distribution races and has the potential to be supplied with a gravity pressurised, piped network, which would eliminate the need for on-farm pumping. The remaining approximately 14,650 ha is below the proposed distribution races and can be supplied by gravity, but some on-farm pumping would be required. Approximately 7,600 ha of this area is below the OIS Main Race and has been assessed as being supplied from that race. Potentially this area could also be supplied by a gravity pressurised piped network from the proposed new high race, thereby further reducing the need for on-farm pumping.

Of the 5,000 ha of irrigable land below Ophir, approximately 4,050 ha is within or adjacent to the command area of the MIS, with the remaining 950 ha within or adjacent to the command area of the GIS. All but 200 ha (McArthur Ridge) of the 4,050 ha associated with the MIS is below the MIS Main Race and can be supplied by gravity, of which approximately 1,500 ha (including 700 ha on Dunstan Flats) is greater than 40 m below the MIS Main Race. This 1,500 ha has the potential to be supplied with a gravity pressurised piped network that would eliminate the need for on-farm pumping. All 950 ha within or adjacent to the command area of the GIS is greater than 40 m below the MIS Main Race and has the potential to be supplied with a gravity pressurised piped network, which would eliminate the need for any scheme or on-farm pumping.

The benefits of gravity pressurised water supplies were summarised in the prefeasibility assessment as:

> *Water delivered under pressure in pipes is the preferred method. The value of the pressure through not having to install and operate pumps is currently equivalent to about $2000 worth of capital expenditure/ha for a typical irrigation system.* (Aqualinc, 2012e).

Option 1 (Falls Dam High Raise) involves large scale irrigation development with irrigation of approximately 25,000 ha in the Manuherikia Valley, which equates to approximately 70 % of the irrigable area. Current (Figure 10) and future (Figure 11) catchment irrigation maps were produced to assist with visualisation of this change.



Golder Associates

TITLE CURRENT IRRIGATION WITHIN THE MANUHERIKIA STUDY AREA

AUGUST 2015

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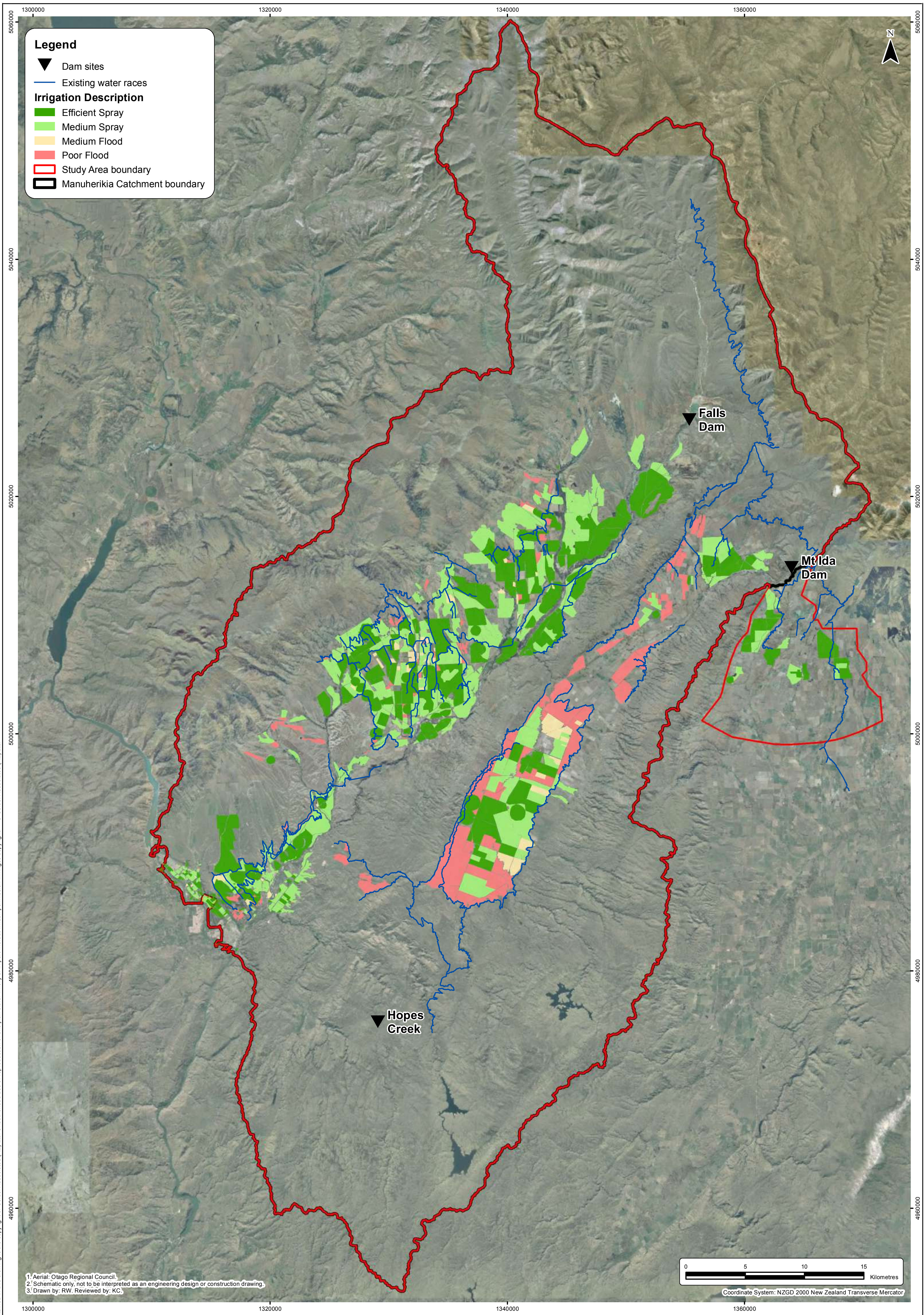

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TITLE Possible Future Irrigation within the Manuherikia Study Area under Option 1 (Falls Dam High Raise) and Option 5 (Mount Ida Dam) combined

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6.0 ENVIRONMENTAL

The findings from the environmental part of the feasibility study are documented in six reports as shown in Table 13.

Table 13: Feasibility Assessment key geotechnical and engineering documents

Report Title	Date	Key topics
Manuherikia Catchment Ecology: Background Review and Technical Assessment Report	April 2014	Provides the results of a background data search for ecological and environmental information for the Manuherikia River catchment. The report provides much of the background that supports the preliminary ecological assessment.
Manuherikia Catchment Water Strategy Group Feasibility Study Landscape and Visual Amenity Issues Report	24 February 2015	Provides a preliminary assessment and discussion of the landscape and visual effects of the identified options and reports on how these effects sit in relation to the relevant statutory documents. Where appropriate, this report also gives recommendations regarding mitigation or enhancement measures that may assist feasibility.
Assessment of effects on River Birds of increasing the height of Falls Dam, Manuherikia River, Central Otago.	March 2015	Outlines the results of a river bird survey of the Manuherikia River upstream of Falls Dam undertaken in December 2014 and summaries existing knowledge of river birds in the area. Includes an assessment of the potential effects of raising the height of Falls Dam and discusses potential mitigation options.
OVERSEER® Nutrient Budget Modelling in the Manuherikia Catchment.	June 2015	Describes the process undertaken using Overseer to assess current and potential nutrient losses from the Manuherikia catchment. The report outlines previous Overseer modelling within the Manuherikia catchment and then discusses a series of case study farms that were set-up to gain an understanding of current and future nutrient losses within the catchment under different irrigation management systems. The case study farms were then used in a catchment scaling-up process to produce catchment nutrient loss maps.
Spring Annual survey at Falls Dam and the proposed Ida Burn Dam sites	April 2015	Outlines the results of surveys undertaken in September 2014 at the two dam sites to assess threatened annual herbs.
Manuherikia Catchment Feasibility Study Preliminary Ecological Assessment Report	June 2015	Describes the implications for the feasibility of proposed expansion of agricultural irrigation based on the results of an evaluation of the ecological characteristics of the Manuherikia River catchment. It is based on a review of previous ecological investigations and new field studies by Golder in summer and autumn 2014.
Letter: Manuherikia Catchment feasibility Study: Water Quality and groundwater Recharge Addendum	July 2014	Uses the nutrient loss and drainage estimates from the Overseer modelling (AgResearch, 2015) to discuss the implications at a catchment level of: ■ Land use intensification on water quality, and ■ Changing from flood to spray irrigation on groundwater recharge.

The key environmental findings contained in the above reports are briefly summarised below.

The Manuherikia and Ida valleys are well developed for pastoral activity. Indigenous vegetation and intact indigenous ecosystems are essentially absent from the valley floors. The Land Environment New Zealand (LENZ) threatened environment classification recognises this with the valley floor Level 4 environment ranked as acutely threatened. The areas on the hillslopes and higher altitude areas are progressively less developed and provide larger areas of indigenous vegetation and the associated fauna. The intermontane basin of the upper Manuherikia Valley above Falls Dam is one of the least modified areas of the Manuherikia Valley.

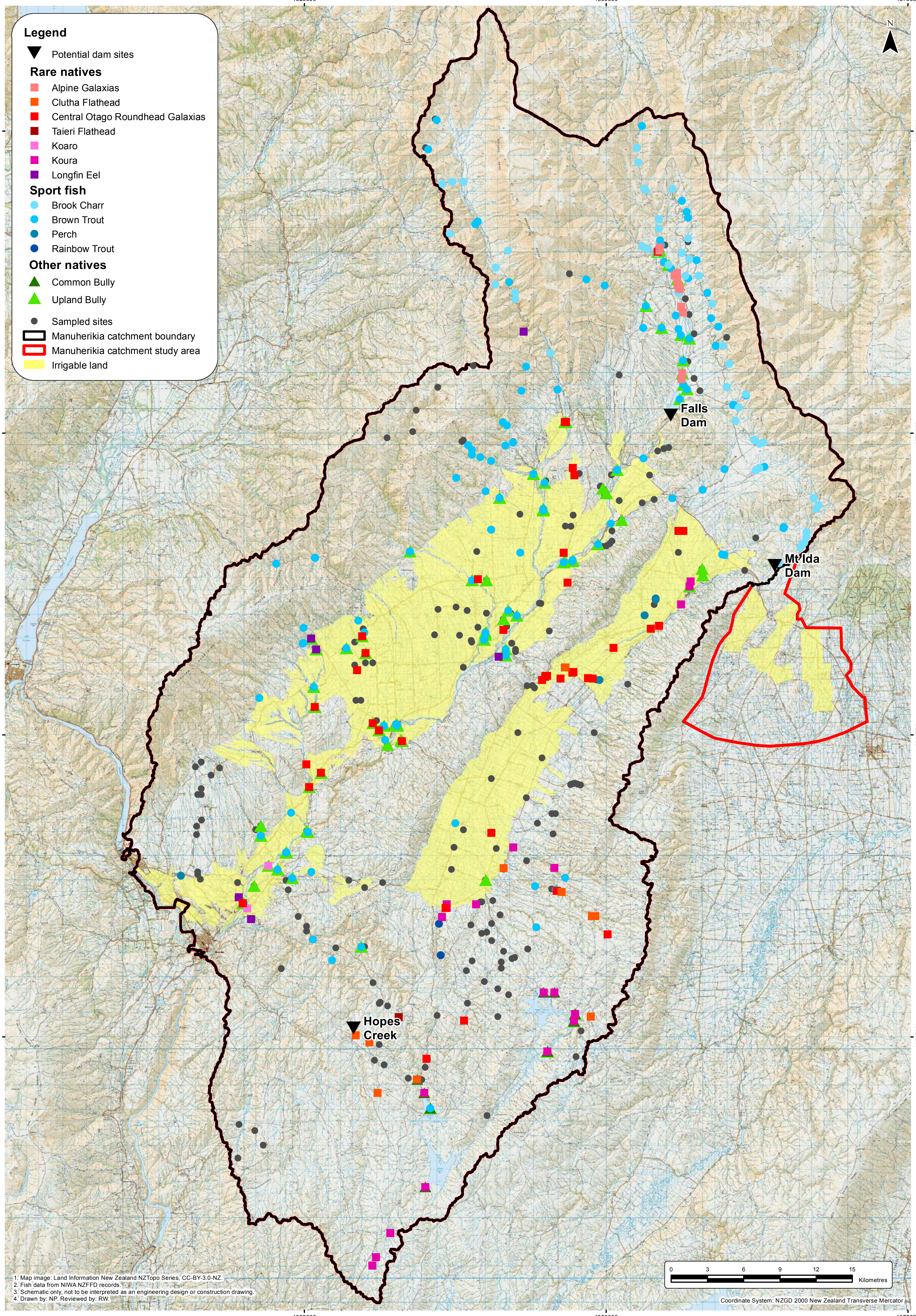
The current data available for all threatened species and ecosystems of the upper Manuherikia River is fairly limited. However, the data that is available identifies the threatened species and ecosystems that are likely to be present, allows generic assessment of potential effects, and potential mitigation options to be developed. It should be noted that further assessment will be required during the detailed design phase of the preferred irrigation development option to confirm the effects and design appropriate mitigation if required. It is anticipated that assessments of this nature would be a requirement of consent conditions.

The Manuherikia River supports a total of 11 fish species. Currently five of these species are classified as threatened (Goodman et al 2014) including the Clutha flathead (*Galaxias* spD) that is ranked in the highest category, Nationally Critical. The distribution of the individual fish species is varied with some species present throughout the Manuherikia catchment and others restricted to small areas of the catchment. Figure 12 provides a summary of the distribution of fish species throughout the Manuherikia Catchment relative to the potential inundation and irrigation command area.

Alpine galaxias (*Galaxias paucipondylus* aff Manuherikia) is the only fish species restricted to just the Manuherikia River catchment and only occurs upstream of Falls Dam. It has been recorded sporadically in the braided river reach and possibly once upstream in Johnsons Creek, a tributary of the East Branch of the Manuherikia River. DOC (2009) and Golder (this study) provide the most recent survey data indicating that the fish is essentially restricted to the braided section of the upper Manuherikia River and that its occurrence in the first 1 km upstream of the Falls Dam reservoir is more sporadic.

Clutha flathead galaxias is a stream resident species that occupies small to moderate sized streams from valley floor areas to steep mountain streams. This species is considered limited to the Clutha River Catchment with populations known from the Cardrona River downstream to tributaries of the Tuapeka River. Currently Clutha flathead galaxias is present in the Pool Burn and Manor Burn sub-catchments of the Manuherikia catchment. One population of Clutha flathead galaxias is present in the upper reaches of Hopes Creek.

The Central Otago roundhead galaxias is present in a number of streams within the irrigation command area. While some of these streams may not be directly influenced by the proposed irrigation developments it is anticipated that some particularly the Ida Burn Thomsons Creek and Lauder Creek will be. Changes to stream flow as a result of reduction in irrigation runoff, or a halt to water abstraction, will alter the instream habitat and may also alter the use of the stream by predatory fish such as salmonids. Riparian management to reduce nutrient and contaminant runoff also has the potential to alter instream habitat and species coexistence, as riparian management will stabilise stream banks and potentially narrow water courses over the long term. Therefore, it is recommended that streams with Central Otago roundhead galaxias populations are managed to maintain the native fish populations. The management of these streams will require an adaptive process because habitat and flow management to protect small galaxiid fishes has not been undertaken before.



Golder Associates

TITLE | DISTRIBUTION OF FISH SPECIES THROUGHOUT THE MANUHERIKIA CATCHMENT

AUGUST 2015

PROJECT | 1378110270

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Longfin eel has been reported from the Manuherikia River catchment. The lack of fish passage at Roxburgh Dam and the small numbers of elvers transferred upstream of the dam means that eels are now very rarely encountered in the Manuherikia River catchment. Until elver numbers at the Roxburgh Dam increase and a successful trap and transfer operation is underway, eel numbers will remain low in the upper Clutha River catchment.

The final threatened fish in the Manuherikia River is koaro. This is a whitebait species that also forms landlocked populations in some lakes, including lakes Wanaka, Hawea, Wakatipu and Dunstan. It is rare in the Manuherikia River catchment due to a lack of juvenile fish migrating into the Manuherikia River from the rearing habitat in lakes or at sea. Koaro have been noted to pose a threat to the smaller non-migratory galaxiids (e.g., Clutha flathead) and the creation of new reservoirs or enlarging of existing reservoirs may provide koaro juveniles with rearing habitat and is a possible threat to the established non-migratory galaxiids.

The Manuherikia River and its tributaries support a significant presence of trout and there is significant trout spawning within the river system.

The upper Manuherikia River valley supports a significant array of indigenous plants, birds, lizards and fish. The braided river habitat in the upper Manuherikia River valley provides the only habitat for the Manuherikia Alpine galaxias and habitat for a number of threatened braided river birds. Additionally, the Manuherikia River gorge immediately downstream of Falls Dam and gullies to the east of Falls Dam provide good habitat for threatened plants and lizard species.

All options to raise Falls Dam will create a larger reservoir thereby inundating some of the braided river system that enters the reservoir. The extent of inundation of the braided river system upstream of the reservoir, for all three dam raise options, are shown on Figure 13.

The upstream extent of the braided river system is evident on aerial photographs where the main stem of the Manuherikia River exits an incised gorge (marked as Point A on Figure 13). South of this point, the ground contours are demonstrably further apart representing a gentler slope where a braided river morphology has formed. Point A on Figure 13 is coincident with the LINZ 700 m contour line and this has been used as the basis for estimating the length of the braided river system. From this, it has been determined that the total length of braided river upstream of the existing Falls Dam reservoir (when full) is 12.8 km.

The consequent loss of braided river habitat for each of the three dam raise options are as follows:

- Total length of braided river for a 570.6 m full storage level: 12.2 km (4.7 % loss, or 0.6 km)
- Total length of braided river for a 580.4 m full storage level: 11.1 km (13.3 % loss, or 1.7 km)
- Total length of braided river for a 592.2 m full storage level: 9.9 km (22.7 % loss, or 2.9 km)

For all dam raise options this habitat loss will have impacts on the Manuherikia Alpine galaxias and the nesting area of the nationally critically threatened black-billed gull in the Manuherikia River valley. A proportion of the nesting habitat of the nationally endangered black fronted tern will also be lost as will some threatened plants and a portion of high value lizard habitat around the reservoir edge. The three dam raises will also reduce the area of the Home Hills Covenant, which has a total area of about 102 ha. The extent of inundation is presented on Figure 13.

- Total area of the Home Hills covenant inundated for a 570.6 m full storage level: 1.9 ha (2 % loss)
- Total area of the Home Hills covenant inundated for a 580.4 m full storage level: 4.3 ha (4 % loss)
- Total area of the Home Hills covenant inundated for a 592.2 m full storage level: 12.8 ha (13 % loss)

Initial field survey work (Golder unpublished data, 2014) indicates that the potential effect on the Alpine galaxias of raising Falls Dam is not restricted to inundation of river habitat and loss of habitat. Alpine galaxias are very rare in the reach immediately upstream of the reservoir for at least some 500 m. The reason for this very low density is at present not understood and at least three options are possibly the cause:

- Salmonids that are resident in the Falls Dam reservoir during winter and spring move upstream in the braided river habitat as the reservoir is drawn down over summer and autumn. These salmonids then prey upon and/or compete with Alpine galaxias, reducing their abundance in the upstream reach; or
- The formation of a delta at the head of the reservoir has created habitat that is too unstable during flood periods to support abundant fish populations and Alpine galaxias are reduced to very low densities due to the flood disturbance of the braids in the delta; or
- Habitat conditions are unsuitable for spawning in the lower section of the river and few larval Alpine galaxias drift downstream to occupy this reach; or
- A combination of these three factors is leading to very low Alpine galaxias density immediately upstream of the reservoir.

Therefore, the potential decline in range for the Alpine galaxias is likely to be due to two factors, habitat loss (via inundation) and for an additional area upstream of the raised reservoir as trout displaces, or unsuitable delta habitat restricts the Alpine galaxias from areas upstream from the reservoir.

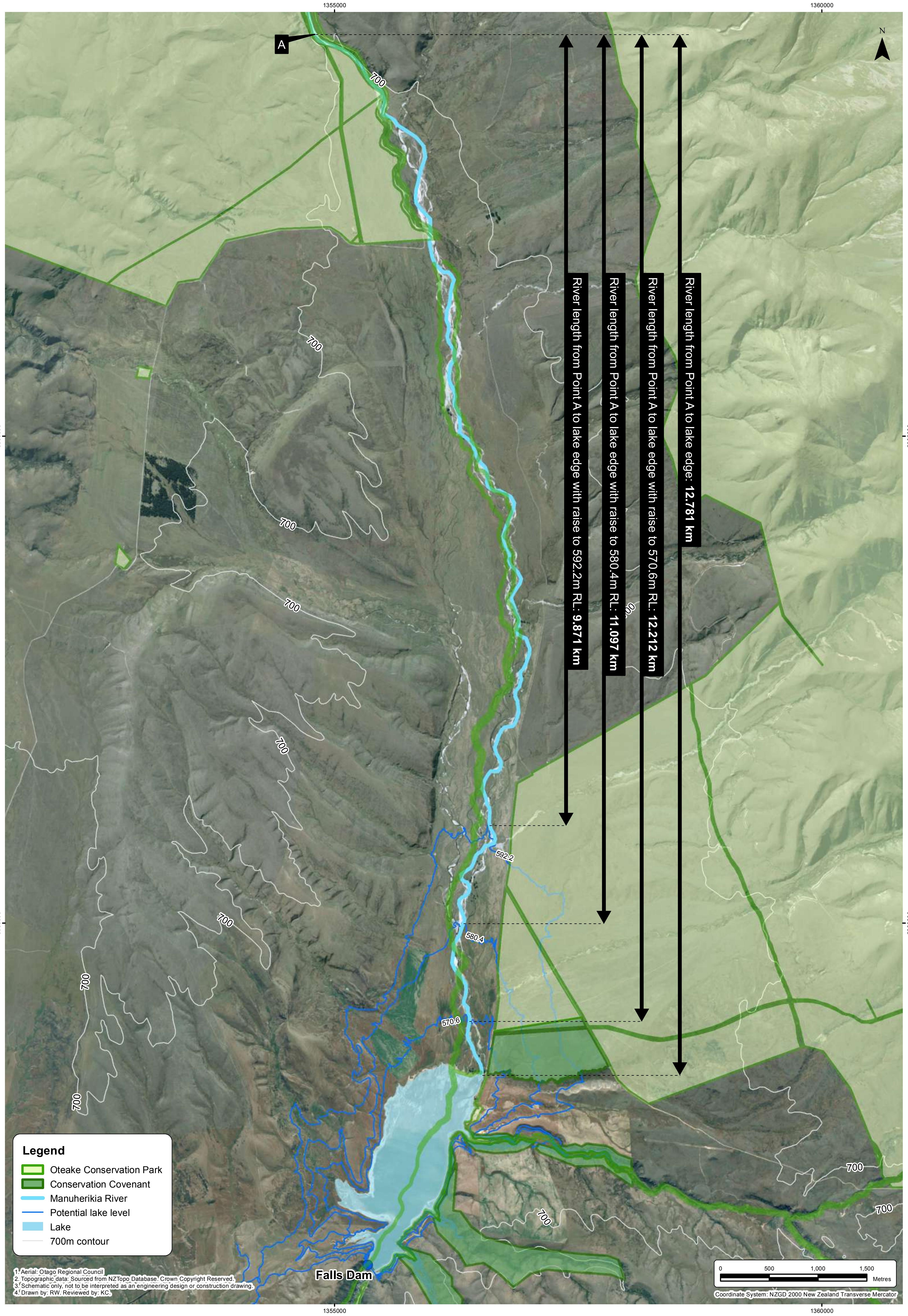
For the black-billed gull, larger nesting sites are known from other braided rivers in the country, but the loss of nesting habitat above Falls Dam may lead to two possible outcomes: the black-billed gulls locate new breeding sites along the other sections of the upper braided reach of Manuherikia River; or alternatively, the birds abandon the Manuherikia River catchment as they seek other braided river habitat for breeding. The effect on black fronted terns is also significant as a greater proportion of the national breeding population nests on the Manuherikia River than do the black-billed gulls (Wildlands 2013). However, the effect on the black fronted terns is unclear as nesting sites are more dispersed along the river. Inundation will only affect a proportion of the nesting areas and availability of breeding habitat is unlikely to be a limiting factor.

Enlarging the impoundment will also have an impact on the indigenous flora and fauna of the upper Manuherikia River. The 570.6 m full storage level option will cause a small reduction in the area occupied by lizards around the reservoir as some inundation occurs in the eastern gullies on Home Hills and of the lizard habitat along the rock and bluff systems of the current shoreline. For threatened plants the coral broom plants on the western shoreline will be lost to inundation.

The 580.4 m full storage level option will increase the loss of lizard and plant habitat and extend the range of threatened plants subject to loss to include the marsh arrow grass and some of the threatened plants including a small number of the Kawarau cress, mat broom, coral broom, *Coprosma intertexta* and *Chenopodium allanii.* The majority of these threatened plants are present within the Home Hills covenant and on the steep faces on the eastern shoreline of the reservoir. The fen on the western side of the reservoir with the marsh arrow grass and willowherb will also be partially submerged.

The 592.2 m full storage level option will flood the largest area of threatened plant and lizard habitat and will include a high proportion of the known Kawarau cress plants in Johnstones Creek and the 2 ha fen on the western side of the reservoir. The impact on individual species will be varied as they are not evenly distributed in the gullies and species that occupy areas on the gully floors and lower hill slopes will be disproportionally affected. This is likely to include species that specialise in scree slope habitats that only occur on the lower slopes of the gullies.

The highly modified valley floors downstream of the Loop Road Bridge on the Manuherikia River provide little indigenous species habitat. However, any remaining areas of indigenous vegetation are of high value due to their rarity as indicated by the LENZ threatened environment assessment. Biodiversity values on individual farm properties have not been identified. While the general extent of irrigation schemes is known, the future individual farm uptake of water and areas on individual properties that may be developed for irrigation are unknown. However, for each farm that becomes part of an irrigation scheme it is recommended that the Farm Management Plans (FMP) include a biodiversity assessment, especially for any areas where new irrigation development is occurring. The results of the assessment are then used in the FMP, with areas of high biodiversity value excluded from development, and consideration being given to protection and enhancement of areas of low to moderate biodiversity value.



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TITLE FALLS DAM: POTENTIAL INUNDATION OF RIVER BRAID

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A larger, scheme-wide objective could also be restoration of a proportion of the indigenous vegetation cover and promoting the establishment of indigenous fauna in areas across the Manuherikia and Ida Valleys. This restoration work could be coupled with riparian management, with fenced off areas being planted with indigenous vegetation and the riparian management zones used to link any larger restoration areas.

A scheme or catchment based approach which co-ordinates individual on-farm activities should be encouraged and it will enhance overall environmental management and maximise the benefit from any mitigation activities.

Saline wetlands in the lower Manuherikia River catchment provide another unique and restricted ecosystem. These saline areas host a range of threatened plants and invertebrates. Five saline sites are recognised in the Manuherikia catchment and these are included in the Otago Regional Plan as regionally significant wetlands. Four of the five saline wetlands are outside or adjacent to the irrigation command area and therefore unaffected by the changes to irrigation and water abstraction. The Rockdale saline wetland is located near Chatto Creek near the boundary between the Tiger Hills part of the Omakau Irrigation Scheme and the Manuherikia Irrigation Scheme. Changes to the irrigation regimes on properties surrounding this wetland, has the potential to effect water level and salinity within the wetland. Local irrigation details are yet to be determined but care will be required when considering irrigation changing in this area. Monitoring of water and salinity levels in these wetlands, to ensure the saline nature of the wetlands is retained, is important and this will ensure the plants dependent on these saline soils continue to be present.

Recent studies have shown the current state of the Manuherikia River and its tributaries is varied. In general, the upper catchment has excellent water quality. However, in the lower reaches of the Manuherikia River at Galloway, the water quality has declined to 'good' (ORC 2011). In the tributaries, water quality declines downstream as each stream flows across the Manuherikia or Ida valley floor. Current irrigation in the catchment is dominated by flood irrigation practices. Large application depths are applied which cause saturation of the soil profile, runoff and significant drainage of water through the soil profile. Increased runoff leads to sediment and phosphorus being washed into the watercourses while increased drainage results in leaching of nitrogen. There is potential for algal blooms, although this is currently limited by low levels of nitrogen in the streams.

AgResearch completed OVERSEER® Nutrient Budget (Overseer) analysis and interpretation for the Manuherikia River catchment. AqResearch (2015) identified catchment scale estimates of nutrient loss and drainage (Table 14) under the following scenarios:

1) Estimated current land use and irrigation.

2) Estimated future land use with no increase in water storage, but a move to more efficient irrigation.

3) Estimated future land use with potential maximum irrigation development associated with a large increase in water storage by raising Falls Dam by 27 m and constructing the proposed Mount Ida Dam.

Table 14: Nutrient loss and drainage from the Manuherikia catchment estimated using Overseer.

Variable	Scenario				
	1 Current	2 Future no increase in water storage		3 Future increased water storage	
	Amount	Amount	Difference from current	Amount	Difference from current
Nitrogen loss (kg)	162,194	151,684	-10,510 (-6.5 %)	161,527	-667 (-0.4 %)
Phosphorus loss (kg)	4,663	4,770	107 (+2.3%)	5,838	1,175 (+25.2 %)
Drainage (Mm^3)	254.8	246.1	-8.7 (-3.4 %)	248.7	-6.1 (-2.4 %)

Note: Values in parentheses represent change as a percentage of current.

The results indicated that the Manuherikia catchment has a number of characteristics (e.g., a dry climate, deep soils with limited susceptibility to phosphorus loss and the ability to significantly reduce drainage and nitrogen loss from existing flood irrigated areas by converting to spray irrigation) which significantly reduce the risk of increased nutrient concentrations. At a catchment level the proposed irrigation development is expected to result in reduced nitrogen loss from the bottom of the root zone. A reduction in catchment scale nitrogen loss is expected to result in reduced nitrogen concentrations in the area's waterways and potentially improved groundwater and surface water quality (Golder 2015d).

At a catchment level the proposed irrigation development is expected to result in increased phosphorus loss from the catchments farms. Phosphorus loss is principally associated with runoff, overland flow and active soils erosion. Measures such as appropriate cultivation techniques, vegetation management to limit erosion, riparian strips, controlling stream bank erosion and preventing stock access to waterways will be required to control phosphorus concentrations in the waterways that drain the irrigated areas.

Farm Management Plans which identify and address potential erosion "hotspots" and which require detailed on-farm nutrient budgeting will be an important mitigation measure to reduce the risk that future land use intensification poses to water quality.

The feasibility assessment included a preliminary assessment of landscape and visual amenity issues associated with the proposed irrigation developments (Espie 2015). The key objective of the assessment was to assess how the landscape and visual effects of the proposed activities sit in relation to the statutory documents; the key issue being whether or not the effects are likely to be fatal or problematic in relation to gaining resource consent. The preliminary assessment identified the following implications in relation to project feasibility:

- The detailed design and finishing of the new Falls Dam and Ida Burn Dam structures should be so as to reduce discordance with the existing landscape character and to visually blend with their context as much as is practical. This may involve design of landform/earthworks to mimic or abstract natural forms and revegetation/rehabilitation of all disturbed ground to tie into surrounding vegetative cover or to create ecological and visual interest.
- A suitable vegetation policy should be adopted and put in place in an ongoing way in relation to the command areas of the Falls and Mount Ida Dams to guide the treatment of riparian areas and on-farm tree planting being incorporated into irrigated operations as appropriate so as to enhance or offset effects on natural character and rural amenity. There is likely to be discussion and public submissions in relation to some individual views within the command areas of the proposed dams, whether from roads, private viewpoints or parts of the CORT. If appropriate, it may be that specific mitigation measures could be proposed in relation to these issues as they come up.
- A carefully formulated flow regime should be put in place in relation to both the Manuherikia River and the Ida Burn to improve and maintain the ecological health and braided habit of the watercourses. Project feasibility would also be improved by a programme for ongoing riparian improvement works (in relation to natural character and recreational opportunities).
- The creation of the Ida Burn Dam reservoir will bring considerable landscape character effects that will be carefully scrutinised by the resource consent process. These will be contentious to some degree but unlikely to be fatal to project feasibility provided that mitigation measures (edge treatment, vegetation, rehabilitation of all disturbed areas) and possible offsets (areas of new habitat/natural character creation) are appropriately included.
- The expansion of the Falls Dam reservoir into the identified ONL to the north and east of the existing reservoir will cause significant uncertainty for feasibility through landscape character effects and, to a lesser degree, visual effects. This uncertainty will reduce (but will not be eliminated) if the encroachment into the ONL is reduced and if significant offsets (most likely creating areas of ecological/habitat/natural character merit) are given.

The Mt Ida dam and reservoir site has been assessed as having relatively low values and mitigation is considered limited or not necessary.

The environmental assessments of the five proposed irrigation development options have identified a number of issues (particularly those associated with endangered species) which will require very carefully management. However, it is anticipated that suitable management and mitigation options can be developed which would allow the proposed irrigation development options to potentially progress.

7.0 ECONOMIC AND COMMERCIAL

The economic and commercial feasibility assessment was completed by the following three specialist providers;

1) **Compass Agribusiness Management Limited** (Compass) - who specialise in on farm feasibility studies, financial budgetary services and economic effects on changes of land use.

2) **Rationale Limited** (Rational) – who specialise in all aspects of infrastructure management; including strategy development; valuations; asset management plans and funding model development.

3) **Butcher Partners Limited** (Butcher) – who are consulting economists and specialise in cost benefit analysis and economic impact modelling.

The feasibility assessment was separated into two components, being on-farm considerations, led by Compass; and off-farm considerations led by Rationale, which included assessment of economic impacts at a district, regional and national level completed by Butcher.

On-farm assessments were completed for the five case study farms (Table 15) selected to represent the common farming types in the study area. The on-farm assessments included Farmax modelling of production and detailed farm budgeting. Various farm types (mixed arable, sheep, dairy and dairy support) were assessed under both dryland and irrigated systems to assess the potential viability of various farming types and potential land use changes under the proposed irrigation development costs. Initial farm budget were based on the off-farm water supply costs provided in the pre-feasibility assessment which indicated that all nine of the potential land use changes that were modelled were economically viable.

The off-farm water supply cost estimates developed during the feasibility study were considerably higher than the earlier prefeasibility estimates and resulted in decreased on-farm economic viability.

Due to the high off-farm water supply costs estimated during the feasibility study the economic assessment of the overall scheme was put on hold while an optimisation process was undertaken to assess options for reducing off-farm costs.

Table 15: Case Study Farms

Area and approx. location	Farm type	Irrigation and water supply type	Climate zone	Elevation zone	Topography	PAW soil type zone	Leaching potential
Hawkdun Oturehua - Neilson Road	Sheep. Large dry land supporting small irrigated area.	Current pumped spray from dam. Future gravity pressurised piped supply from Mount Ida Dam.	Blackstone Hill rain, Ranfurly ET	High	Flat	Light 30 - 90 mm	Low-medium
Lower Manukerikia Springvale - Keddell road	Dairy support	Current contour irrigation with some spray. Future gravity pressurised piped supply from MIS race.	Clyde/Alexandra for rain and ET	Low	Flat - Undulating	Light 30 - 90mm (flat) to medium 91 - 140 mm (undulating)	Low
Downs Gidding Downs - Long Gully Road	Sheep	Currently dryland. Future gravity partial pressurised piped supply from new high race.	Cambrian rain Lauder or Ranfurly ET	High	Rolling	Heavy >140 mm but some drainage issues	Low
Omukau Dairy Omukau-Lauder SH85	Dairy	Current spray pumped from buffer storage pond fed from the, Manuherikia River. Future no change.	Ophir rain, Lauder ET	Medium	Flat - Undulating	Medium 91 - 140 mm	Medium
Omukau McWinney Racecourse-McWinney Road	Arable	Current contour irrigation. Future gravity partial pressurised piped supply from new high race.	Matakanui rain, Lauder ET	Medium	Flat	Light 30 - 90 mm	Medium

8.0 CONCLUSIONS AND RECOMMENDATIONS

The hydrology of the catchment is very seasonal and summer droughts and periods of low flows are common. Water allocation in the catchment is very high with an estimated 24.3 m^3/s of surface water allocated for consumptive use the majority of which is for irrigation. Water supply reliability varies across the catchment and is often poor with frequent irrigation restrictions. Hydrological investigations indicate that water storage is critical to ensuring adequate water supply reliability.

Irrigation in the catchment is currently characterised by an extensive open race distribution network which is operated on a roster system that supplies water to predominantly on-farm flood irrigation. On a catchment level the irrigation is very efficient in terms of both scheme distribution efficiency and catchment water use. Inspection and monitoring of the open race network indicates that race leakage is limited and within the 10 % which is considered acceptable for open race based distribution networks. Irrigation water is spread very thinly and often recaptured and reused down gradient. While water use efficiency is high at a catchment level, on an individual paddock or farm basis it is often poor. Improving water use efficiency at a farm or paddock level essentially represents a move from flood irrigation, which currently dominates, to spray irrigation. Spray irrigation requires a constant, on demand water supply and the irrigation schemes would need to shift away from rostered supplies.

Conversion to spray provides production benefits but is expensive ranging from $2,000/ha to $10,000/ha (Aqualinc 2012). To justify the conversion costs a reliable water supply is required. The spray conversions that have occurred within the catchment are on properties with one or more of the following: reliable high priority water rights; a large quota; access to water from scheme storage reservoirs (i.e., Falls Dam) and on-farm buffer storage.

The feasibility study is focused on five irrigation development options which were identified during the prefeasibility study (Aqualinc 2012d). The first three options involve raising the impoundment of Falls Dam by building a new dam or raising the existing dam. The fourth option is to improve the efficiency of irrigation within the Manuherikia Valley by developing efficient water distribution systems. The fifth option is the construction of a new dam (the Mount Ida Dam) on the upper Ida Burn.

This feasibility assessment has identified a number of issues (documented in this report) which suggest that large scale irrigation development in the Manuherikia Catchment will be significantly more complicated than implied by the earlier prefeasibility study. Principal among these are the following two issues:

1) The feasibility cost estimates are substantially higher than those suggested in the prefeasibility assessments and are at a level where securing widespread irrigator support may be difficult. The costs associated with water storage is the dominant contributor to the overall cost estimates.

2) A number of threatened species and ecosystems have been identified within the Manuherikia Catchment particularly surrounding and upstream of Falls Dam. The proposed irrigation developments particularly enlarging the impoundment of Falls Dam has the potential to inundate areas of both significant ecosystems and habitat for threatened species. Managing theses risk and developing suitable avoidance or mitigation measures will be challenging.

Given the estimated high costs there is need to look critically at water demand, hydrology, storage options, engineering design, costings and to a lesser extent distribution and environmental issues to determine an optimised solution which could progress to more detailed investigations. Of the environmental issues, the area of new inundation above Falls Dam is considered the issue most likely to affect selection of the optimum solution. Based on the investigations to date the optimum solution is expected to involve a smaller dam, lower supply reliability and possibly review of expected water demand to include consideration of land uses which are less water intensive.

To progress the project and to assist in the identification of the optimum water management and irrigation development solution for the Manuherikia Catchment the following investigations are recommended.

- The hydrological models prepared for the Manuherikia Catchment provide a means for quickly assessing potential development scenarios. However some refinement of the models is recommended to:
  - Better assess tributary contributions.
  - To include the production implications of water supply restrictions.
  - To provide more flexibility in terms of future water demand, so that different crops and climate change can be assessed.
  - To allow whole catchment water management options to be quickly assessed.
- That the predicted future irrigation demand requirements be reviewed to assess if future water demand and hence storage requirements can be reduced. Water demand could be reduced by a combination of:
  - Reducing the proposed irrigated area, and/or
  - Including land uses which require less water than pasture, and/or
  - Reducing water supply reliability and accepting a level of irrigation restrictions. For this latter option information on the production implications of any water supply restriction is required to make informed decisions.
- Progress the optimisation of Falls Dam to identify the preferred dam design and location and then confirm estimated costs. Distribution aspects of the projects including the ability to stage development should be included in the optimisation process. Following selection of the preferred scheme, particularly the preferred water storage option, potential flow regimes and water supply reliability needs to be confirmed through an open stakeholder process similar to the one conducted for irrigation development Option 1: Falls Dam high (27 m) raise and documented in Golder 2014d. Following confirmation of the flow regime and supply reliability further design work is required to optimise the distribution networks and confirm estimated distribution costs. This work would include: confirmation of supply areas and design flows, hydraulic design of key infrastructure (particularly the siphons and intakes), alignment walkovers (particularly for the proposed High Race alignment through the Drybread Diggings) and estimated costs.
- Given the substantially higher estimated costs of the development it is recommended that irrigator support for each of the development options be assessed. Once potential irrigator support is known the storage requirements can be confirmed and the distribution refined to reflect a known supply area. To assist landowners with their decision regarding the proposed development options, it is recommended, that the irrigation development costs (both on-farm and off-farm) that differing land uses, water supply reliabilities and management practices can support, be investigated.

9.0 REFERENCES

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APPENDIX A

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APPENDIX B

Feasibility Study Reports

Summary of Manuherikia Feasibility Study Reports

Discipline	Document Title	Document Reference	Date Delivered
Water	Manuherikia Valley Hydrology: 2013 update Report	Aqualinc	September 2013
Water	Mt Ida Dam hydrology	Aqualinc	September 2013
Water	Resource Management Act 1991 and Statutory Planning Considerations	1378110270_203	March 2014
Water	MT Ida Dam Hydrology Review	1378110270_204_LR_Rev0	March 2014
Water	Manuherikia Hydrology Review	1378110270-210-LR-Rev0	March 2014
Water	Consent review – Current Resource Consents	1378110270-211-LR-Rev1-2000	April 2014
Water	Water supply options for the Moutere Disputed Spur Road area – Preliminary Assessment	1378110270-207-LR-Rev0	April 2014
Water	Consent Strategy	1378110270_201 (Rev1)	May 2014
Water	Groundwater and Drinking Water Supply Reviews	1378110272-Rev2	May 2014
Water	Dam Break Assessment - Raised Falls Dam, full supply level of 588 m	1378110270_2000_214_R_Rev0_219	July 2014
Water	Hydrological Model Runs	1378110270-2000-L-Rev0-221	September 2014
Water	Flow Regimes	1378110270-2000-L-Rev1-222	December 2014
Water	Irrigation Distribution Report	1378110270-2000-R-Rev1-223	June 2015
Water	Water Quality and Groundwater Recharge Addendum	1378110270-2000-L-Rev0-225	July 2015
Geotechnical	Memorandum: Proposed Geotechnical Investigations at proposed Falls and Mt Ida Dam Sites	1378110270_3020	December 2013
Geotechnical	Hopes Creek – STAGE 1 Engineering Assessment	1378110270-304-LR-Rev0-3040	April 2014
Geotechnical	Geotechnical STAGE 1 Report: Background Review and Investigations	1378110270_3000_3060-306-Rev1	May 2014
Geotechnical	Mt Ida Dam Site	1378110270_3000-3080-308-LR-Rev0	May 2014
Geotechnical	Mt Ida Dam – updated information – June 2014	1378110270_3000-3080-308-L-Rev0-309	June 2014

Geotechnical	Manuherikia: Falls Dam Recommended Option	1378110270-3070-LR-Rev0-310	July 2014
Geotechnical	Falls Dam Proposed Scope of Preliminary Design	1378110270-312-L-Rev0	August 2014
Geotechnical	Hopes Creek Dam: Stage 2 Engineering Assessment Report	1378110270-3000-3040-R-Rev0-311	August 2014
Geotechnical	Mt Ida Dam – updated information – September 2014	1378110270_3000-3080-308-L-Rev0-314	September 2014
Geotechnical	Geotechnical Stage Three Report: Falls Dam Preliminary Design and Cost Estimate	1378110270-3000-3090-R-Rev1-313	February 2015
Geotechnical	Manuherikia: Falls Dam Optimisation	1378110270-3100-LR-Rev1-315	February 2015
Geotechnical	Manuherikia Catchment Feasibility Study: Mount Ida Dam Water Supply Options	1378110270-2000-LR-Rev0-226	August 2015
Environmental	Manuherikia Catchment Ecology: Background Review and Technical Assessment	1378110270_4000-400-R-Rev0	April 2014
Environmental	Spring annual survey at Falls Dam and proposed Ida Burn Dam sites	K Wardle	September 2014
Environmental	Assessment of Effects on River Birds of increasing the height of Falls Dam, Manuherikia River, Central Otago	Wildlands	January 2015
Environmental	Manuherikia Catchment Water Strategy Group Feasibility Study Landscape and Visual Amenity Issues Report	Vivian + Espie	February 2015
Environmental	Nutrient losses within the Manuherikia Catchment	AgResearch	June 2015
Environmental	Preliminary Ecological Assessment	1378110270-4000-R-Rev1-401	June 2015

APPENDIX C

Falls Dam Design Drawings

MANUHERIKIA CATCHMENT FEASIBILITY STUDY

FALLS DAM RAISE OPTIONS

REFERENCES

1. EXISTING GROUND SURVEY WAS PROVIDED BY BTW SOUTH ON 27 JUNE 2014. COORDINATE SYSTEM, SURVEY, AND ALL ELEVATIONS ARE IN REFERENCE TO LINZ LISTED TRIG N No 2 AND DUNEDIN VERTICAL DATUM 1958.

SITE PHOTO
N.T.S.

INDEX OF FIGURES

NOT FOR CONSTRUCTION

DRAFT

CLIENT
MANUHERIKIA CATCHMENT WATER STRATEGY GROUP

PROJECT
MANUHERIKIA CATCHMENT FEASIBILITY STUDY

CONSULTANT
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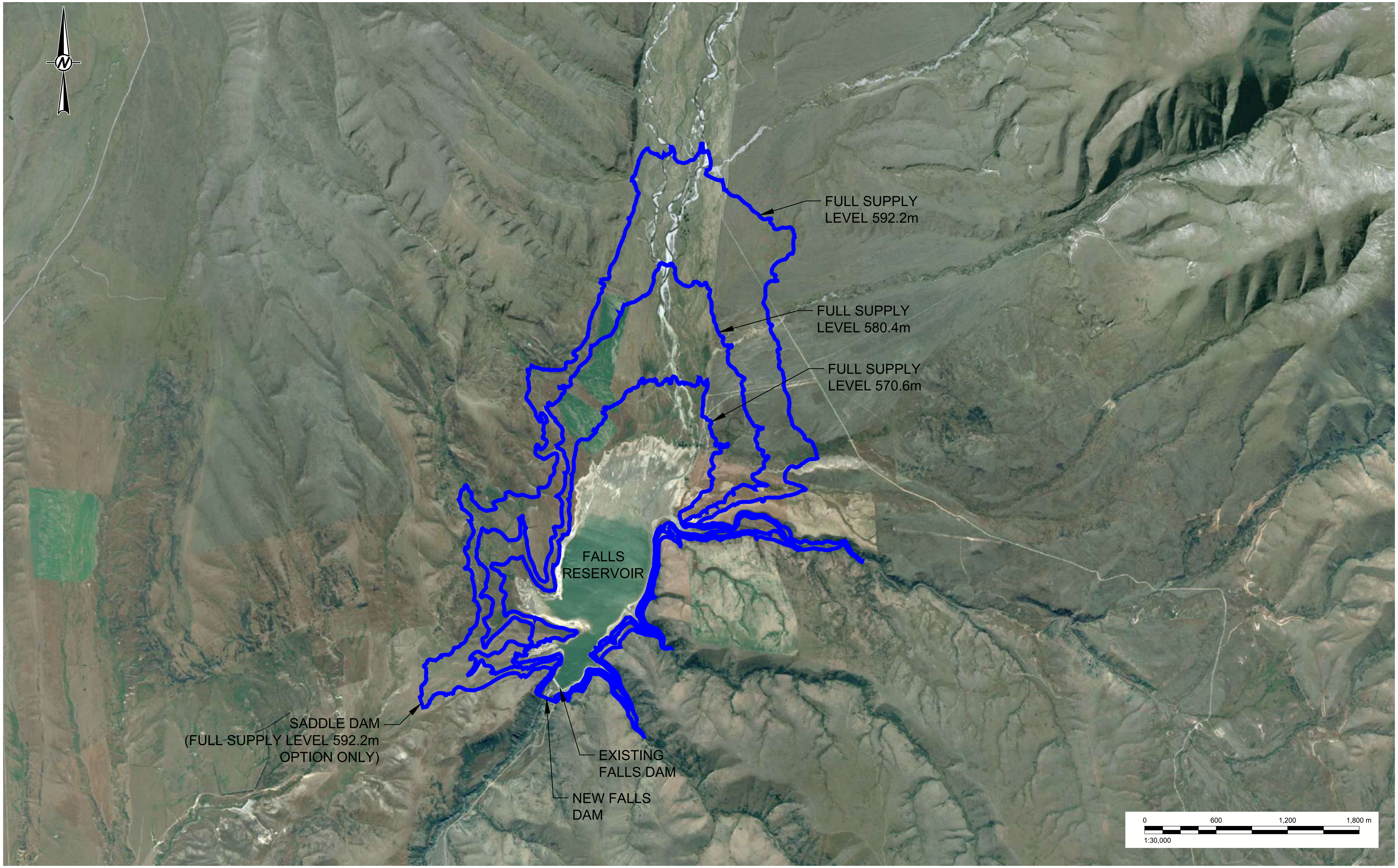
TITLE
TITLE SHEET AND SITE MAP

PROJECT No. 1378110270
Rev. A
Figure 1



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TITLE
RESERVOIR AREA

PROJECT No.	Rev.	Figure
1378110270	A	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25 mm

0

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TITLE
PLAN VIEW OF FULL SUPPLY LEVEL 570.6 m DAM RAISE OPTION

PROJECT No.	Rev.	Figure
1378110270	A	3

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TITLE
PLAN VIEW OF FULL SUPPLY LEVEL 580.4 m DAM RAISE OPTION

PROJECT No. 1378110270 | Rev. A | Figure 4

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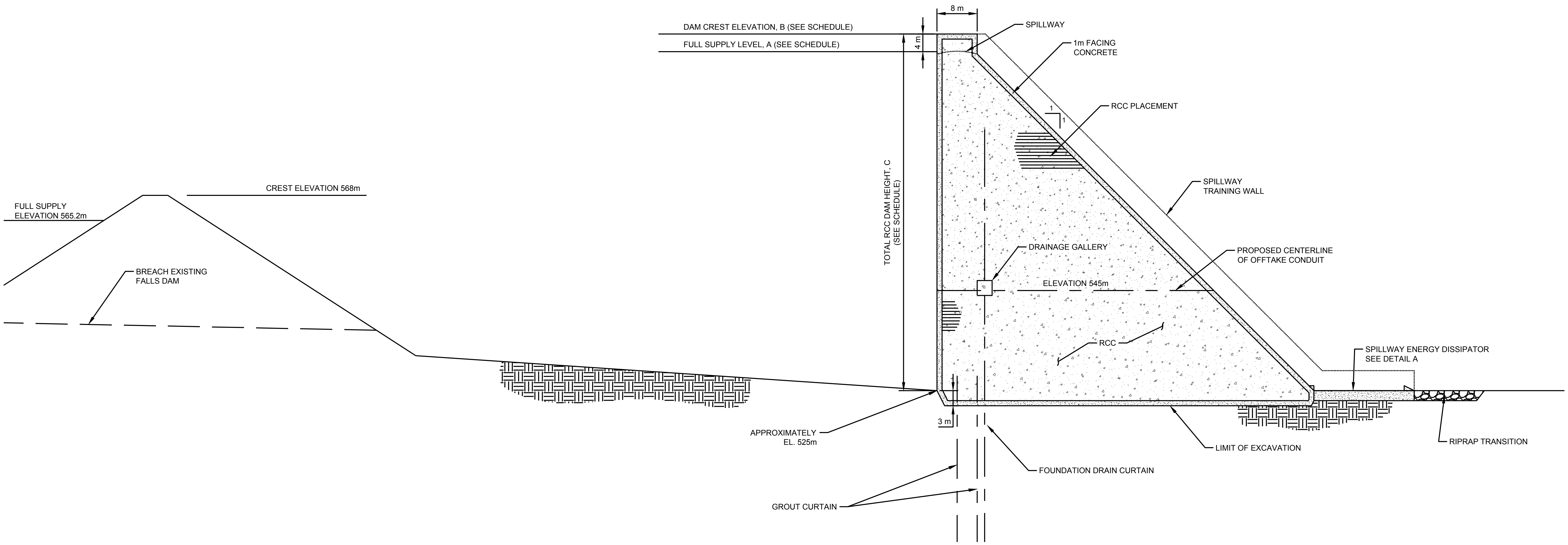
TITLE
PLAN VIEW OF FULL SUPPLY LEVEL 592.2 m DAM RAISE OPTION

PROJECT No. 1378110270

Rev. A

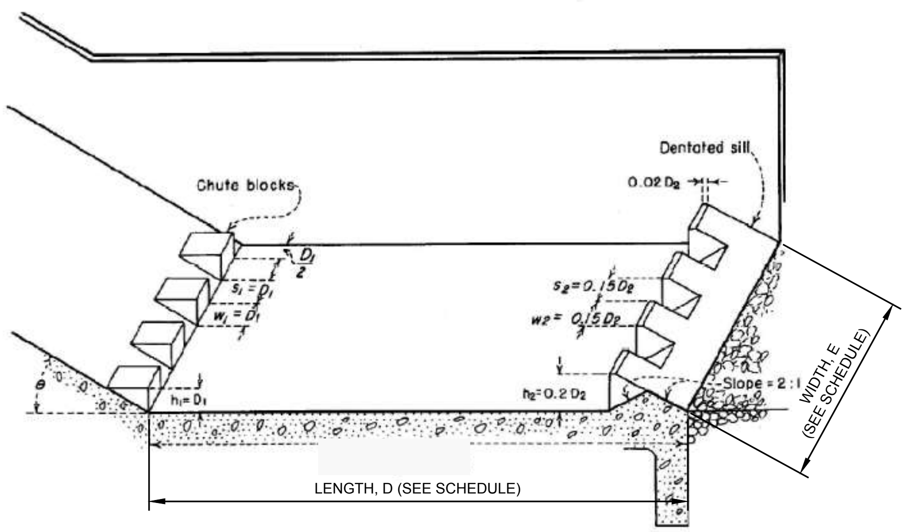
Figure 5



1 TYPICAL MAXIMUM CROSS SECTION OF NEW RCC DAM

0 16 32 48 m

1:800



NOT TO SCALE A ENERGY DISSIPATOR TYPICAL DETAIL (USBR TYPE II)

NEW FALLS RCC DAM SCHEDULE

FULL SUPPLY LEVEL, A	DAM CREST ELEVATION, B	TOTAL DAM HEIGHT, C	ENERGY DISSIPATOR LENGTH, D	ENERGY DISSIPATOR WIDTH, E
570.6m	574.6m	49.6m	30m	50m
580.4m	584.4m	59.4m	30m	42m
592.2m	596.2m	71.2m	30m	35m

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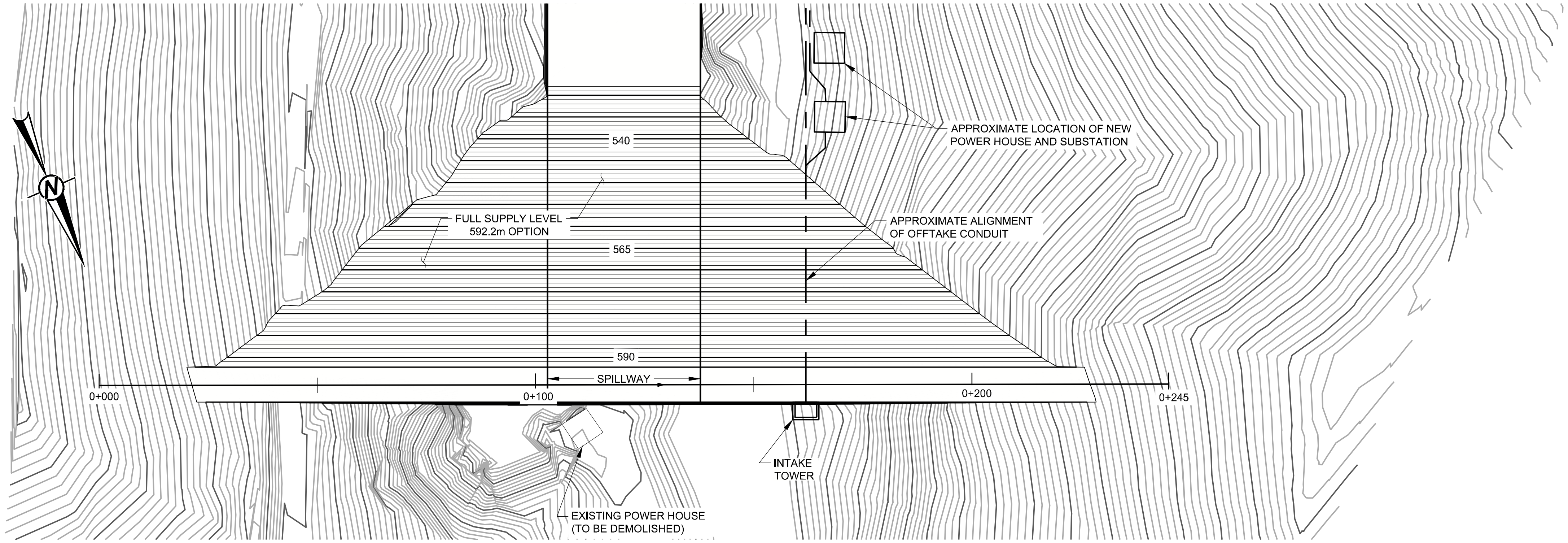
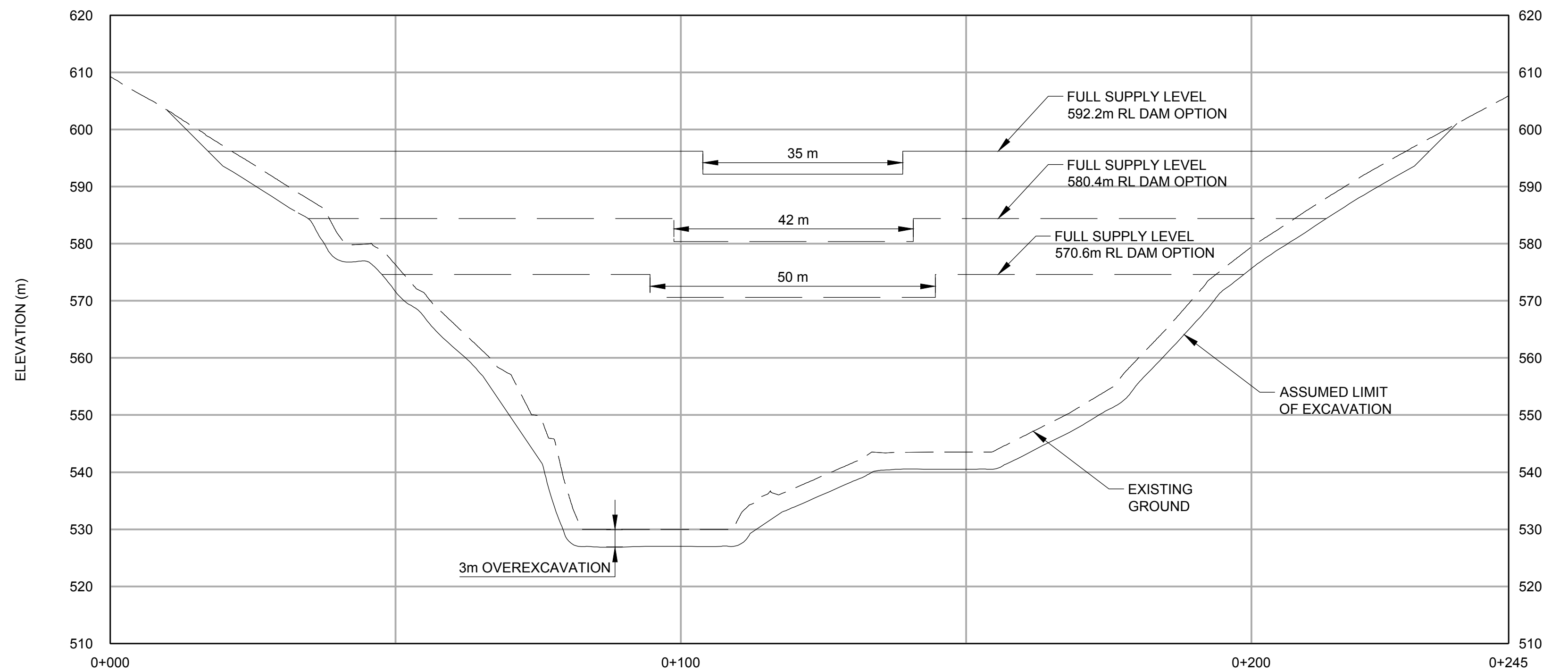
TITLE
TYPICAL MAXIMUM CROSS SECTION OF NEW RCC DAM

PROJECT No. 1378110270 | Rev. A | Figure 6



0 25 50 75 m

1:1,250



1 PROFILE ALONG DAM CREST

0 25 50 75 m

1:1,250

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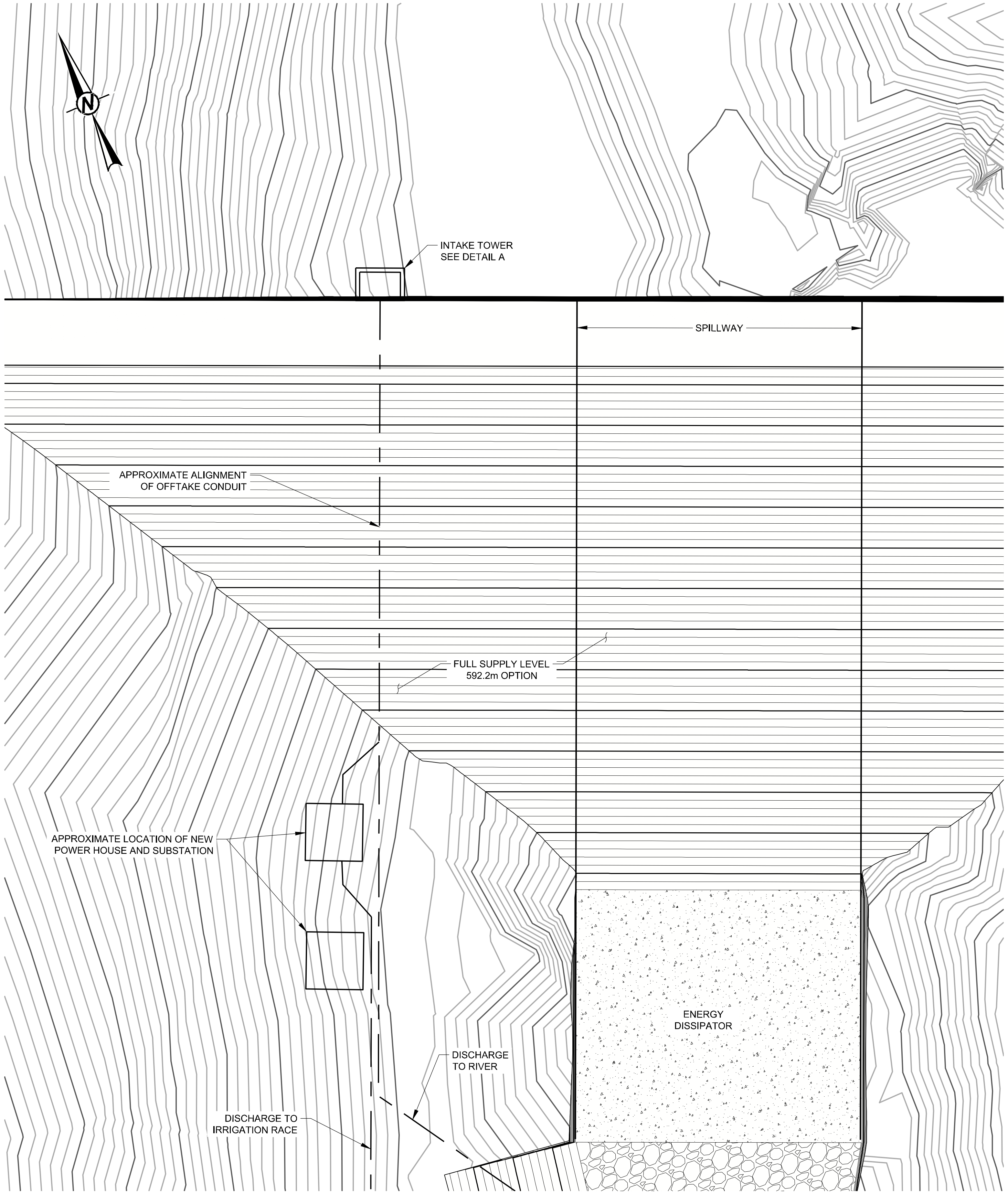
TITLE
PROFILE ALONG DAM CREST

PROJECT No.	Rev.	Figure
1378110270	A	7



0 12 24 36 m

1:600

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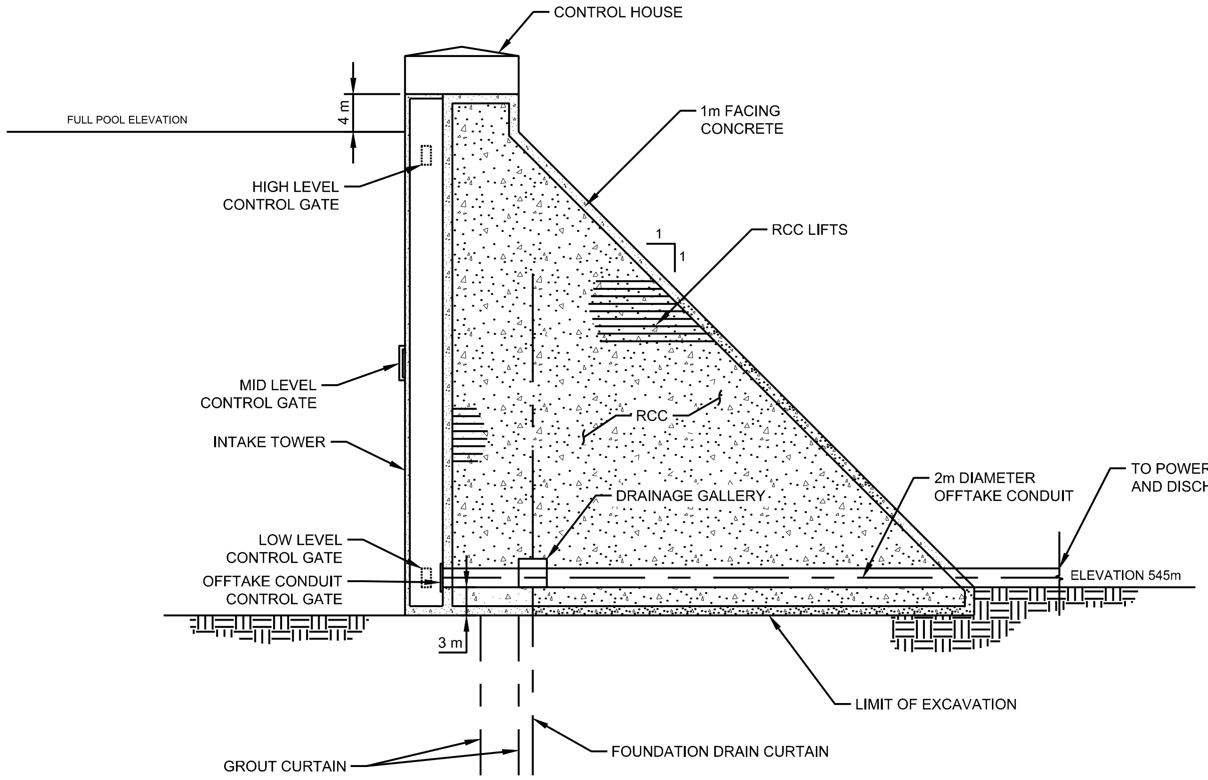
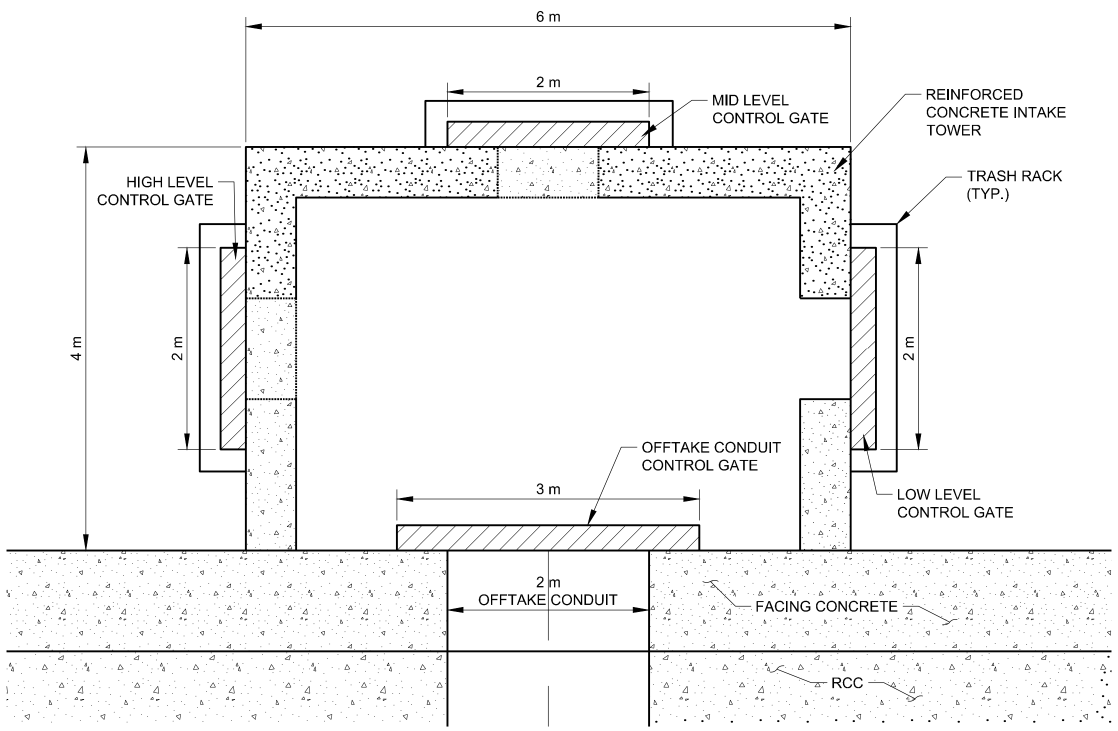


NOT TO SCALE (1) SECTION THROUGH OFFTAKE CONDUIT LOCATION



NOT TO SCALE (A) INTAKE TOWER DETAIL

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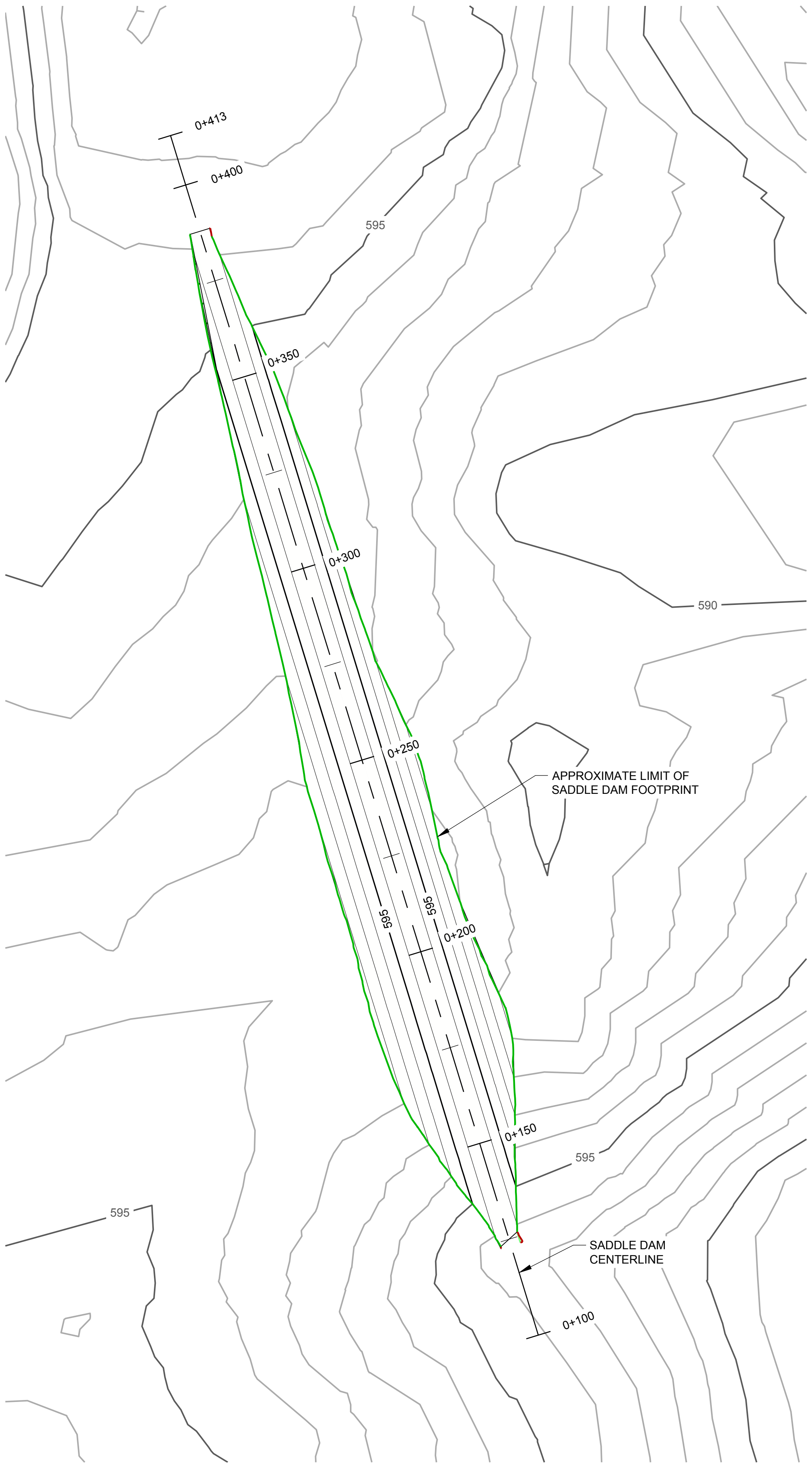
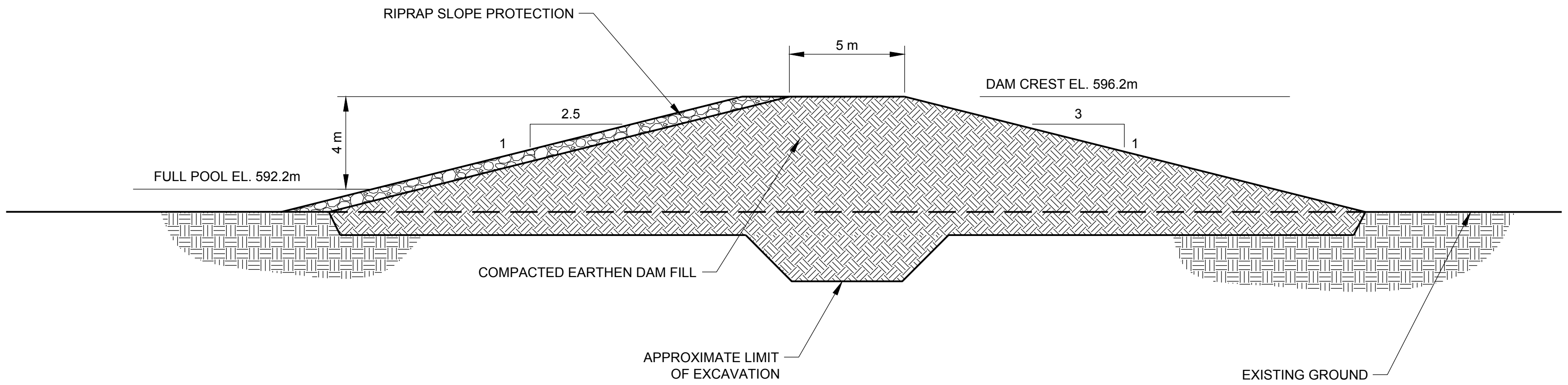
TITLE
OFFTAKE STRUCTURE SECTION AND DETAILS

PROJECT No.	Rev.	Figure
1378110270	A	8

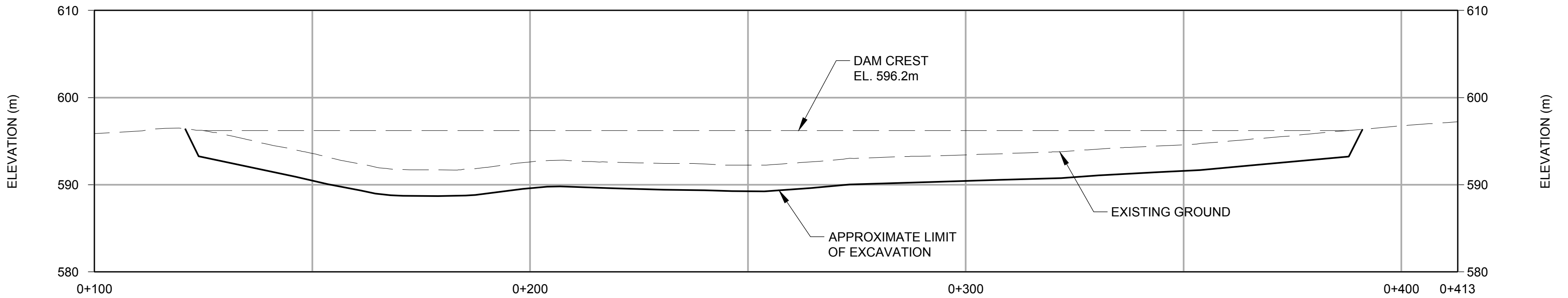


0 30 60 90 m

1:1,500



NOT TO SCALE (1) SADDLE DAM - MAXIMUM SECTION



(2) SADDLE DAM PROFILE

2X VERTICAL EXAGGERATION

0 30 60 90 m

1:1,500

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TITLE
SADDLE DAM PLAN VIEW AND MAXIMUM SECTION

PROJECT No.	Rev.	Figure
1378110270	A	9

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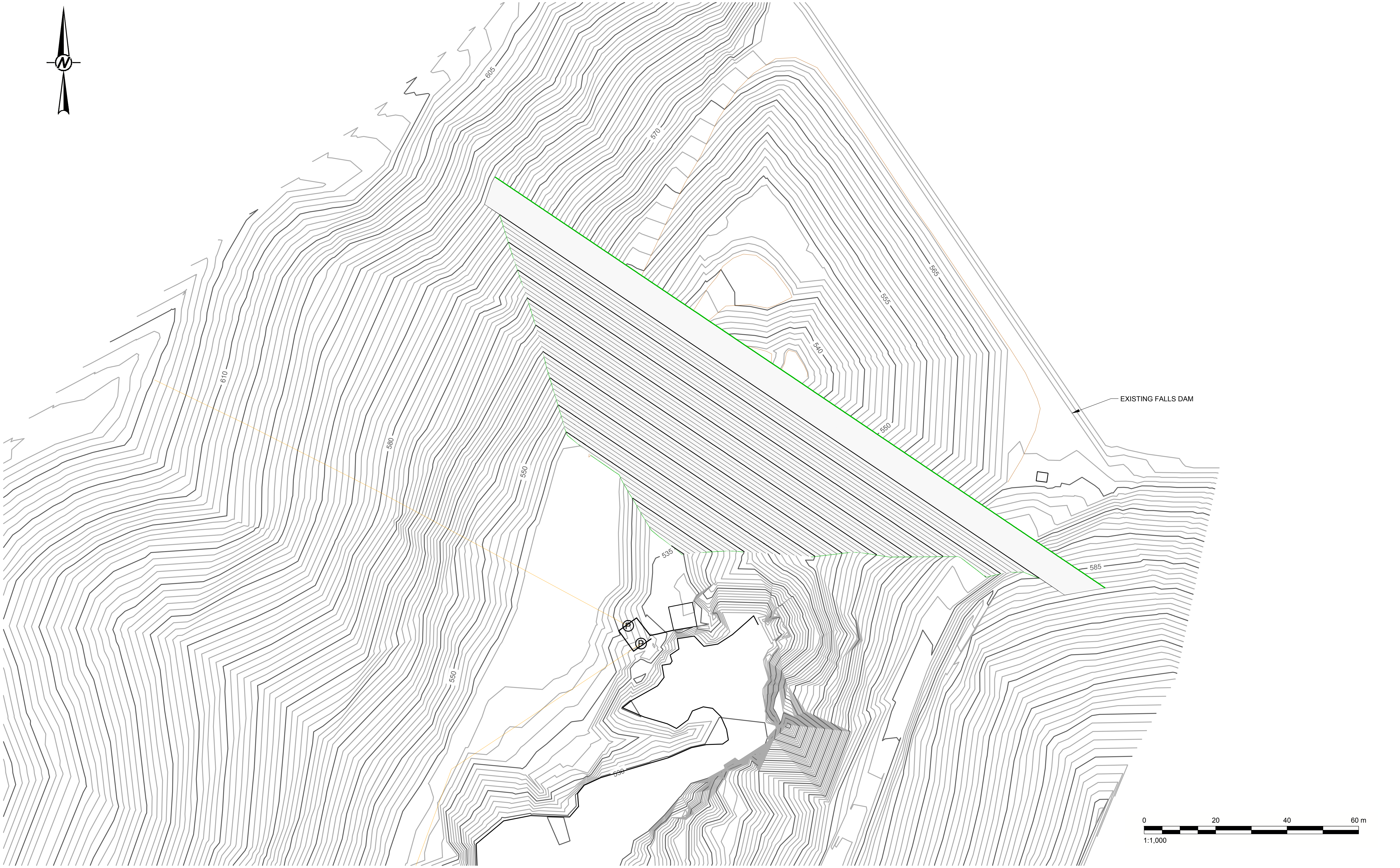
TITLE
PROPOSED CONSTRUCTION LAYOUT

PROJECT No.	Rev.	Figure
1378110270	A	10



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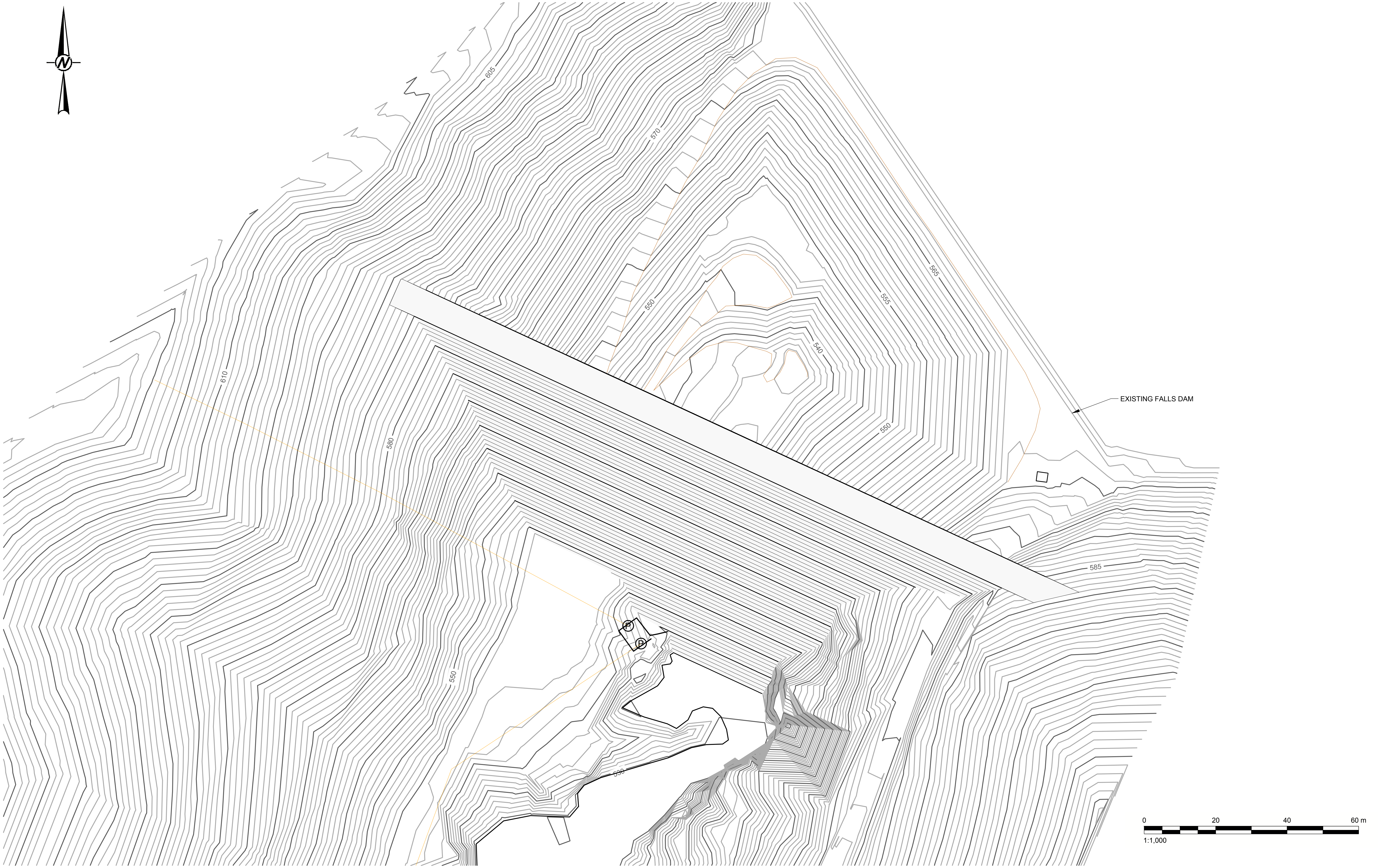
MANUHERIKIA CATCHMENT FEASIBILITY STUDY

TITLE
SCENARIO 4

PROJECT No.	Rev.	Figure
1378110270	A	-



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TITLE
SCENARIO 5

PROJECT No.	Rev.	Figure
1378110270	A	-

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