August 2015

PRELIMINARY ECOLOGICAL ASSESSMENT

Manuherikia Catchment Feasibility Study

Submitted to:
The Manuherikia Catchment Water Strategy Group

Report Number. 1378110270-4000-R-Rev2-401

REPORT

Golder Associates

Executive Summary

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 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.

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

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. These sites are currently recognised in the Otago Regional Council (ORC) water plan as regionally significant wetlands.

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.

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.

The water resources of the Manuherikia Catchment are very highly allocated and potentially over-allocated during summer. This has resulted in depleted flows in some reaches of the mainstem and in a number of tributaries.

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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 water storage and water management options for water users within the Manuherikia River catchment.

Approximately 25,000 ha is currently irrigated within the Manuherikia catchment, of which approximately 15,000 ha is consider fully irrigated with the remainder only partially irrigated (Aqualinc 2012a). 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, Blackstone Irrigation Company, Hawkdun / Idaburn Irrigation Company, Ida Valley Irrigation Company, Manuherikia Irrigation Company and the Galloway Irrigation Company. The Omakau, Manuherikia, Galloway and Blackstone companies have shares in the Falls Dam Company Limited which manages Falls Dam, a key water storage infrastructure for these irrigation companies (MCWSG 2013). Falls Dam is also used for the generation of hydro-electricity and managed by Pioneer Generation Limited. The Ida Valley Irrigation Company 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. 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 2012 and references within). This was followed by a Prefeasibility Study which assessed potential development options for improved irrigation within the catchment (Aqualinc 2012). 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 (of which this report is a part), which is due for completion in early 2015. The Feasibility Study will assess the technical, environmental, economic and financial feasibility of the options that have been identified. In addition, the Feasibility Study is required to ensure that sufficient information is available upon its completion for MCWSG to proceed to the next phase of the project (i.e., including sufficient information to support resource consent application(s)).

The feasibility study is focused on five development options which were identified in the Prefeasibility Study. 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). An overall site map of the project site is presented on Figure 1.

1.2 Purpose of this Report

This report describes the implications for the feasibility of proposed increased water storage and water use (predominantly for 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 (previously documented in Golder, 2014) and new field studies by Golder in summer and autumn 2014. This is one of a series of reports that assess the feasibility of five water development options in the Manuherikia River catchment. This report assembles the existing information available on the environments, terrestrial, aquatic and avian species and habitats that may be affected by the five proposed water development options for the Manuherikia River catchment and uses the available data to assess:

- The type and significance of environments, terrestrial and aquatic values supported in the Manuherikia River catchment;
- The likely nature and magnitude of any effects on the environment and ecology of the Manuherikia River catchment associated with the proposed development options; and
- Appropriate strategies for mitigation, if required, to address any significant adverse ecological effects.
- Where appropriate knowledge gaps and the potential need for further work are highlighted.

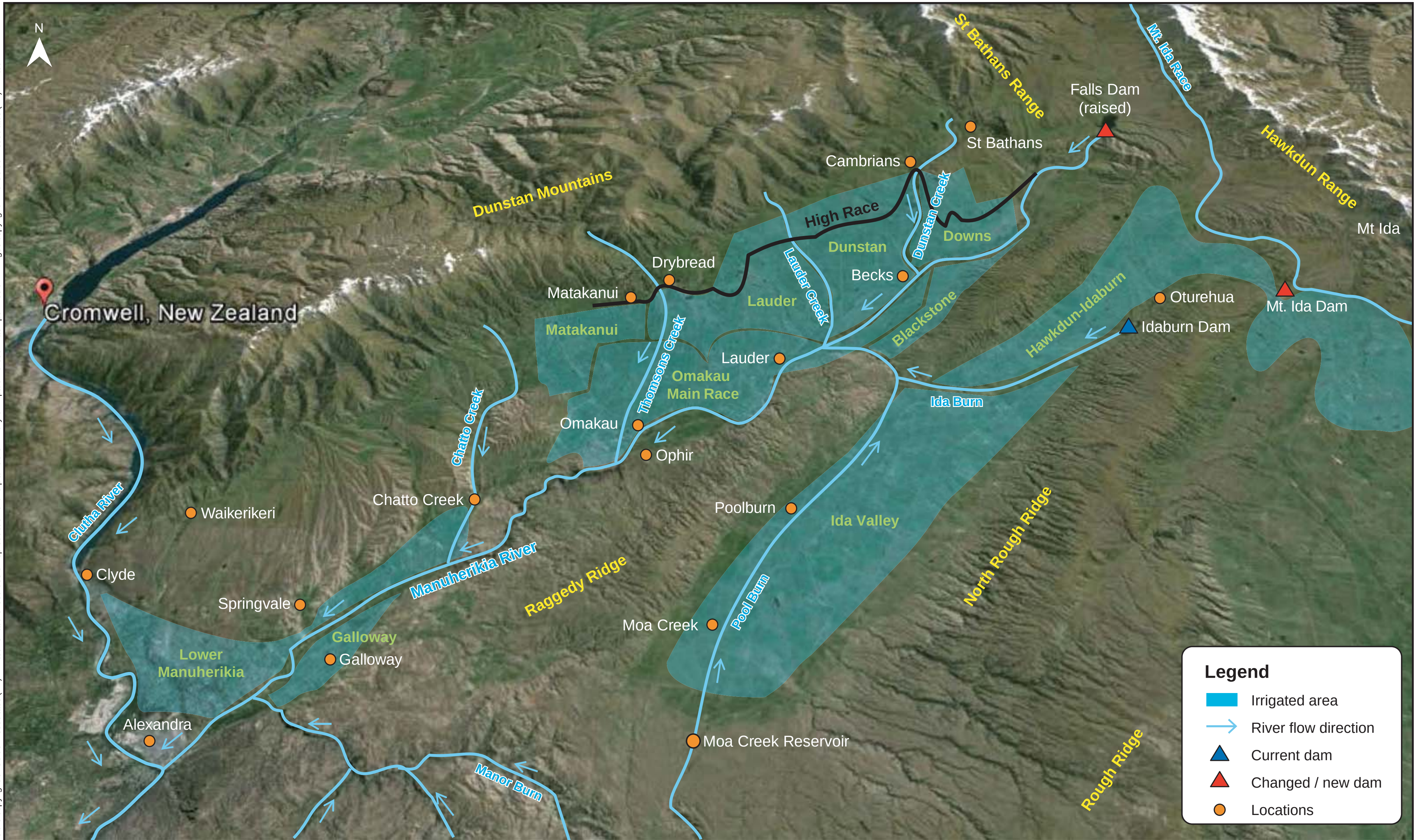
This ecological assessment has relied on the findings of the various other feasibility reports and assessments the most critical of which are outlined below:

- Golder 2015a *Geotechnical Stage Three Report: Fall Dam Preliminary Design and Cost Estimate*. Contains a detailed description of Falls Dam and outlines the proposed construction works associated with the three options for increasing storage at Falls Dam.
- Golder 2015b *Distribution Report:* Contains a description of potential distribution options for each of the five water development options including an outline of potential construction works. The distribution report also outlines the irrigable area within the catchment, current and potential future irrigation types and the areas potentially inundated if Falls Dam is raised or Mt Ida Dam is constructed.
- Various hydrology reports and letters including Aqualinc 2013a, 2013b and 2014, Golder 2014b, 2014c and 2014d. Two hydrological models have been prepared which allow the hydrological implications of various storage, irrigation and flow regime scenarios to be assessed for both Falls Dam (Aqualinc 2013a) and Mt Ida Dam (Aqualinc 2013b). The Manuherikia Valley model (Aqualinc 2013a) predicts potential changes in flow at various locations down the main stem of the Manuherikia River while the Mt Ida Model is more focused on operation of the dam. The models have been used to determine the potential changes in flow associated with the various irrigation development scenarios. These reports have been used to assess the potential changes in flow that are expected under the five irrigation development scenarios.
- AgResearch 2015 OVERSEER® *Nutrient Budget Modelling in the Manuherikia Catchment.* AgReserach are modelling nutrient loss from various case study farms and the Manuherikia catchment as a whole. Both current nutrient loss and loss under a maximum irrigation development option (i.e., large increase in storage at Falls Dam and construction of the new Mt Ida Dam) are being assessed and will be used to assess potential changes in water quality. AgResearch 2015, indicates that nutrient loss is very dependent on irrigation efficiency and moving from the current predominantly flood based irrigation system to spray irrigation is expected to significantly reduce nutrient loss. This is predominantly due to the catchments dry climate and deep soils which under efficient spray irrigation results in very limited drainage. Areas of shallow bony soils which are generally located on river terraces adjacent to the Manuherikia River remain susceptible to increased nutrient loss as will sub-catchment where there are significant areas of new irrigation. For the maximum potential development scenario (i.e., a large increase in storage at Falls Dam and the Mount Ida Dam) overall catchment nitrogen loss from the root zone is expected to decrease by approximately 0.4 %. Further discussion on potential water quality changes are included in Golder 2015c.

This assessment does not consider landscape issues which have been addressed in Espie, 2015.

1.3 Report Limitations

Your attention is drawn to the document, “Report Limitations”, as attached in Appendix A. The statements presented in that document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks to which this report relates which are associated with this project. The document is not intended to exclude or otherwise limit the obligations necessarily imposed by law on Golder Associates (NZ) Limited, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.



1. AERIAL IMAGE: Google Earth Pro.
2. NOTE: Oblique Basemap – Not to scale.
3. Schematic only, not to be interpreted as an engineering design or construction drawing
4. DRAWN BY: SG REVIEWED BY: RW

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TITLE MANUHERIKIA OVERVIEW MAP

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2.0 ECOLOGICAL ASSESSMENT OF THE MANUHERIKIA RIVER CATCHMENT

This section summarises the results of an assessment of the ecological characteristics of the Manuherikia River catchment, including threatened environments and species. A more detailed description of the environments and species present in the catchment is presented in Appendix B.

2.1 Environmental Setting

The Manuherikia River catchment, including both the Manuherikia and Ida valleys, covers an area of approximately 3,000 km^2. The area is surrounded by mountainous terrain with the exception of where it joins the Clutha River / Mata-Au at Alexandra to the south-west. The headwaters lie within the Hawkdun Range. The catchment has two major valleys; the Manuherikia Valley and the Ida Valley which connect via the Pool Burn gorge. The catchment's surrounding terrain and distance from the ocean creates a climate unique in New Zealand that is more "continental" with cold winters, warm summers and high diurnal ranges, (NIWA 2001, ORC 2012). This distinctive combination of climate, topography and geology has led to locally adapted ecosystems and species present in the Manuherikia catchment.

The ecosystems present include:

- Lowland catchment drylands including semi-natural and agricultural landscapes
- Tall tussock and tussock grasslands
- Subalpine and scree slopes
- Grey shrublands
- Wetlands - both upland and lowland
- Lowland cushion/herbfield ecosystems
- Saline ecosystems
- Riverine habitats including some sections of braided river
- Still water reservoir habitats

This broad range of ecosystems also supports a diverse range of flora and fauna, some of which is unique to Central Otago as described below.

The catchment has a long history of extensive pastoral farming and irrigation which has resulted in the majority of the lowland areas of the catchment being highly modified. Current landuse is dominated by dryland sheep and sheep and beef farming Table 1.

Table 1: Manuherikia Catchment - Current Landuse.

Landuse(1)		% of Area
Dryland	Native (including conservation estate, riverbeds and reservoirs)	11.0
	Sheep or Sheep and Beef	76.1
	Beef or Deer	2.8
	Urban areas, Road, Tracks etc.	1.1
	Total dryland	**92.0**
Irrigated	Sheep or Sheep and Beef	6.5
	Beef or Deer	0.5
	Dairy or Dairy support	0.3
	Vineyards, Orchards. Lifestyle Blocks etc.	0.7
	Total Irrigated	**8.0**

Notes: (1) Calculated from Landuse maps used for OVERSEER® modelling (AgResearch 2015).

2.2 Terrestrial Environment Classification

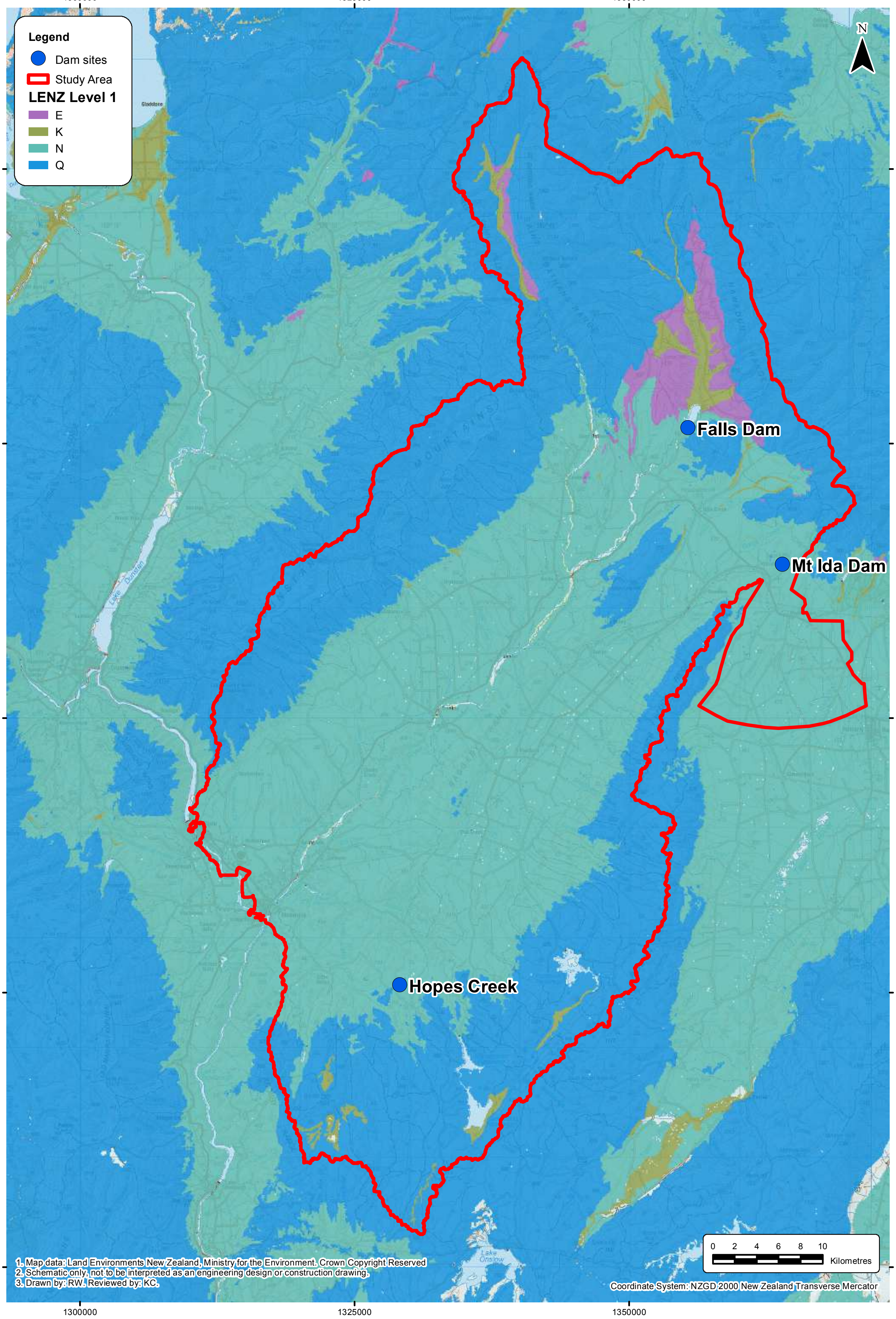
The Land Environment New Zealand (LENZ) environment classification system provides a basis for describing the environments present within the Manuherikia Valley. LENZ uses a range of geologic, climate, soil and geographic (e.g., aspect, elevation) data to cluster land areas with the same or similar attributes into environmental categories (Leathwick et al. 2002, Leathwick et al. 2003). The system has a four tier output that has:

- 20 level 1 broad scale environments useful for national analyses
- 100 level 2 environments useful for national and regional analyses
- 200 level 3 environments useful for regional analyses
- 500 level 4 fine scale environments useful for regional and local analyses

The majority of the Manuherikia Valley and surrounding mountain ranges fall into two Level 1 environments (Figure 2). The valley floors of the Manuherikia and Ida valleys are within Environment N – Eastern South Island Plains. The valley floors of the Manuherikia and Ida valleys comprise an environment with a cool climate, moderate sunshine and moderate water and vapour deficits. The land is mostly flat and soils are generally alluvial sands and gravels derived from greywacke and schist rocks and these are often overlain by loess. These areas are characterised as 'Environment N – Eastern South Island Plains'. The Dunstan, Saint Bathans and Hawkdun Ranges, parts of the Raggedy Range and Rough Ridge are within Environment Q – Southeastern Hill Country and Mountains. These are areas with a cool climate, low annual and winter solar radiation that lie in the rain shadow of the Southern Alps. This leads to low rainfall and drier conditions than most New Zealand mountain areas. The terrain is often steep although less so in the Manuherikia and Ida valleys and the underlying geology is generally schist or greywacke.

The floor of the upper Manuherikia River valley above Falls Dam comprises a recent flood plain area with alluvial soils derived from greywacke rocks (Environment K – Central Upland Recent Soils). The climate is cool, and water and vapour deficits are low. Rainfall varies from relatively high close to the main divide to low in more eastern areas. The hill slopes at the foot of the Hawkdun and Saint Bathans Ranges comprise gentle hill country with underlying greywacke (Environment E – Central Dry Foothills). The climate is cool and rainfall is low. The Dunstan Creek and Manuherikia River sites for Environment E represent the most southern extent of this environment.

Within each of these Level 1 environments the Manuherikia Valley is divided into one of Level 2, 3, and 4 Environments (Figure 3). Within the Manuherikia Valley 41 level 4 environments are recognised. The distinctive upper Manuherikia River area is again evident at the level 4 classification level.



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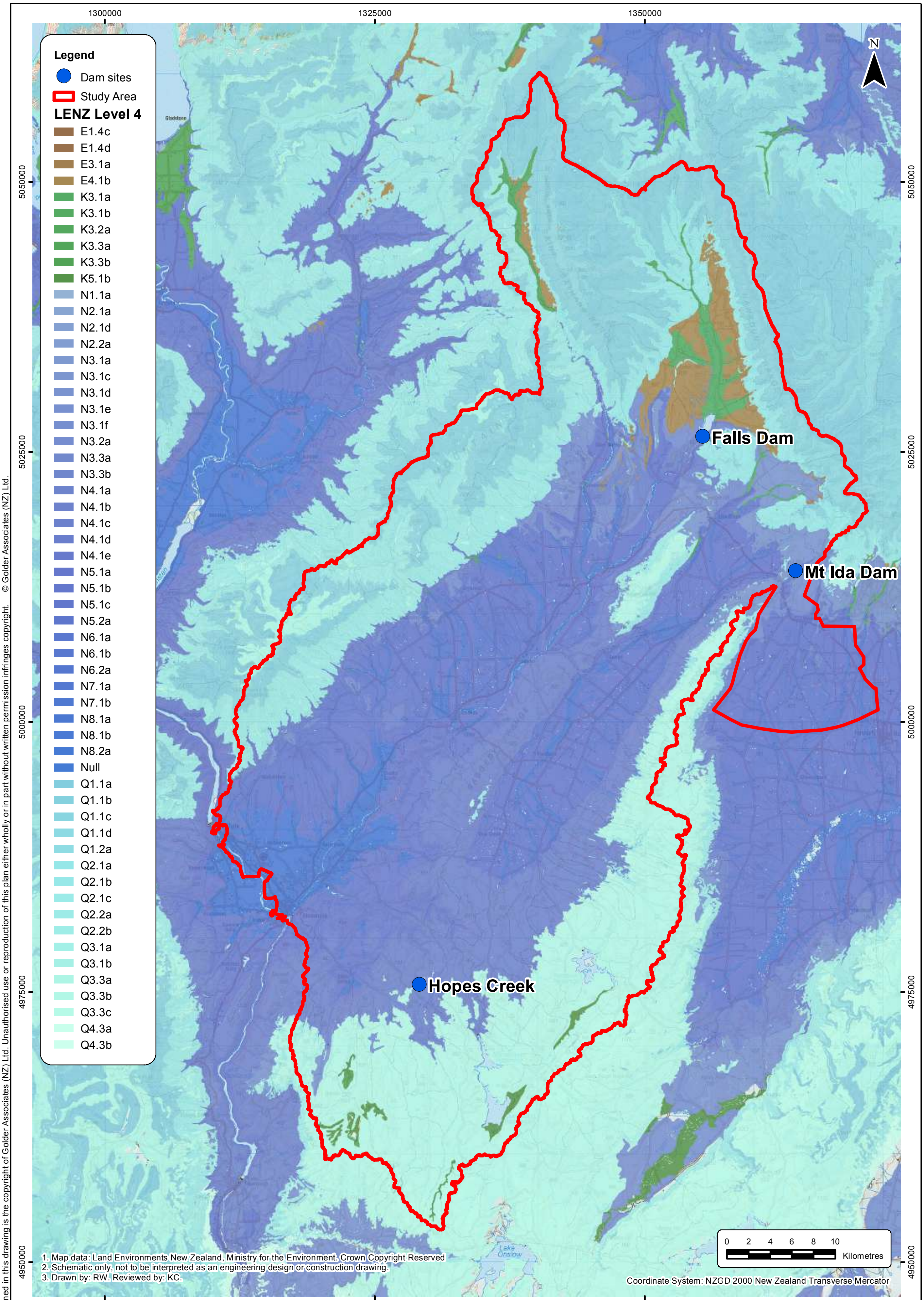

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2.2.1 Threatened Environments within the Manuherikia River catchment

LandCare Research and DOC conduct reviews of the threat levels of each level 4 environment using the LENZ level 4 environments, the Land Cover Database (LCBD) and areas of legally protected land (e.g., DOC estate, QE II covenants). A five-tier threat classification is used (Table 2) which provides a measure of both the environmental change that is occurring and the level of protection.

Table 2: LENZ threatened environment classification (Walker et al 2008).

Category	Indigenous vegetation criteria
Acutely threatened	<10 % indigenous cover left
Chronically threatened	10 - 20 % left
At risk	20 - 30 % left
Underprotected	>30 % left and <10 % protected
Critically underprotected	>30 % left and 10 - 20 % protected
Less reduced and better protected	>30 % left and >20 % protected

The current threatened environment classification indicates that all Level 4 environments in the Manuherikia Valley are in the top two categories of the threatened environments with less than10 % (i.e., acutely threatened) or less than 20 % (chronically threatened) of the indigenous vegetation remaining (Figure 4). Areas on the lower hillslopes and in the upper Manuherikia Valley (above Falls Dam) are also threatened or at risk as only up to 30 % remains in indigenous vegetation.

In April 2007, the Minister of Conservation and Minister for the Environment issued a Statement of National Priorities for protecting rare and threatened native biodiversity on private land. The Statement sets the following four priorities:

National Priority 1: To protect indigenous vegetation associated with land environments, (defined by Land Environments of New Zealand at Level IV), that have 20 percent or less remaining in indigenous cover.

National Priority 2: To protect indigenous vegetation associated with sand dunes and wetlands; ecosystem types that have become uncommon due to human activity.

National Priority 3: To protect indigenous vegetation associated with 'originally rare' terrestrial ecosystem types not already covered by priorities 1 and 2.

National Priority 4: To protect habitats of acutely and chronically threatened indigenous species.

The valley floors of both the Manuherikia and Ida valleys are highly modified with less than 20 % of their indigenous vegetation remaining (Figure 5) and therefore protection of the remaining indigenous vegetation falls under National Priority 1. Similarly any wetlands within the catchment are covered by National Priority 2. The 'originally rare' terrestrial ecosystem types covered by National Priority 3 included inland saline, inland outwash gravels and braided riverbeds which are present within the Manuherikia Catchment.

2.2.2 Threatened species

DOC undertakes a threat ranking process for all native species (flora and fauna) using a standard ranking process (Townsend et al. 2008). This ranking classifies species according to the number of mature individuals and/or the area the species occupies and the rate of decline or increase the species is undergoing. This ranking has three categories for Threatened species: Nationally Critical, Nationally Endangered and National Vulnerable. Additional species are classified as At Risk with a series of qualifiers declining, naturally uncommon, relict and recovering. If insufficient data is available to conduct a ranking for a species it is classified as data deficient. The DOC threat ranking has no legal status and does not convey any protection for the threatened species. However, protection is provided for the majority of indigenous fauna via the Wildlife Act and the Conservation Act.

Table 3 highlights the species from DOC's treat rankings that are present or likely to be present in the Manuheirkia and Ida valleys.

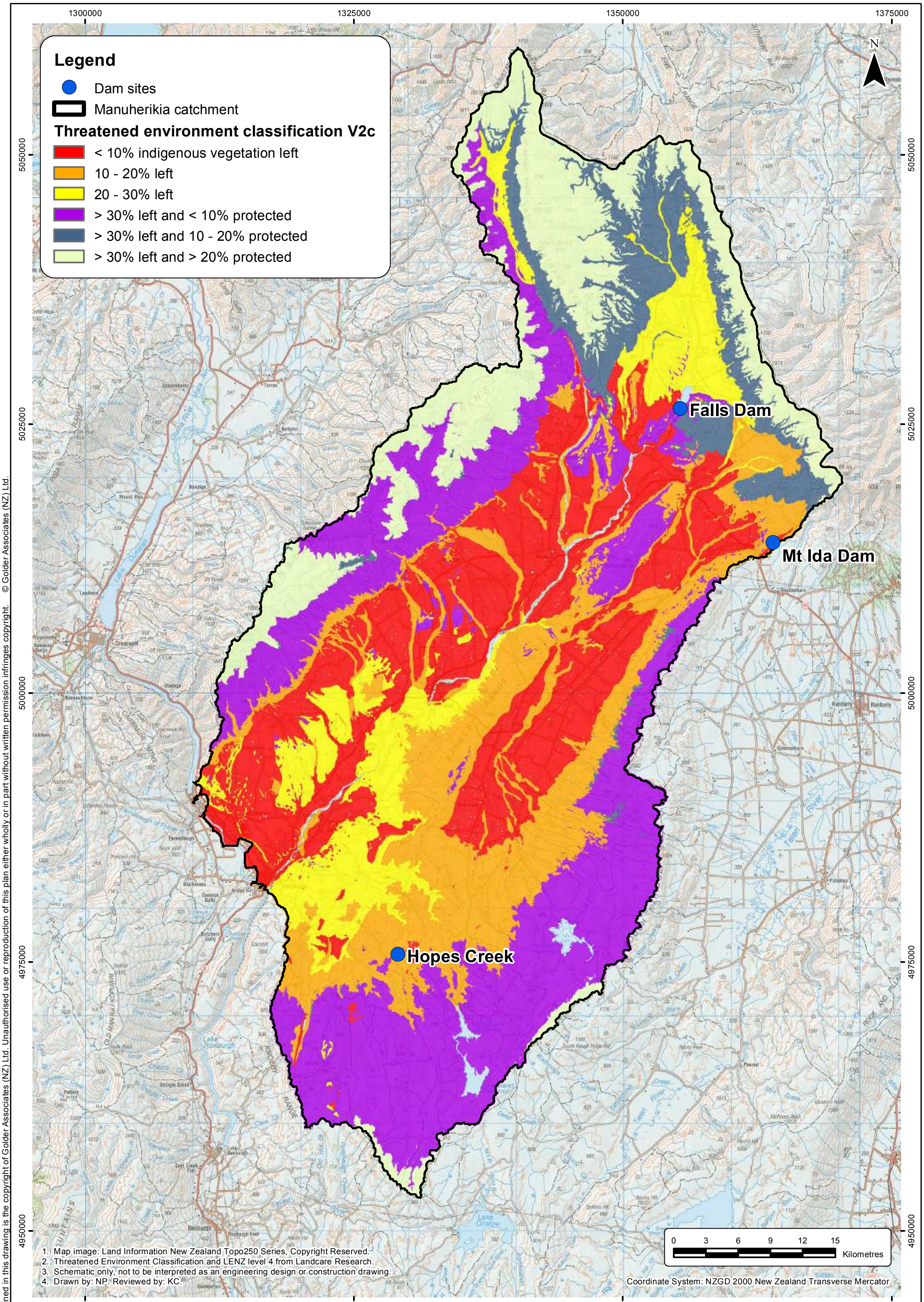

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Table 3: Threatened and at Risk species present or likely to be present in the Manuheirkia and Ida Valleys

	Number of species present or likely to be present						**Comment**
	Threatened Species			**At Risk Species** (no relict or recovering species were identified)		Data deficient	
	National Critical	Nationally endangered	Nationally Vulnerable	Declining	Naturally uncommon		
Plants	14	10	18	33	47	15	Two of the national critical plant species are only known from Central Otago (de Lange et al. 2013). *Aceana aff rorida* is a small herb that grows in damp areas amongst tussock grasses; this plant has only been recorded from the Pool Burn catchment. Kirk's scurvy grass is restricted to saline areas in Central Otago and currently known from only twelve sites centred on the Galloway and Springvale areas (NZPCN 2014a).
Reptiles			Scree skink	Green skink			Scree skinks occupy steep unstable scree slopes and was found at altitudes greater than 700 m on the southern flanks of the Hawkdun Range at sites above the altitudes potentially affected by the Manuherikia water project.
Birds	Black billed gull (Black Stilt)	Black fronted tern	Banded dotterel, Wrybill	Pied oystercatcher			The Manuherikia River above Falls Dam is the focal point for the six species. Black stilts have been historically reported in the area, but none have been reported for several decades
Fish	Clutha flathead	Alpine galaxias, Central Otago roundhead galaxias		Longfin eel, koaro			Of the five species alpine galaxias is the only one restricted to just the Manuherikia River catchment and only occurs upstream of Falls Dam.

2.3 Terrestrial Ecosystems of the Manuherikia Valley

2.3.1 Upper catchment and surrounding ranges

The range crests surrounding the upper catchment are part of an ancient erosion surface that forms one of New Zealand's most extensive and ancient landforms. The Oteake Conservation Park is the largest reserve in this area and centres on the Saint Bathans, Ewe, Hawkdun, Ida and Saint Marys Ranges and includes areas of the upper Manuherikia Basin. The draft Otago Conservation Management Strategy (CMS) (DOC 2013) has identified many of the extensive tussock grasslands, successional shrublands, subalpine grasslands, wetlands and scree slopes within the upper Manuherikia valley and surrounding ranges as priority ecosystem sites for protection (DOC 2013). The intact altitudinal vegetation present on both the Saint Bathans and Hawkdun Ranges provide significant biodiversity values and habitat for threatened species.

2.3.2 Lower catchment drylands

The lower catchment drylands, which include the Manuherikia and Ida valley floors, are characterised by semi-natural and agricultural landscapes and wide open spaces set amongst rolling hills. The rain shadow effect of the main divide and ranges to the east of the main divide creates extremely dry conditions leading to highly adapted plant and animal communities. Schist rock formations (tors) often feature prominently on the ridges in the landscape and can also be refuges for threatened plants and animals.

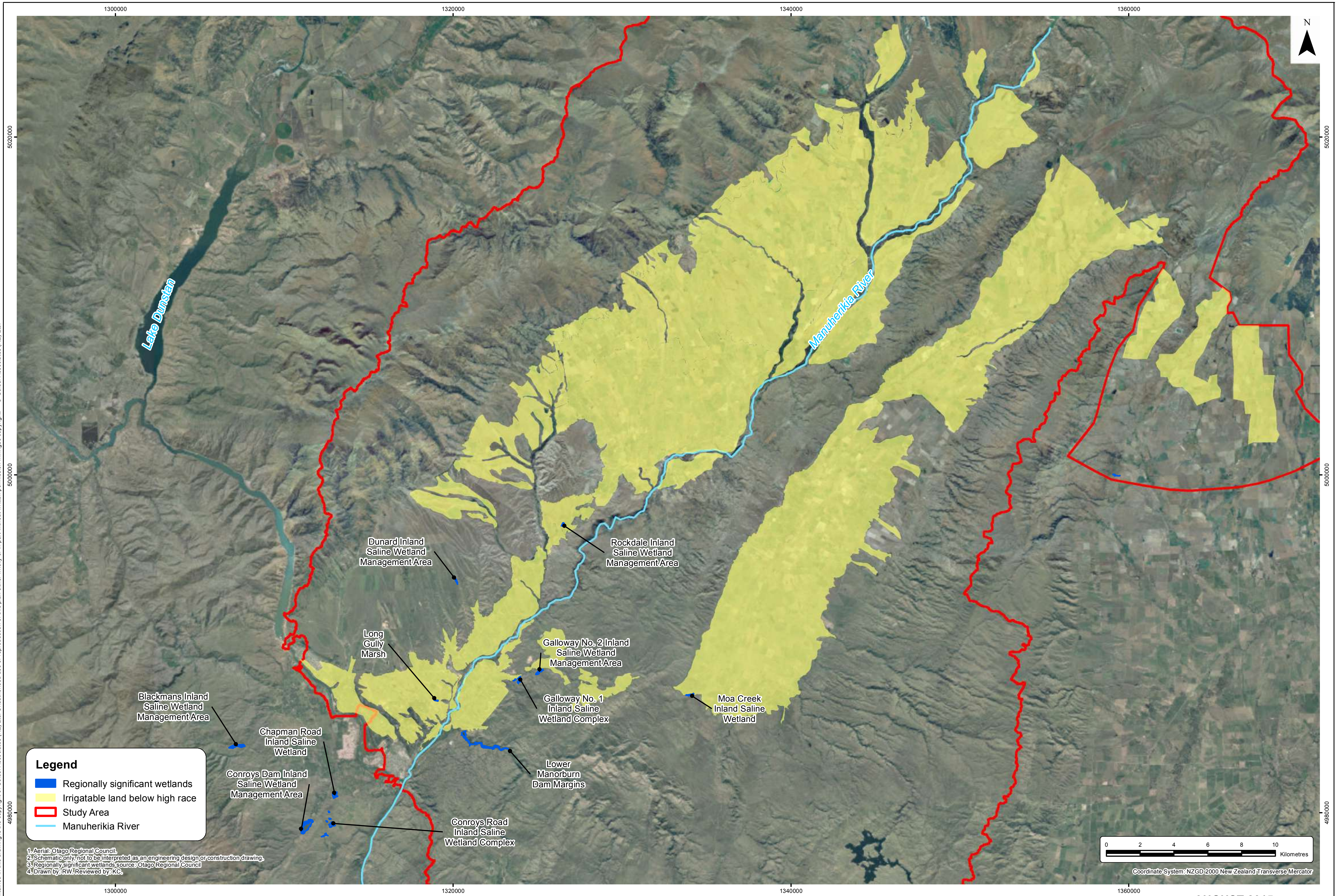
One highly distinctive feature of the drylands is the inland saline ecosystems. These are scattered, small pockets of saline soils and wetlands that contain their own specialised salt-tolerant communities. Five saline sites are recognised in the Manuherikia catchment and these are included in the Otago Regional Plan as regionally significant wetlands. The location of these saline wetland sites is shown relative to the irrigation command area in Figure 5. Four of the five saline wetlands are outside or adjacent to the irrigation command area. 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.

The indigenous ecosystems and landscapes of the drylands have been modified extensively during human settlement. Impacts from gold mining, pastoral farming, weed invasions, fire, pest browsers and more recently cropping, viticulture, horticulture, intensive grazing, dairying, forestry and lifestyle blocks have all lead to widespread loss of the indigenous vegetation. For the indigenous fauna of the lowlands the change in vegetation and land-use coupled with the impacts of introduced predators have led to substantial declines in the range and abundance of many dryland species. However, the Manuherikia catchment does contain some remnant dryland habitats that provide some of the only remaining habitat for some nationally threatened species.

2.3.3 Falls Dam environment

The Home Hills tenure review report (DOC 2006), Grove (1994) and Wildlands (2011) identified a range of terrestrial ecosystems and associated threatened plants in the vicinity of Falls Dam, Fiddlers Flat and along the braided river valley of the upper Manuherikia River Valley. Several of the vegetation communities that are present are now rare nationally and are also home to several declining or threatened species. Figure 6 presents a summary of terrestrial ecosystems in the area around Falls Dam, relative to the potential area of inundation. Areas of bluff rockland and mixed diverse grey shrubland are located within the potential inundation area in the valleys associated with Johnsons Creek and tributaries between Johnsons Creek and Falls Dam.

Browntop (*Agrostis capillaris*) pasture grassland is the dominant vegetation community in the vicinity of the Falls Dam. The development of pasture grassland for grazing has led to vegetation communities dominated by browntop across the Manuherikia riverbed upstream and on the true right bank of the reservoir. Small areas of shrublands and rock bluffs occur on the true left of the Falls Dam reservoir. None of the vegetation communities are restricted to the inundation area with all extending to areas outside the mapped zone.



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Grey shrubland is a feature of the Falls Dam area, being particularly well established on the rocky slopes and gullies on the eastern side of the reservoir and along both sides of the Manuherikia River below the dam wall.

Localised patches of usually low-stature matagouri with golden speargrass and extensive browntop are common on the western side of Falls Dam reservoir. 'At risk' coral broom (*Carmichaelia crassicaulis* subsp. *Crassicaulis,* see photograph in Appendix B) is commonly associated with this shrubland, with a large mixed age population present within a stock exclusion area along a 10 m wide strip of the western shore of Falls Dam reservoir.

Sparsely vegetated scree is present above the reservoir, particularly just upstream of Falls Dam (see photograph in Appendix B). Screes, characterised by large blocky boulders and no interstial soils, are sparsely vegetated (0.2 % cover), but where the scree is more stable with gravel and soil present, vegetation cover may be 5 %.

The Falls Dam area is characterised by the presence of acidic greywacke rock outcrop systems that extend up the tributaries on the east side of the reservoir, as well as in the gorge below the dam. A particularly extensive bluff system is present midslope in Johnstones Creek (see photograph in Appendix B), where it extends upslope to approximately the 27 m raise impoundment level. The bluffs nestle into often dense grey shrublands. The rocklands vary from steep rock faces with vertical cracks that support a range of native plant species, to more fragmented areas with lots of soil-filled mini-platforms and cracks.

Native species diversity is reasonably high given the acidic nature of the rock. On a rocky spur on the true left of Johnstones Creek, *Hebe buchananii, Luzula ulophylla,* 'At Risk' mat broom *Carmichaelia vexillata, Carex breviculmis, Scleranthus uniflorus* grow in the vicinity of a population of Kawarau cress.

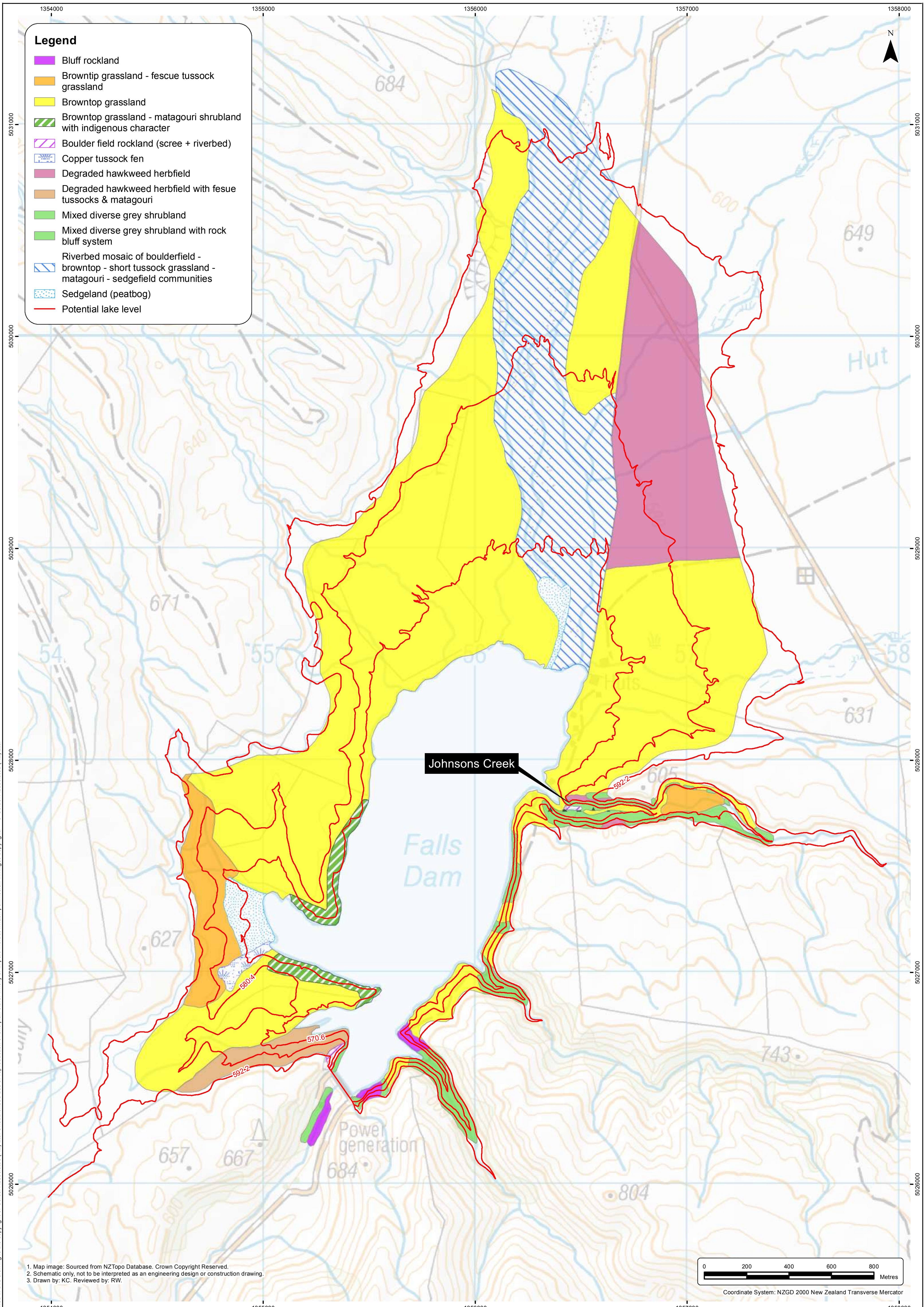
The rock bluffs immediately below Falls Dam support a small population of the threatened Waitaki broom (*Carmichaelia curta*), threatened Kawarau cress, blue-wheat grass (*Elymus falcis*) and *Rytidosperma buchananii*. Current options for increasing the storage of Falls Dam are related to the construction of a new RCC embankment immediately downstream of the current dam (Golder 2015a). Construction methodologies will be finalised during detailed designed however it is anticipated that the construction zone will stretch for approximately 200 - 300 m downstream of the current embankment. Considerable disturbance is expected within the construction zone which includes the small populations of the threatened Waitaki broom (*Carmichaelia curta*), threatened Kawarau cress, blue-wheat grass (*Elymus falcis*) and *Rytidosperma buchananii*. Downstream of the new embankment disturbance will focus around upgrading the assess road and the formation of an open race both of which will be located on the river terrace and are not expected to impact the rock bluffs.

On the western side of Falls Dam, there is one gently sloping basin where peat has accumulated in conjunction with a copper tussock fen. The threatened marsh arrow-grass (*Triglochin palustris*) was observed growing in a seep at this location.

The upper Manuherikia River that flows into Falls Dam has braided river characteristics and supports a mosaic of plant communities (boulderfield, fescue short tussock grassland, silver tussock grassland, brown top grassland, matagouri shrubland and wetland communities of *Carex* sedgeland and shallow water). The most consistent vegetation feature of the river bed ecosystem is the dominance of the browntop grass, which extends over most of the stable river bed, particularly on the western side of the river.

At Falls Dam three rare ecosystems were recognised by Williams et al 2007:

- A seep within the copper tussock fen area on the true right of Fall Dam reservoir.
- The Manuherikia braided river bed upstream of the reservoir.
- The acidic rock outcrop areas in Johnstones Creek and the other gullies on the Home Hills property and downstream of Falls Dam in the Manuherikia River gorge.



1. Map image: Sourced from NZTopo Database. Crown Copyright Reserved.
2. Schematic only, not to be interpreted as an engineering design or construction drawing.
3. Drawn by: KC. Reviewed by: RW.

TITLE SUMMARY MAP OF TERRESTRIAL ECOSYSTEMS AT FALLS DAM

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Three 'Threatened' plants and four 'At Risk' plant species where identified in the area that could be inundated by an enlarged Falls Dam impoundment or alongside the Manuherikia River immediately downstream of the dam (Table 4). The most abundant rare plant was the Kawarua cress which was relatively abundant on the bluffs in Johnstones Creek and is also present downstream of the dam around Fiddlers Flat (Figure 6). Two of the plants, marsh arrow-grass and willowherb are restricted to the fen on western side of the reservoir (Figure 6). A survey of spring annual plants (Wardle 2015 copy attached in Appendix E) did not find any within the area that could be inundated by an enlarged Falls Dam impoundment.

Table 4: Threatened plants recorded during 2013 – 2014 field surveys in the vicinity of Falls Dam.

Common Name	Species name	Location	Number of plants	Threat category*
Native broom	*Carmichaelia curta*	Downstream of dam	2	Nationally critical
Marsh arrow-grass	*Trigochin palustris*	Seepage western side of reservoir	5	Nationally critical
Kawarau cress	*Lepidium sisymbrioides*	Johnstones Creek SW side of reservoir Downstream of dam on bluff	62 4 4	Nationally endangered
Mat broom	*Carmichaelia vexillata*	Johnstones Creek SW side of reservoir	65 present	At risk declining
Coral broom	*Carmichaelia crassicaulis subsp crassicaulis*	Majority on SW side of reservoir, other scatter throughout survey area	c. 400	At risk declining
-	*Coprosma intertexta*	Johnstones Creek, un-named gullies, reservoir faces and downstream of dam	108	At risk declining
-	*Chenopodium allanii*[#]	Base of bluffs and under dense grey shrubland	Not counted	At risk, naturally uncommon
Willowherb	*Epilobium insulare*	In fen western side of reservoir	Not counted	Data deficient

* threat categories from de Lange et al 2012.

[#] listed as *Einadia allanii* in de Lange et al 2012.

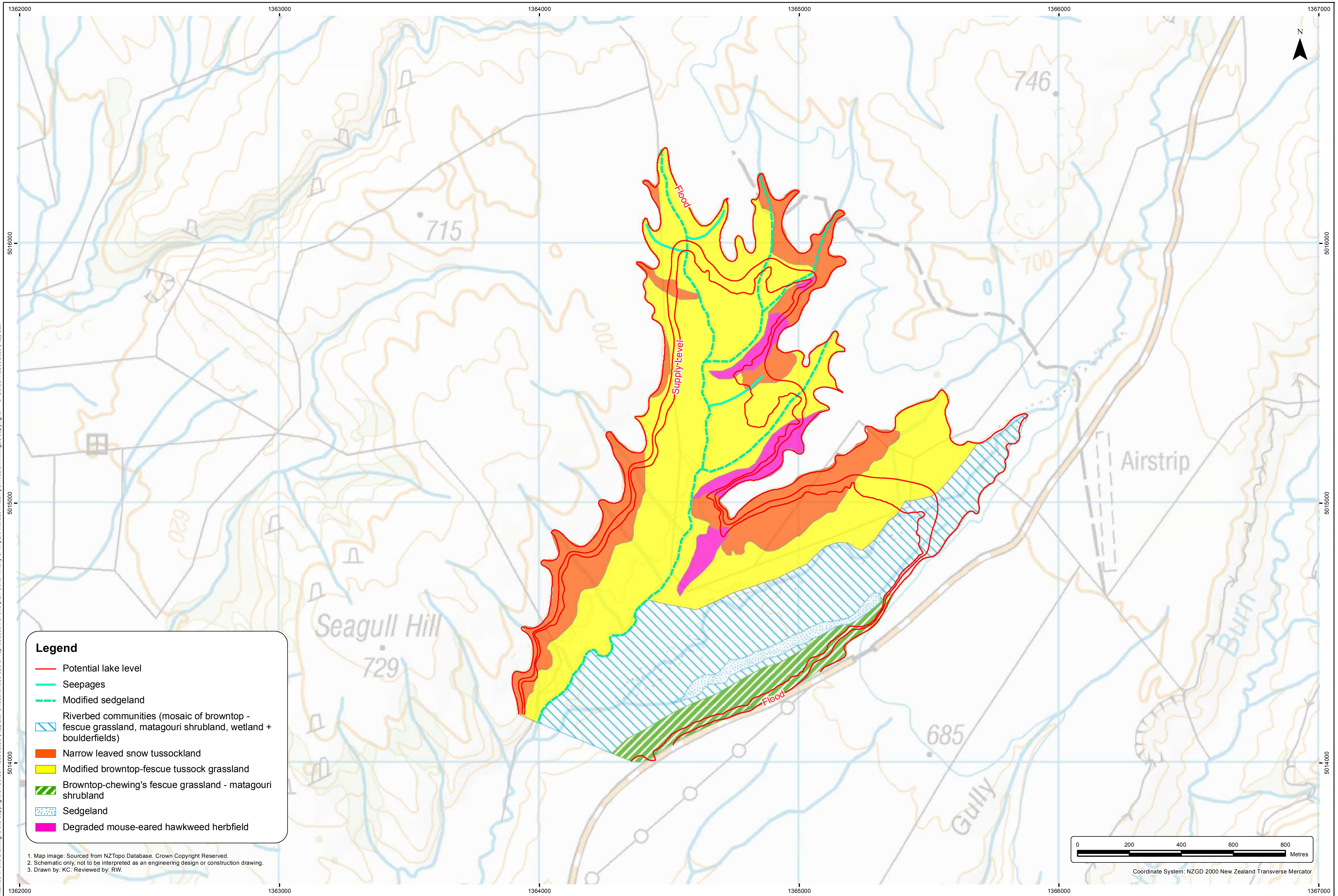
2.3.4 Mount Ida Dam area

Figure 7 summarises the ecosystems present in the vicinity of the proposed Mount Ida Dam impoundment relative to the potential area of inundation.

The Ida Burn braided river bed, which owes its origin to the greywacke rock and periodic flooding, has cut off meanders and levees that support a mosaic of modified hard and silver short tussock grasslands, occasional narrow-leaved snow tussock, and localised patches of matagouri – mingimingi shrubland. These communities are not presented separately on the vegetation map.

The Ida Burn riverbed was dry at time of survey. However, recently flooded channels have sparsely vegetated boulderfields, with scattered native willowherb, bidibid and creeping pohuehue. The vegetation cover elsewhere is a mosaic of grassland, shrubland and hawkweed herbfield.

Native species diversity declines with increasing time since flooding disturbance, and with increasing soil depth. Areas of old flood plain surfaces are dominated by an exotic brown top-Chewing's fescue grassland that may have residual fescue tussocks and matagouri present - this community also occupies the high terrace surface and risers, and lower hillslopes. Snow tussock frequency and cover increase upstream.



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TITLE SUMMARY MAP OF TERRESTRIAL ECOSYSTEMS AT THE PROPOSED MT IDA DAM IMPOUNDMENT

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Silver tussock short tussock grassland is present on heavier soils on the flood plain. Matagouri shrubland is present on older terraces within the floodplain, and on the adjacent hillsides.

A linear bog extends approximately 800 m along the valley floor at toe slopes on the eastern side of the valley. This permanently wet bog is 5 - 15 m wide, and comprises patches of *Carex secta*, with *C. gaudichaudiana* and sharp spike-sedge (*Eleocharis acuta*), while much of the channel is dominated by *Carex diandra*, exotic oval sedge and soft rush. Patches of comb sedge, *Gonocarpus micranthus*, cudweed, daisy, *Juncus pusillus*, and *Ranunculus amphitrichus* are present at the drier margins of the sedgeland.

A number of seepages flow down the eastern terrace face to the main valley, feeding the linear bog. These appear to arise from a subsurface pan that is deflecting water from its normal downward movement through the gravels. The flushes have flowing water and are predominantly mossy, with *Sphagnum cristatum* present in places, together with native *Carex coriacea*, comb sedge, viola, spike sedge, and wind grass (*Lachnagrostis filiformis*) present with exotic pasture species, musk and selfheal.

The majority of waterways within the dam footprint are small and have limited flow during summer, and support a modified sedgeland community that has been grazed down to a turf. Species are difficult to identify due to their cropped nature. The most modified areas are dominated by exotic species: oval sedge, soft rush, browntop and Yorkshire fog. Native species persist in other areas and include localised sphagnum moss with *Gonocarpus micranthus*; or a matfield of *Leptinella squalida*, *Celmisia gracilenta*, *Ranunculus royi*, white clover, browntop and sweet vernal.

A small tributary channel in the centre of the footprint supports a *Carex gaudichaudiana* sedgeland, which additionally has gentian (*Gentianella grisebachii*), and comb sedge, cutty sedge and sedge tussock at its margins.

A reasonable sized mixed age population (192 plants recorded) of the ‘At Risk’ sedge *Carex tenuiculmis* is present in a grazed dryish *Carex ovata-C. diandra-C. gaudichaudiana-Eleochaeris gracilis* sedgeland that drains a south-eastern facing slope. A handful of copper tussocks and willowherb are also present.

A very small localised ephemeral wetland (dry at time of survey) occupies a narrow depression within a Chewing’s fescue-browntop grassland, and is dominated by native wetland plants including *Crassula sinclairii*, with *Lobelia angulata*, plantain (*Plantago triandra*), *Gonocarpus micranthus*, moss and sedge *C. gaudichaudiana* also present. A larger ephemeral wetland supports a grass that was unable to be identified due to heavy browsing.

Localised ponds of shallow water are present within waterways some of which have red pondweed and floating sweet grass present.

The most widespread vegetation community within the proposed dam footprint is modified browntop-fescue short tussock grassland. On the lower slopes at the western side of the footprint, fescue tussock cover is about 15 %, and is present with exotic pasture grass and clover species. Mouse eared hawkweed is present with 1 – 40 % cover. With increasing altitude or on shady faces, scattered narrow-leaved snow tussocks (*Chionochloa rigida*) are present, grading into patches of narrow-leaved snow tussockland (described later).

Within this grassland, there are localised patches of matfield, dominated by mats of *Gaultheria macrostigma* and *Coprosma atropurpurea,* with grassland daisy (*Celmisia gracilenta*), the mauve flowered grass lily (*Herpolerion novae-zelandiae*) and pasture grasses and clover present.

The high terrace that occupies the eastern side of the footprint supports a browntop-Chewing’s fescue exotic grassland, with mouse eared hawkweed common. Scattered native shrub species include matagouri, coral broom, desert broom sub-shrubs the mat-forming turfy coprosma (*Coprosma petriei*) and dwarf mingimingi; herbs, grassland daisy and turf mat daisy (*Raoulia subsericea*); and grasses occasional fescue tussock, blue tussock, plume grass.

This community extends down the terrace face, where increased soil moisture has resulted in taller shrubs and tussocks.

Localised patches of matagouri shrubland are present both on the river flats, and on the adjacent hillslopes. These are dominated by matagouri, with desert broom, coral broom and porcupine shrub occasionally present. Shrublands of the hillslopes have been oversown and top dressed, resulting in a groundcover dominated by pasture grasses, and narrow-leaved snow tussock in places.

Shrublands on the river flats have a ground tier that includes native species such as creeping pohuehue, bidibid, silver tussock, blue wheat grass and *Geranium aff. microphyllum*.

On sunny faces there are localised areas of herbfield with greater than 50 % cover of mouse-eared hawkweed, and an occasional emergent fescue tussock, desert broom or matagouri present. Browntop, Chewing's fescue, and clovers are also present.

The north-facing terrace edge in the centre of the footprint has 65 % bare ground, and supports a degraded herbfield of mouse-eared hawkweed, turfy coprosma, creeping pohuehue, *Scleranthus uniflorus*, and occasional pasture grasses and clovers, blue tussock, and porcupine shrub. About 10 'At Risk' mat broom were recorded.

Relatively dense tall tussock grassland extends down to approximately 750 m asl. (close to the maximum water level), and to lower altitudes on shady faces. Where oversowing and top dressing has taken place, pasture grasses and clovers dominate the intertussock spaces, though scattered matagouri, coral broom, desert broom, Maori onion and golden speargrass may be present.

However, where such development hasn't taken place, or not for some time, a range of native herbs, grasses, and shrubs (including coral broom) are present. Examples of these better tall tussocklands include the shady face in the centre of the dam footprint, and at the northern (higher) extent of the site where tussock cover exceed 50 %. Native intertussock species include blue tussock, *Pimelea oreophila*, comb sedge, *Gaultheria macrostigma*, *Coprosma atropurpurea*, viola, daisy, and the sprawling coprosma (*C. cheesemanii*). Tussock hawkweed is occasionally present.

In the Ida Burn footprint area, three rare ecosystems were identified, two of which are in the wetland category - seepages and flushes, ephemeral wetland, and one in the alpine and inland category – braided river beds.

At Ida Burn, seepages are present on the eastern high terrace riser, and these feed the linear bog feature in the valley floor. In addition, two very small ephemeral wetlands are present; neither support threatened or at risk plants.

The Ida Burn has characteristics of a braided riverbed, and support communities that include relict species of the postulated pre-human vegetation cover for Maniototo Ecological District (Grove 1994) fescue tussock and matagouri, while now dominated by exotic grasses, would have once dominated the very stony areas in the riverbed.

The spring annuals survey (Wardle 2015 (refer Appendix C)) at Mt Ida located the New Zealand mousetail (*Myosurus minimus* subsp *novae-zelandiae*) along a ridgeline within the inundation area. The plants were common at stock camp sites on the ridge immediately west of the Ida Burn. The plant was not found on any other ridgelines or stock camp areas. New Zealand mousetail tends to grow as clusters of plants and determination of the number of plant present is not possible. However, 153 clusters of plants were located and these are estimated to have on average 100 plants. These plants were spread along a 90 m section of the ridge and occurred in an altitudinal range between 675 and 690 m asl. The expected inundation height for the Mt Ida Dam is 680 m so not all the plants are at risk of inundation, although flooding and wave action driven erosion will impact on the population above the 680 m inundation level.

Threatened species at Mount Ida

Of the native vascular plant species present, three are listed as 'Threatened' or 'At Risk' and one as 'Data Deficient' in the most recent threat classification system listing (de Lange et al. 2013). A list of these species with their threat of extinction status and distribution within the dam footprint is provided below in Table 5.

Table 5: Threatened plant species found within the proposed Mount Ida dam footprint.

Super Category	Threat Category	Species	Location
Threatened	Nationally Endangered	New Zealand mouse-tail (*Myosurus minimus* subsp *novae-zelandiae*)	153 plant patches located along the ridgeline in the centre of the dam inundation area.
At Risk	Declining	Sedge (*Carex tenuiculmis*)	192 plants, both mature and young; in modified *Carex* sedgeland in side gully on western side of Ida Burn.
	Declining	Coral broom (*Carmichaelia crassicaulis subsp crassicaulis*)	73 plants recorded; scattered through snow tussock grassland, modified browntop-fescue grassland, and browntop-Chewings fescue-matagouri shrubland on the high terrace surface.
	Declining	Mat broom (*Carmichaelia vexillata*)	10 plants recorded in degraded herbfield on terrace edge at centre of footprint.
Data Deficient		Willowherb (*Epilobium insulare*)	Associated with the *Carex tenuiculmis* population in modified sedgeland.

2.4 Reptiles

The area around Falls Dam and its immediate tributaries has been recognised as good lizard habitat with dense shrubbery, rocky outcrops and scree slopes that provides good feeding, sun basking and predator refuge areas. This habitat extends downstream through the Manuherikia Gorge from immediately below Falls Dam for approximately 1 km and includes the terrace slopes at Fiddlers Flat.

Five lizard species have been reported within the Home Hills pastoral lease: green skink, McCann's skink, common skink, cryptic skink and Southern Alps gecko. Scree skink (a threatened skink), while not confirmed as present may also occupy the gullies in the Home Hills area. This species is known to occupy scree slopes and was found at altitudes greater than 700 m on the nearby southern flanks of the Hawkdun Range at sites above the altitudes potentially affected by the Manuherikia irrigation project. The presence of similar greywacke screes at Falls Dam does provide the appropriate habitat for scree skink and this is the furthest south such habitat exists.

Although not all these species are threatened, all indigenous lizards are protected under the New Zealand Wildlife Act. Any activity that will harm lizards will require permission from the Minister of Conservation and any approval can be expected to include efforts to mitigate effects and transfer lizards away from the area affected.

The area around the proposed Mount Ida Dam is not considered significant lizard habitat although species such as McCann's Skink and common skink are expected to be present. During a site inspection prior to test pitting of the embankment site no significant lizard habitat was identified.

2.5 Birds

The Manuherikia River above Falls Dam regularly supports substantial breeding populations of three threatened bird species, black-billed gull, black-fronted tern, and banded dotterel, and one At Risk species, South Island pied oystercatcher. It also supports a substantial population of southern black-backed gull, a species known to prey on the eggs and chicks of braided river birds. Populations of all species, particularly black-billed gulls, demonstrate natural fluctuations in numbers from year-to-year. Wrybill have been historically reported in the area but were not observed during surveys by Wildland's in 2010, 2011 and 2014

(Wildling, 2015). DOC reported[1] Wrybill in both spring and December 2014. Black stilts have also been historically reported in the area, but none have been reported for several decades.

Wildland (2015) (refer Appendix C) has undertaken a detailed assessment of effects on river birds of increasing the height of Falls Dam. Wildlands (2015) concluded that increasing the height of Falls Dam by 27 m would result in a loss of approximately 25 % of the breeding habitat for four key species: black-billed gull, black-fronted tern, banded dotterel and pied oystercatcher. Black-billed gulls and black-fronted terns would be less affected because they nest in colonies and tend to move colony sites from year to year. Banded dotterel and pied oystercatchers are solitary nesters and Wildlands note that a reduction in breeding habitat could result in a similar scale of population reduction. It is also noted that a pest control programme for black-backed gulls could successfully mitigate the potential population reduction of banded dotterel and pied oystercatchers and generally offset adverse effects on river birds.

The area around the proposed Mount Ida Dam is not considered significant bird habitat and no bird issues have been identified.

2.6 Aquatic Ecosystems

Within the Manuherikia River catchment there is a broad range of freshwater habitats including upland and lowland wetlands, braided rivers, reservoirs, large rivers flowing through dryland environments and numerous smaller streams.

Water Quality

Data collected as part of the current study indicate that the water quality of the Manuherikia River itself is relatively good, particularly in the upper reaches, but that the water quality of its tributaries is typically much poorer (Appendix B). Bacterial populations and nutrients in the tributaries were elevated, in particular the lower Ida Burn and Thomsons Creek. Overall, the results of the 2014 survey were consistent with historical ORC monitoring data for the catchment. The gradual degradation in water quality from the upper to lower Manuherikia River can be attributed to the nutrient loads from the tributaries.

Periphyton

The current study found algal abundance in the Manuherikia River was generally low (Appendix B). Thin and medium thickness algal mats were the most common algal communities found. The exception was the Manuherikia River at Loop Road site, where algae formed a thick mat with some additional filamentous algal and the algal community extended across all wadeable areas of the river. Upstream of Falls Dam didymo was present in some areas and in Johnstones Creek formed large continuous thick mats. The presence of didymo upstream of Falls Dam means all reaches of the Manuherikia River downstream of Falls Dam and any tributaries that receive water from Falls Dam will be exposed to didymo. Local stream conditions will then control the extent to which didymo growths are apparent.

The Manuherikia River downstream of the Dunstan Creek confluence had patchy algal communities. The most notable observation was the occurrence of medium to thick black mats at the Omakau - Ophir bridge site. These mats covered less than 10 % of the river bed, but were noteworthy because these are potentially the blue-green algae *Phormidium,* that can at times release toxins to the water.

Macroinvertebrates

Macroinvertebrate taxa richness recorded in the Manuherikia River at Blackstone Hill between late 2009 and late 2013 has ranged from 15 taxa to 24 taxa. The number of "pollution-sensitive" Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa has varied between years, ranging from 7 EPT taxa to 13 EPT taxa, and consequently there has been no clear trend in either increasing or decreasing EPT taxa richness over time. MCI scores recorded over time have ranged from 99 to 108 and have been indicative of "fair" to "good"

[1] Email from Jacob Dexter of DOC to Kate Scott of the MCWSG dated 19 January 2015.

water and/or habitat quality. The macroinvertebrate indices determined from samples collected in 2014 indicate that tributary sites have poorer water and/or habitat quality.

Details of the available macroinvertebrate data are provided in Appendix B.

Mount Ida Dam

At the proposed Mount Ida Dam site the Ida Burn is a typical small creek which over summer has very limited flow. Downstream of State Highway 85 (approximately 1.5 km downstream of the proposed Mount Ida Dam_ the Ida Burn regularly goes dry. Upstream of the proposed dam site the Hawkdun IdaBurn Irrigation Company has approval to divert most of the Ida Burn's summer flow (up to 227 L/s) into the Mount Ida Race to be used predominantly for irrigation. Given the very low summer flows and almost ephemeral nature of the Ida Burn at the proposed Mount Ida Dam site it is not considered to have significant aquatic ecosystem value.

2.7 Fish

The Manuherikia River supports a total of 11 fish species (NZFFD; ORC records, a list of species is provided in Appendix B). Currently three of these species are classified as threatened and two as at risk (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 8 provides a summary of the distribution of fish species throughout the Manuherikia Catchment relative to the potential inundation and irrigation command area. Individual distribution maps for each fish species are provided in Appendix D.

The most widespread fish in the Manuherikia catchment is the introduced species, brown trout (*Salmo trutta*) and the most widespread native fish is the upland bully (*Gobiomorphus breviceps*). It is also understood that the common bully (*Gobiomorphus cotidianus*), while a native species, has been introduced to many Central Otago reservoirs generally as forage food and bait fish for the trout fisheries.

Alpine galaxias (*Galaxias paucipondylus* aff Manuherikia) is the only fish species restricted to just the Manuherikia River catchment (Appendix D, Figure 1) 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 2014) 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. In December 2014 DOC surveyed 30 sites on the upper Manuherikia River between Falls Dam (site 1) and the Hawkdun Runs Road Bridge (site 30). Sites 1 to 14 were located below the 592.2 m contour and are within the area that would be inundated by a 27 m raise of Falls Dam. The other 16 sites were at located at fairly regular spacing up to the Hawkdun Runs Road Bridge. Large numbers of brown trout were regularly identified up to site 16 after which very low number of brown trout were identified. An essentially opposite trend was found in the numbers of Alpine galaxias. Very low numbers of Alpine galaxias were identified in sites 1-8 after which numbers started to increase with sites from 19 onwards having high numbers of Alpine galaxias particularly sites 23, 25 and 29. These findings mirrored the surveys conducted by Golder in February 2014 the data for which is shown in Appendix B.

Clutha flathead is a stream resident species that occupies small to moderate sized streams from valley floor areas (e.g., Cardrona River) to steep mountain streams (e.g., Cluden Creek). This species is considered limited to the Clutha River Catchment with populations known from the Cardrona River downstream to tributaries of the Tuapeka River. The Clutha flathead has risen rapidly from the lowest to the highest threat ranking in the last ten years as a result of the observed population losses (Hitchmough 2002, Hitchmough et al. 2007, Allibone et al. 2010, Goodman et al 2014). Currently Clutha flathead is present in the Pool Burn and Manor Burn sub-catchments of the Manuherikia catchment. One population of Clutha flathead is present in the upper reaches of Hopes Creek.

Central Otago roundhead galaxias resides in valley floor streams in the Manuherikia and Maniototo (Taieri River catchment) regions. Desktop analysis of populations in the Manuherikia and Ida Burn Valley concluded that stable co-existence occurred between salmonids and Central Otago roundhead galaxias (Leprieur et al. 2006). However, within the Manuherikia Valley the majority of populations discovered in the period 1996 - 2006 have now disappeared (DOC unpublished data). The local extinctions are believed to be due to predominantly trout predation, as Central Otago roundhead galaxias are generally only found in reaches occupied by few if any trout but will also be influenced by drought and low flow effects. A population of Central Otago roundhead galaxias still exists in the Ida Valley in Spain Creek and scattered remnant populations occur in tributaries of the Manuherikia River. No known populations will be affected by the proposed construction of the Mt Ida Dam or the raising of Falls Dam and the inundation of areas upstream of the dams. However, irrigation activity and other farming practices together with salmonids and climate effects have the potential to continue to impact on the remaining populations.

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.

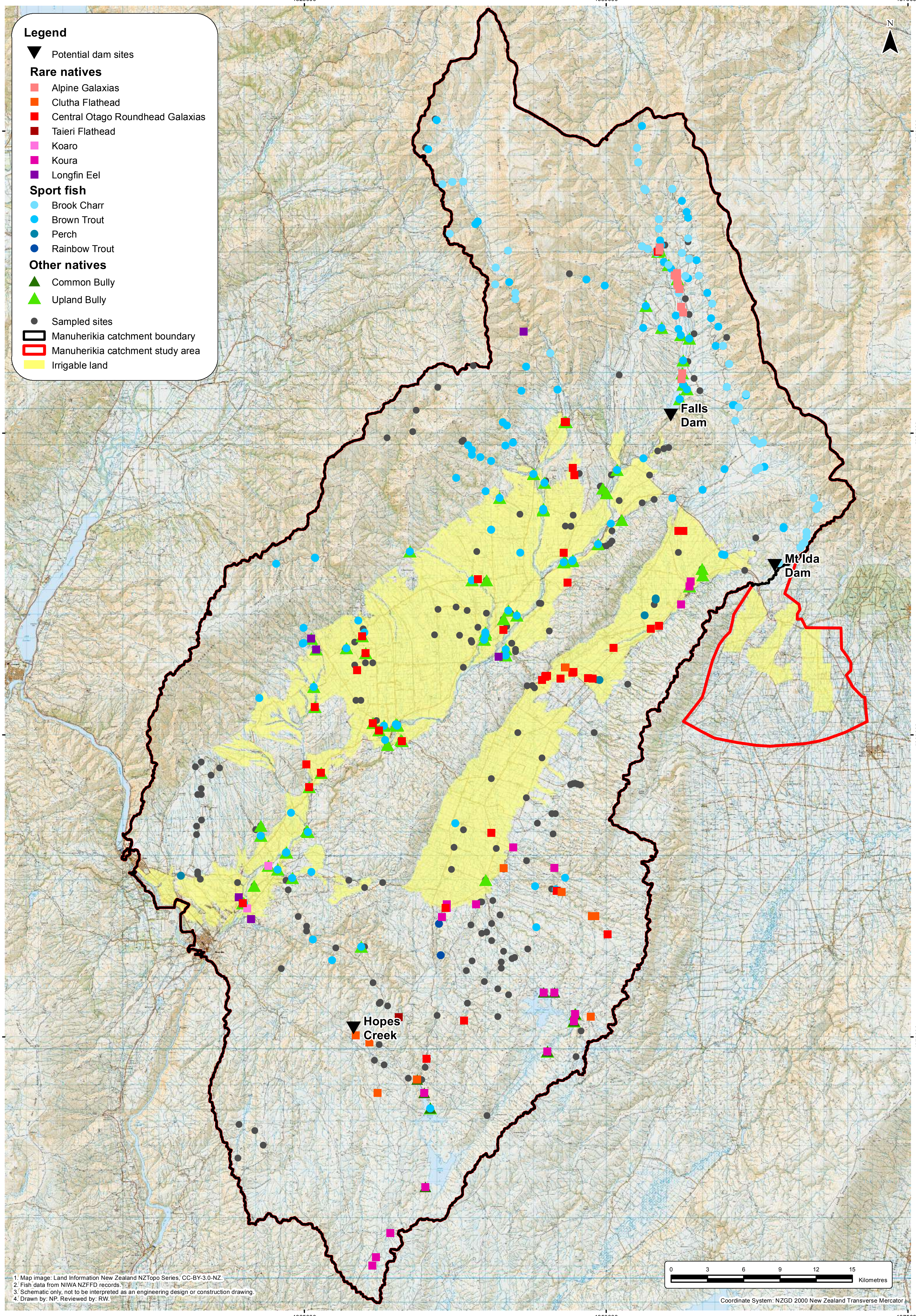
2.7.1 Sport fish and game birds

The section below has been summarised from data and a draft report provided by Fish & Game Otago (Fish & Game Otago 2013). Brown trout and rainbow trout are the most significant sports fishery values in the Manuherikia Valley with reservoir and riverine fisheries present. The Manuherikia River and its tributaries support a significant presence of trout and there is significant trout spawning within the river system. Brook char and perch form smaller incidental sports fisheries. Fish survey records show brown trout are widespread whereas the other three species are more restricted in distribution (See Appendix D for distribution maps). Key sports fisheries areas are the main stem of the Manuherikia River and Dunstan Creek and the overall river's trout fishery is considered regionally significant. The upper Manuherikia River (above Falls Dam) and Dunstan Creek above Loop Road have a remote "backcountry" feel which adds to the overall fishing experience. Falls Dam and the Poolburn, Manorburn and Greenland reservoirs are also popular fishing locations. In some areas the potential of the riverine trout fishery is limited by depleted river flows and channel modification.

In addition to the main water bodies the Manuherikia Catchment has a large number of ponds and wet areas many of which are associated with irrigation. These ponds and wetland provide habitat to waterfowl particularly paradise ducks and mallards and hunting of wildfowl is a popular local activity.

2.7.2 Mount Ida Dam

The lack of summer flow and almost ephemeral nature of the upper Ida Burn at the proposed Mount Ida Dam site results in it having very limited fishery values.



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TITLE DISTRIBUTION OF FISH SPECIES THROUGHOUT THE MANUHERIKIA CATCHMENT

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3.0 POTENTIAL ECOLOGICAL EFFECTS OF INCREASING IRRIGATION WITHIN THE MANUHERIKIA RIVER CATCHMENT

3.1 Enlarging Falls Dam Impoundment

3.1.1 General ecological values

Falls Dam and the area upstream is a distinct and rare environment within the Otago region for its terrestrial environmental classification and the braided river habitat. This area represents the furthest southern extension of the Central Dry Foothills environment (LENZ environment E) and also part of the relatively small Central Upland Recent Soils environment (LENZ environment K). The upper Manuherikia River above Falls Dam also provides important braided river habitat in the Manuherikia River catchment. This area supports a number of threatened braided river bird populations and a fish species restricted to just the braided reach of the main stem of the upper Manuherikia River. The terrestrial areas around Falls Dam also support abundant and specious lizard populations including at least one taxa of high conservation value – green skink (west Otago) and possibly scree skink. The best lizard habitat appears to be concentrated in the rocky gorges of tributaries to Falls Dam and downstream in the Manuherikia Gorge. The terrestrial vegetation around the dam also includes a number of threatened and at risk plant species much of which is contained within the Home Hills covenant area.

3.1.2 Potential ecological impacts of enlarging Falls Dam Impoundment

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 9.

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 9). 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 9 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)

Prior to construction of Falls Dam the braided section of the river is expected to have extended downstream to approximately the site of the current dam i.e. an extra approximately 2.3 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 9.

- 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)

Field survey work (Golder unpublished data, 2014 and DOC 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.

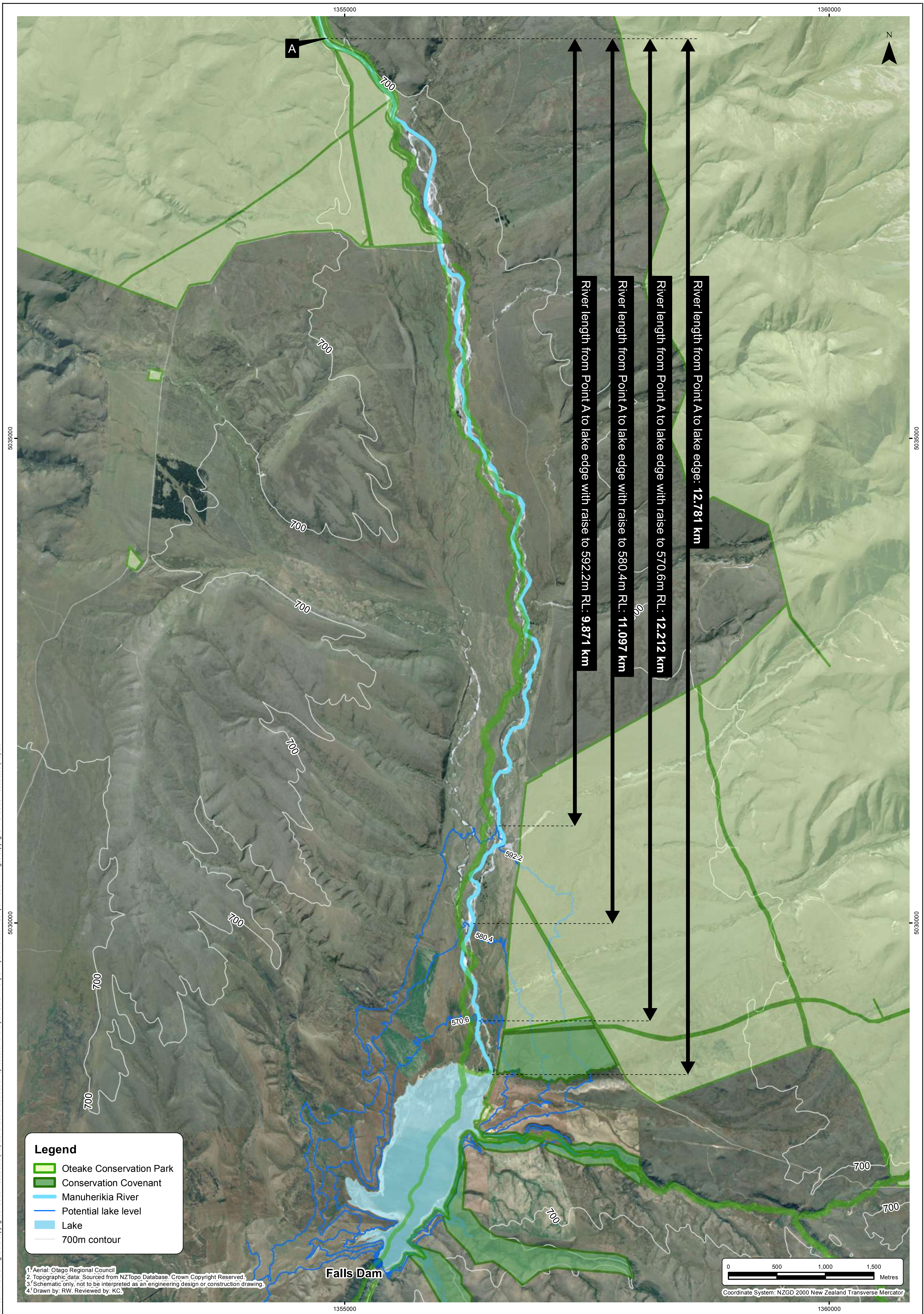
Therefore, the potential decline in range for the Alpine galaxias is likely to be due to two factors, habitat loss (via inundation) and for an additional area upstream of the raised reservoir as trout displaces, or unsuitable delta habitat restricts the Alpine galaxias from areas upstream from the reservoir.

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.



Golder Associates

TITLE FALLS DAM: POTENTIAL INUNDATION OF RIVER BRAID

AUGUST 2015

PROJECT 1378110270

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3.1.3 Data quality

It is important to note that 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.

Wildlands (2013) has reported the results of a three year bird survey on the upper Manuherikia River. Much of this survey was conducted by observing the birds from public roads in the valley as access to private property was not available. Wildlands (2015) has addressed some of the issues associated with limited observations along the river bed but further information on species such as wrybills and nesting along the full length of braided upper river would still be beneficial. Wildlands (2010) also note that to conduct robust bird surveys the work should be conducted over a period of years so that variation in habitat use and population size can be assessed.

The available fisheries data from the NZFFD, DOC (2009 and 2014) and from the site visits by Golder staff indicates that the Alpine galaxias has a patchy distribution in the upper Manuherikia River. The December 2014 DOC survey assessed 30 sites between Falls Dam and the Hawkdun Runs Road Bridge a distance of approximately 9 km. The intensity of that survey coupled with the fact that it findings mirror those from the Golder survey in February 2014 provide a good understanding of the distribution of Alpine galaxias in the upper Manuherikia River although the underlining reasons for the distribution and the detailed habitat requirement of Alpine galaxias are not well understood.

Within the braided reaches of the Manuherikia River occupied by Alpine galaxias there is expected to be an ongoing interaction between the salmonids and the Alpine galaxias. As noted above, salmonids may be excluding the Alpine galaxias from some areas of the braided river, whereas in other areas trout are rare or absent and the alpine galaxias is abundant. This is further complicated by the complete absence of alpine galaxias from some areas where few, if any, salmonids are present. Based on our current knowledge and understanding it appears that the upper Manuherikia River provides a mosaic of habitats that support different fish populations. It is therefore likely that the abundance of alpine galaxias is controlled by a number of factors including the abundance of salmonids, the occurrence of different habitats such as stable braids, unstable eroding braids and the proximity to Falls Dam and to salmonid spawning areas in the main channel or tributaries. Given this intricate interplay it is difficult to fully estimate the likely decline in Alpine galaxias with the various dam raise scenarios aside from indicating the area of riverine habitat that is lost.

Gaining information on the detailed habitat preferences of Alpine galaxias, the distribution of such habitat and how erosion and channel stability in the braided river control the distribution of the salmonids and alpine galaxias is important for understanding the long-term population survival and to fully assess the potential effects of the three Falls Dam storage enlargement options.

3.2 Potential Ecological Effects on the Manuherikia River downstream of Falls Dam

Schedule 2 of the Regional Plan: Water for Otago sets a minimum flow for the Manuherikia River of 0.82 m^3/s at Ophir. Currently there are no other minimum flow requirements in the catchment other than those stipulated on a number of individual abstraction consents, the most significant of which relates to operation of Falls Dam and requires a residual flow of 0.5 m^3/s below Falls Dam.

Flow information provided by Aqualinc (2014) indicates that during the 40 year period from 1 June 1973 to 31 May 2013, average daily flow in the Manuherikia River at Ophir fell below 0.82 m^3/s on 53 occasions which were split between 4 years (February 1974, March 1976, February / March 1982, and February / March 1999). Flows during the irrigation season tend to be elevated at Ophir due to irrigation releases from Falls Dam. This beneficial effect of irrigation releases is important in maintaining the health and the amenity values of the river in the middle reaches and any changes in irrigation water supply arrangements would need to consider the effects on river flows. Flow in the Manuherikia River at Campground which is below all the irrigation takes is a better representation of residual flows in the river. Flow information provided by Aqualinc (2014) indicates that during the period 23 October 2008 to 31 May 2013, average daily flow in the Manuherikia River at Campground fell below 0.82 m^3/s on 66 occasions with flows below 0.82 m^3/s occurring each year. Similarly during the period 4 February 1999 to 18 April 2013, average daily flow in the Manuherikia River below Falls Dam fell slightly below 0.5 m^3/s for 11 days from 28 June to 8 July 2001.

Flow information provided by Aqualinc (2014) indicates that naturalised 7 day mean annual low flow (7 day MALF) for the Manuherikia River is 3.54 m^3/s at Ophir and 3.77 m^3/s at Campground.

The hydrological regime proposed by the MCSWG and used in the hydrological modelling undertaken by Aqualinc is aimed at providing the following:

- A residual flow of 0.5 m^3/s in the Manuherikia River below Falls Dam.
- Flushing flows immediately below Falls Dam of three times median reservoir inflow (i.e., 3 x 3.88 m^3/s = 11.64 m^3/s). The flushing would occur as required over the irrigation season (mid September to mid April) with flushing flows triggered whenever flow below Falls Dam is less than three times median inflow for 30 consecutive days and the periphyton build-up has been assessed as excessive.
- A minimum flow of 0.82 m^3/s in the Manuherikia River at Ophir in line with Regional Plan: Water for Otago.
- To increase low flows, where possible, in the Lower Manuherikia River (i.e., at Campground) up to approximately 1.5 m^3/s, as well as ensuring flow variability in the range 1.5 - 2.5 m^3/s.
- In addition it is proposed to hold some water in the reservoir to allow for additional flushing and other environmental releases.

The above regime was developed by the MCWSG during a consultation process which considered irrigation reliability and environmental requirements. It was based on a large irrigation development option (i.e., 27 m raise of Falls Dam) but did not consider in any detail the cost implications of increasing the storage. It was recognised that the larger the storage at Falls Dam the greater the potential for increased environmental releases (i.e., flushing flows). Golder understands that if a smaller development option is favoured then the above regime would need to be revisited particularly when the cost implications of the development options are better understood.

The increase in the minimum flow in the Manuherikia River at Campground and the proposed flushing is expected to improve the water quality and ecological health of the main stem of the Manuherikia River.

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 flow on the tributaries and at Campground (2 m^3/s).
3. Large scale development (27 m raise) and 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. Large scale development (27 m raise) minimum flow on the tributaries and at Campground (2 m^3/s).

Flow exceedance curves, for flow in the Manuhuerikia River; immediately below Falls Dam, at Ophir and at Campground, under the four scenarios are shown in Figures 7, 8 and 9 respectively.

The proposed large scale development (27 m raise of Falls Dam) significantly increases storage which potentially allows higher minimum flows to be maintained compared to current. Under scenario 4, flow in the Manuhuerikia River at Ophir is projected to exceed 3 m^3/s 98 % of the time assuming the main stem of the river continues to be used to transport water for irrigation. Flow in the Manuhuerikia River at Campground is projected to always exceed 2 m^3/s and exceed 3 m^3/s 79 % of the time. This will reduce low flow stress on the aquatic ecosystem throughout the lower sections of the river. However, due to the increased water harvesting (i.e., the larger storage takes significantly longer to fill) flow in the Manuhuerikia 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 Manuhuerikia 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 Manuhuerikia River immediately below Falls Dam is projected to exceed 0.5 m^3/s 56% of the time. This would result in long periods of very stable flow which would provide stable habitat for aquatic ecosystems but would encourage the growth of periphyton. Regular flushing would be required in the reach from Falls Dam to the Dunstan Creek confluence to prevent excessive periphyton build-up. Provided the release of flushing flows is appropriately managed the proposed large scale development option (27 m raise) is expected to improve ecological health in the main stem of the Manuherikia River below Falls Dam.

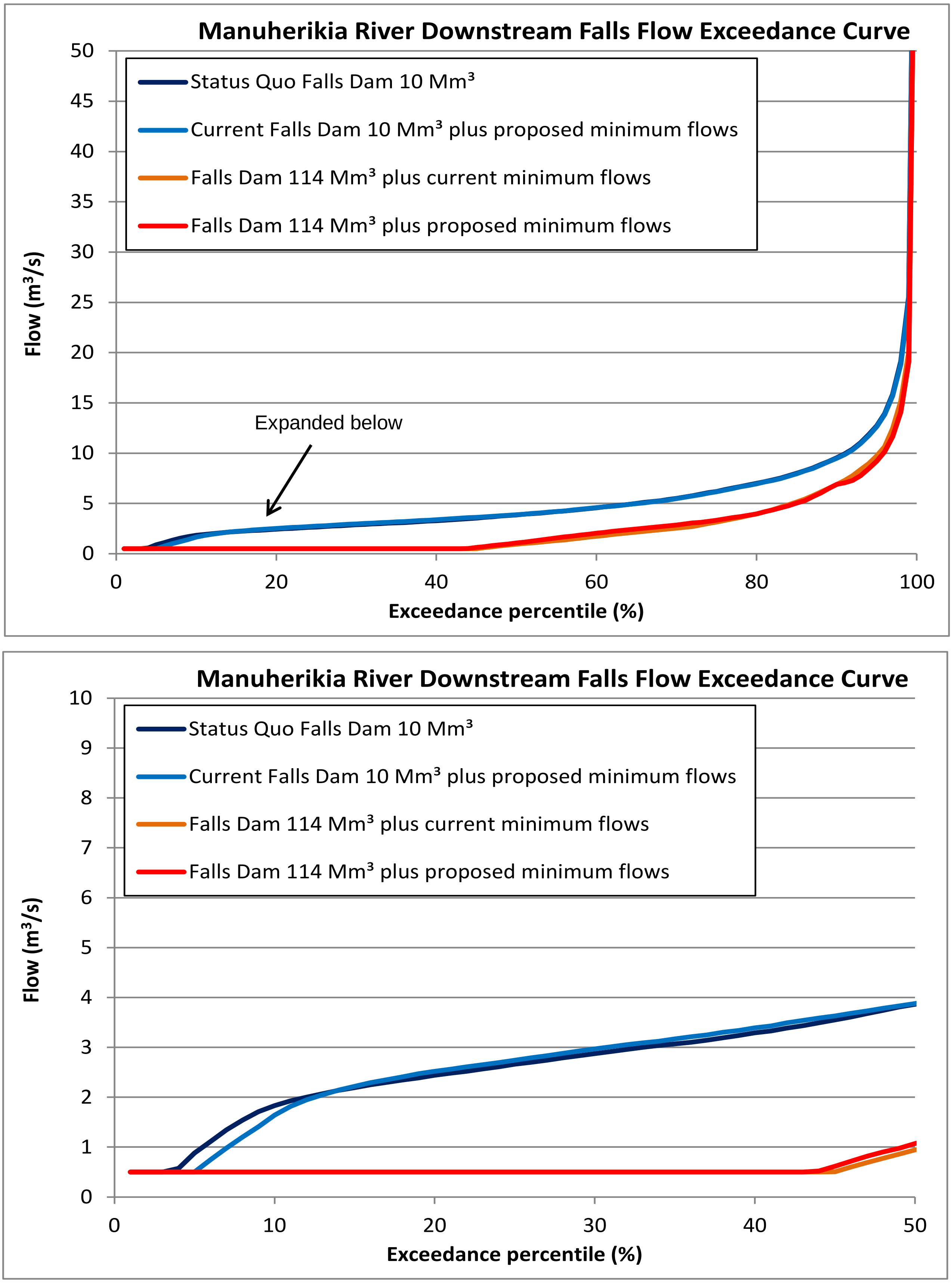
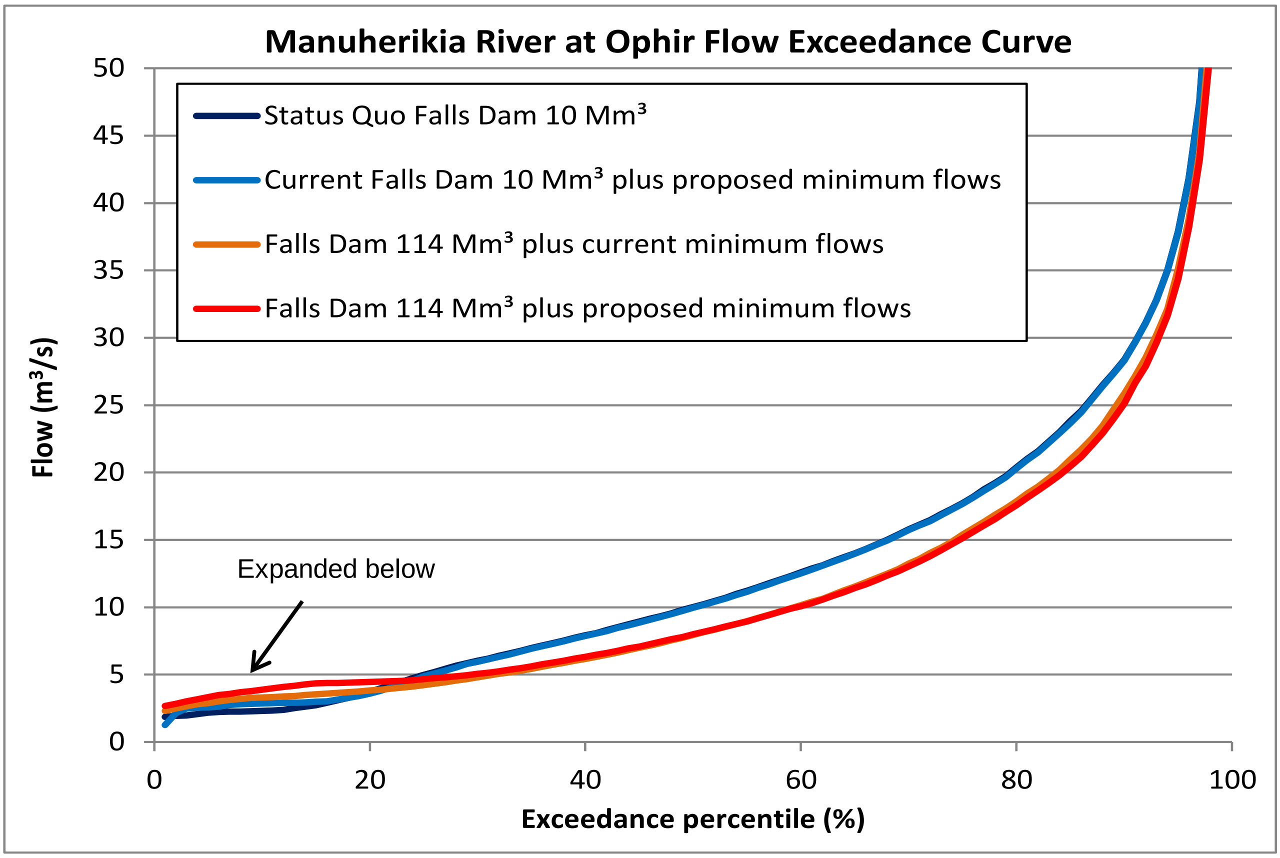


Figure 10: Flow Exceedance Curve for the Manuherikia River downstream of Falls Dam.



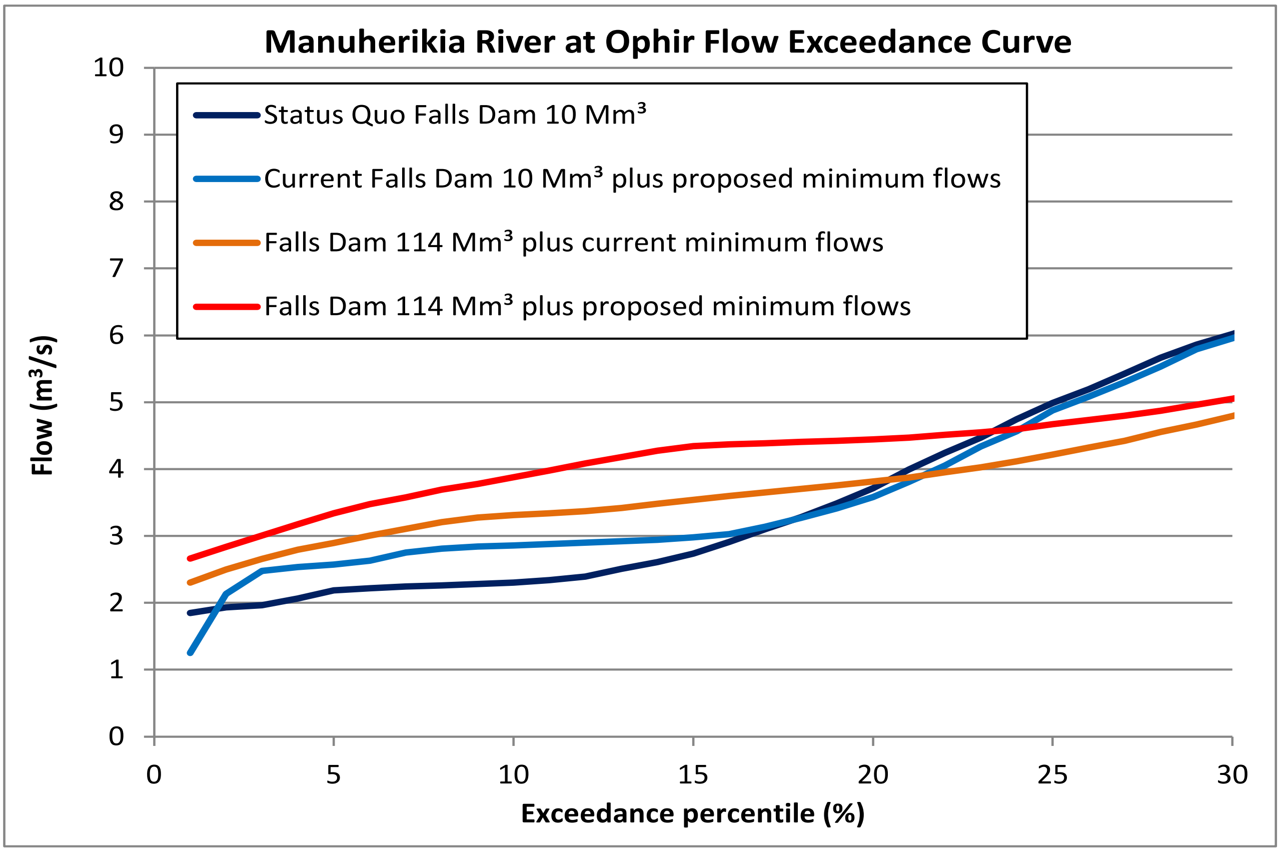
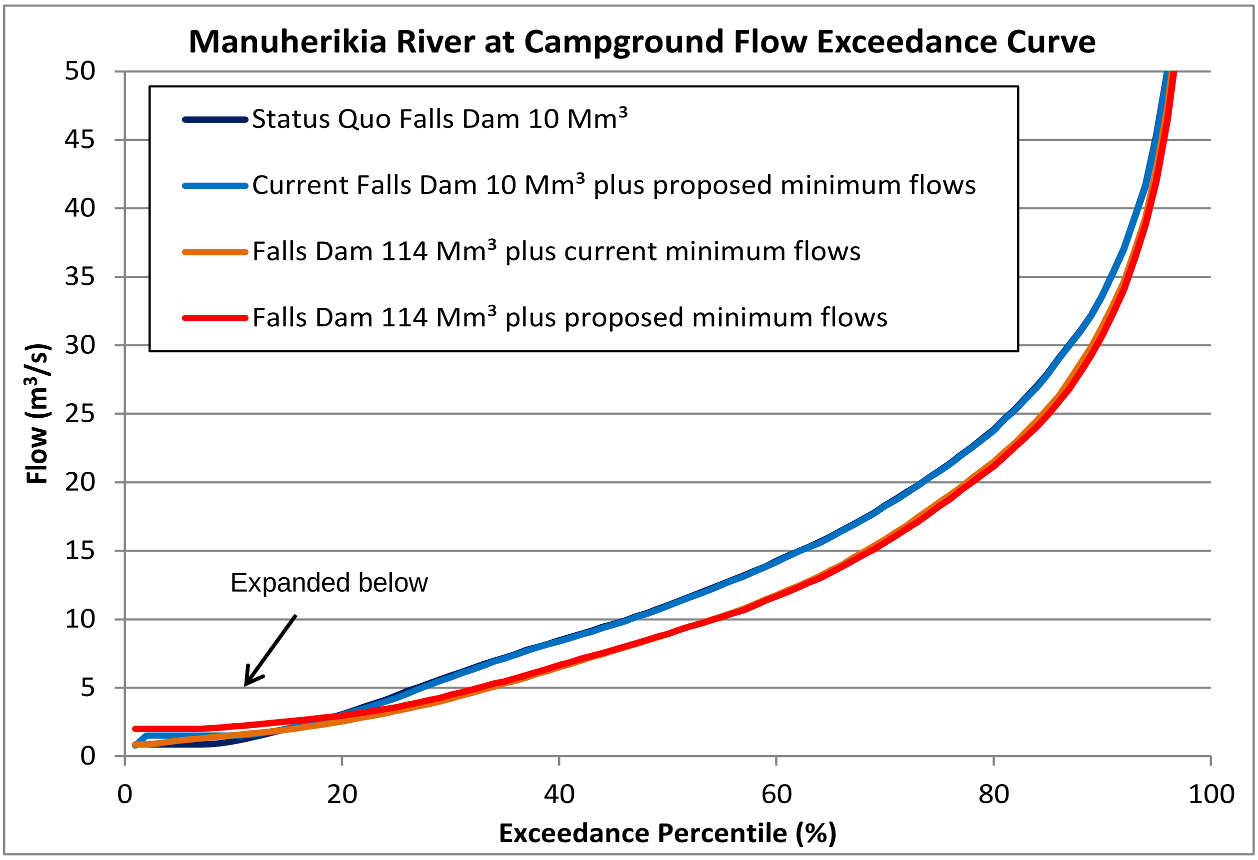


Figure 11: Flow Exceedance Curve for the Manuherikia River at Ophir.



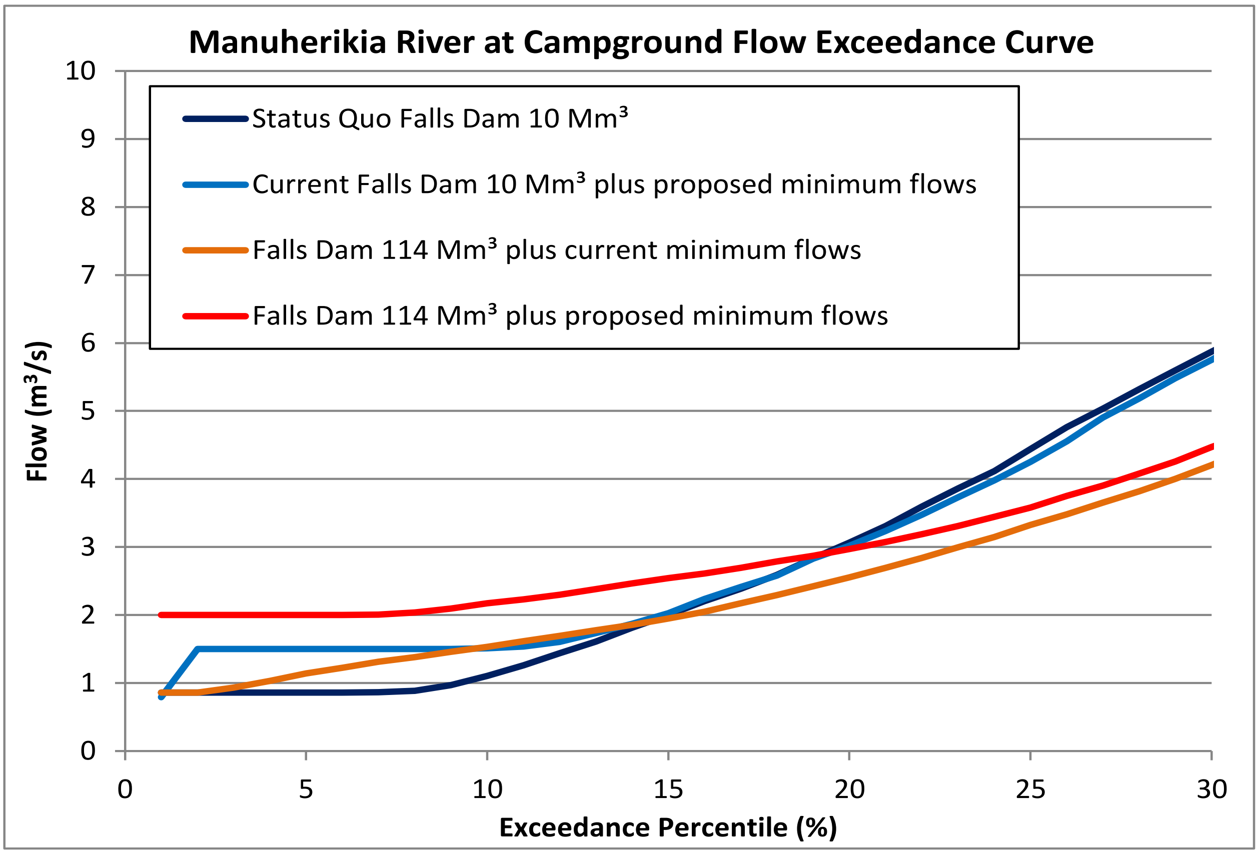


Figure 12: Flow Exceedance Curve for the Manuherikia River at Campground.

3.3 Fiddlers Flat

The construction works associated with raising Falls Dam or building a new dam will likely entail the loss of some of the downstream vegetation along the side of the Manuherikia River. This grey shrub community includes some rare native broom plants that may be present in the dam construction footprint. It is expected that the overall reduction in high value vegetation will be limited as the objective is to place any new dam as close as possible to the existing dam and this will restrict vegetation loss. This grey shrub community is also an area where green skinks have been reported and geckos are also present. A small loss of habitat for these lizards can also be expected due to the dam construction.

Fiddlers Flat will also be affected by the upgrade to the access road and also by the construction of a proposed High Race that will convey water from Falls Dam. As noted above Fiddlers Flat has been recognised as an area with a number of threatened plant species. The full effects of the road and race construction have not been determined as this will depend on the desired alignments, which would be determined during detailed design. There is likely to be some flexibility in the alignment of both the road and proposed High Race and it is recommended that ecological expertise is included in the detailed design of the road and High Race to ensure, where possible, the threatened plants communities and areas of significant lizard habitat in the Fiddlers Flat area are avoided.

3.4 Manuherikia River Tributaries

The effects of the irrigation scheme on the tributaries, their flows and habitat provided are less certain, due to a lack of hydrological data. Currently there are no minimum or residual flow requirements for the tributaries other than those stipulated on a very small number of individual abstraction consents. In future it is expected that most water takes will be subject to residual flow requirements that are expected to provide more water immediately downstream of any take points, when compared with the current deemed permit takes. However, more efficient irrigation practices such as spray irrigation, as opposed to flood irrigation, is expected to mean that recharge of stream flows via shallow groundwater inflow and irrigation runoff will be reduced and a reduction in flow in the lower reaches of some tributaries is possible.

The assessment of effects on fish will need to consider the habitat preferences of the indigenous and sports fish species concerned. Fish species preferring low velocity flows, such as the Central Otago roundhead galaxias and Clutha flathead galaxias, may benefit from low residual flows whereas salmonids may gain little benefit unless large instream flows are provided. An adaptive case by case approach to setting minimum and residual flows, waterway management and fish barriers is recommended to allow site specific issues and values to be considered within a whole catchment approach. The Central Otago roundhead galaxias is present in a number of streams within the catchment (see distribution map in Appendix D). While most of these streams are outside of the irrigation command area some small remnant populations are likely to remain within the command area which potentially could be influenced by the proposed irrigation developments. The Clutha flathead is only known to be present in the Pool Burn and Manor Burn sub-catchments of the Manuherikia catchment with no other confirmed sightings in the catchment. Neither the Pool Burn nor the Manor Burn catchments are affected by the five irrigation development options currently being considered.

The hydrological regime proposed by the MCSWG for large irrigation development option (i.e., 27 m raise of Falls Dam) is aimed at providing the following residual flows in the tributaries of the Manuherikia River:

- A residual flow of 80 % of natural 7 Day MALF in both Dunstan Creek (0.5 m^3/s) and Lauder Creek (0.18 m^3/s) below the proposed High Race. The objective of this residual flow was to maintain or improve the life supporting capacity of the waterways and to provide benefit to salmonids 7 Day MALF for Dunstan Creek at the Gorge is 0.62 m^3/s and for Lauder Creek at the Cattle Yards is 0.23 m^3/s (Aqualinc 2014).
- A residual flow of 0.05 m^3/s (50 L/s) in Thomsons Creek below the proposed High Race. The objective of this residual flow was to provide benefit to native fish species while avoiding such flow that would encourage increased use of the watercourse by salmonids. 7 Day MALF for Thomsons Creek at the diversion weir is 0.17 m^3/s (Aqualinc 2014).

Due to a lack of hydrological data the hydrological model (Aqualinc 2013) does not differentiate the other tributaries of the Manuherikia River and hence residual flows have not been proposed. Based on current information it is proposed that the main stem of the Manuherikia River up to Falls Dam, the catchment's large reservoirs (i.e., Falls, Manorburn, Greenland, Poolburn and Lower Manorburn reservoirs), Dunstan Creek and to a lesser extent Lauder Creek and Chatto Creek be managed mainly for salmonids. The tributaries above Falls Dam, Thompsons Creek, Pool Burn, Ida Burn and other smaller tributaries should be managed for native fish species where they are present. It is expected that further aquatic ecological assessment will be required during detailed design of the preferred irrigation development option to confirm any residual flow requirements and site-specific management options. It is anticipated that assessments of this nature would be a requirement of consent conditions.

The imposition of residual flows on the tributaries is expected to improve the water quality and ecological health of those water courses and is considered to be an improvement on the current situation of no tributary minimum flows.

3.5 Potential Ecological Effects of Proposed Mount Ida Dam

The Mt Ida Dam and reservoir site is predominantly highly modified dryland pasture with few remaining natural values. The area has been assessed as having relatively low values and no significant ecological effects are anticipated. A small number of threatened plant species have been identified in the area which would be inundated. These plants could potentially be transplanted although their loss in the wider context of the surrounding landscape is not considered significant.

There may be beneficial effects on aquatic ecosystem values with the development of the Mount Ida Dam through the creation of a still water reservoir.

3.6 On Farm Impacts

On farm impacts due to any changes in farm management have not been assessed as this will be determined by individual farm management at the time changes are implemented. It is expected that Farm Management Plans would be a requirement of any future irrigation development. Such plans should include environmental and biodiversity protection goals to ensure potential impacts are avoided or mitigated. Given the rarity of indigenous vegetation in the valley floors of both the Manuherikia and Ida valleys it is important that the farm plans identify the remaining areas.

4.0 MITIGATION OPTIONS

4.1 Water Quality Improvement

Sampling conducted for this study indicates that under current conditions and irrigation usage the water quality in tributaries of the Manuherikia River has the potential to breach the ORC Plan Change 6A water quality rules. Nutrient modelling undertaken (AgResearch 2015) indicates that nutrient loss is very dependent on irrigation efficiency and moving from the current predominantly flood based irrigation system to spray irrigation is expected to significantly reduce nutrient loss. This is predominantly due to the catchments dry climate and deep soils which under efficient spray irrigation results in very limited drainage. Areas of shallow bony soils which are generally located on river terraces adjacent to the Manuherikia River remain susceptible to increased nutrient loss as will sub-catchment where there are significant areas of new irrigation. For the maximum potential development scenario (i.e., a large increase in storage at Falls Dam and the Mount Ida Dam) overall catchment nitrogen loss from the root zone is expected to decrease by approximately 0.4 %.

Given this, the following management actions are likely to be required:

- A reduction in runoff when irrigating to reduce the risk of overland flow carrying nutrients and contaminants to water courses. Runoff is reduced by ensuring irrigation does not saturate the soil and that application rates do not exceed the soils infiltration rate.
- A reduction in drainage when irrigating to reduce the risk of leaching of nutrients through the soil profile and potential contamination of shallow groundwater and spring fed watercourses. Drainage is reduced by improved irrigation management, applying smaller application depths and deficit irrigating.
- Fencing of riparian zones along streams to prevent stock access. This reduced the potential for both direct faecal contamination and stream bank erosion.
- Planting of riparian zones to reduce overland flow and to encourage nutrient uptake and to provide shading to the watercourses.
- Farm management plans that include nutrient management objectives.
- The creation of treatment wetland areas to strip nutrients and to capture contaminants from spring discharges and runoff. Treatment wetlands are often difficult to develop and manage and are usually only considered an option in areas of very elevated nutrient levels. The creation of wetlands does provide additional biodiversity and habitat values.

The balance of management actions on any individual property or stream catchment will depend on the on-farm activities, ability to construct wetlands and stream flow regimes.

In addition to the on farm activities to reduce runoff effects, flushing flows for the Manuherikia River can be provided. Flushing flows will scour the river bed and remove the majority of algae and flush fine sediment from the bed of the river. Both these actions improve the habitat for aquatic species and the flushing removes nuisance algal build up and will remove the potentially toxic *Phormidium* algae. The current recommended flushing regime for a river is to provide a flow three times the median flow for between 24 and 48 hours. Depending on the rate of algal growth the flushing flow may be provided at intervals of 30 days or more. The flushing flows can also be combined with natural high flow events to maximise or enhance the natural flushing effect.

The Manuherikia River from Falls Dam to the confluence with Dunstan Creek is the reach most in need of flushing, particularly during periods of stable flow associated with either dam filling or relatively constant irrigation releases. Periphyton monitoring and observations during Golder's site visits indicate that freshes and floods in Dunstan Creek provide flushing downstream of the confluence. Periyphon growth may also require management in the lower reaches of the Manuherikia River below the irrigation intakes due to the high public use of that area and the lower residual flow that remains following the upstream irrigation abstractions. The hydrological regime proposed by the MCSWG for the 27 m raise and used in the hydrological modelling undertaken by Aqualinc is aimed at providing flushing flows immediately below Falls Dam of three times median reservoir inflow (i.e., 3 x 3.88 m^3/s = 11.64 m^3/s). The flushing would occur as required over the irrigation season (mid-September to mid-April) with flushing flows triggered whenever flow below Falls Dam is less than three times median inflow for 30 consecutive days and the periphyton and/or macrophyte build-up has been assessed as excessive. In addition, it is proposed to hold some water in the reservoir to allow for additional flushing and other environmental releases.

These flushing flows will provide a significant improvement to the Manuherikia River immediately downstream of Falls Dam, where currently algal communities exceed national periphyton guidelines through the late summer and autumn, as little or no natural flushing occurs during the irrigation season. Flushing flows will only occur in the Manuherikia River and flushing cannot be used to reduce algal growth or to provide fine sediment removal in the tributaries. For the tributaries, riparian management can reduce fine sediment inputs. If shade trees are planted the shading can reduce algal growth and will also beneficially reduce water temperatures.

4.2 Mitigation of Potential Adverse Effects of Enlarging Falls Dam Impoundment

4.2.1 Lizard and plant mitigation options

Mitigation options are available to address the effects of habitat loss due to construction works around Falls Dam or inundation due to an enlarged impoundment. Standard practice management activities such as predator control and reduction in browsing pressure are often applied as mitigation. The scale of such operations will need to be determined but mitigation management areas are usually considerably larger than the areas to be submerged. More recently mitigation for impacts on lizard populations has include the creation of new habitat for lizards and translocation of lizard from the impact areas to the new habitats.

Potential management sites for plants and lizards in the vicinity of Falls Dam include:

- Areas of the Home Hills covenant not submerged by raising larger impoundment.
- The Fiddlers Flat Conservation area.
- The true right bank of the Manuherikia River in the gorge section downstream of the Falls Dam site.

All these sites are recognised as retaining native plant and lizard species. Potential mitigation activities include fencing areas to exclude stock, weed removal and enhancement planting with native plants and conducting pest animal controls to reduce browsing and predation pressure. Some of these mitigation activities, such as fencing and planting, would require a significant initial effort but would then reduce to low maintenance level activities. Other mitigation such as pest control would require an ongoing commitment.

For long-term protection of the mitigation activities and the gains made, the creation of DOC or Queen Elizabeth II National Trust covenants could be undertaken for any areas of private land that the work is conducted on subject to approval of private landowners. Currently there are six registered National Trust covenants in the Manuherikia Catchment[2].

4.2.2 Manuherikia Alpine galaxias

Enlarging the Falls Dam impoundment will result in the inundation of habitat of the Alpine galaxias that cannot be readily replaced. As no populations of the Manuherikia Alpine galaxias occur elsewhere there are no other sites at which the offset works can occur. Therefore, any mitigation efforts would likely have to be applied to the alpine galaxias population in the upper Manuherikia River. Salmonids are currently recognised as a significant threat and removal of salmonids is expected to benefit the alpine galaxias. However, the removal of salmonids is not feasible on the scale of the whole of the upper Manuherikia River valley, an area with approximately 450 km of watercourse, the majority of which are likely to be inhabited by salmonids. Small scale trout removal in one or more tributaries of the upper Manuherikia River may be possible, though a feasibility study would be required. It is likely that this would require the installation of a permanent fish passage barrier at the lower end of any salmonid removal area. Local scale habitat management could be attempted that seeks to influence the instream habitat of the upper Manuherikia River to provide habitat features that benefit Alpine galaxias rather than salmonids. This mitigation would require some investigation of the habitat preferences of alpine galaxias and the likely completion of a demonstration site showing the benefits to Alpine galaxias before it is likely to be accepted. Finally, local scale trout control could be undertaken to reduce the density and size range of salmonids present to reduce the predation and competition impacts of salmonids.

The three possible mitigation activities above would all require ongoing commitments to maintain effectiveness.

Translocation of the Alpine galaxias to a new river could be attempted to provide new habitat. This would require the permission of the Minister of Conservation under section 26zm of the Conservation Act and may also need the approval of Ngai Tahu. To gain permission it can be expected that sufficient information would

[2] Based on information shown on the following website http://www.openspace.org.nz/Site/Publications_resources/Annual_statistics_maps_and_graphs.aspx accessed on 3 June 2015.

need to be provided to show the translocation would be successful, but not impact on other values at the translocation sites. The translocation site would need similar habitat to the upper Manuherikia River, i.e., a high altitude, low gradient (possibly braided) river system. To improve the likelihood of success the translocation site should be free of predatory fish, such as salmonids. However, salmonid free areas are not common.

Finally, any potential translocation should not endanger the existing values of the translocation sites. The presence of didymo in the Manuherikia River does mean that there is a potential to transfer didymo to a new river system. A translocation to another waterway with didymo would pose no issue. However, if a suitable translocation site is identified that is didymo free then any translocation process would require decontamination of the fish, the water they are transported in and any other equipment used. This will increase the operational difficulties for a translocation and most likely increase fish mortality. Salmonid free habitats are also more likely to be didymo free as angling, a common method of transfer would not occur in those waters and didymo invasion is less likely to have occurred.

No translocation of this species or the closely related alpine galaxias of Canterbury and Southland has ever been conducted and there is no proven method for a translocation. Fish transfers are routinely conducted for some species (e.g., brown trout) and are successful. However, for other species, success is more limited and establishment of large healthy populations has not occurred. For instance, a recent translocation of the lowland longjaw galaxias to the Waianakarua River as part of the conservation management programme has failed to establish a large healthy population and the long term success of the translocation is uncertain (DOC unpublished data). In the event that a translocation of the alpine galaxias is undertaken, it should be expected that monitoring of the translocated population will be undertaken for some years to prove the fish has established. This proof of establishment maybe required prior to the any inundation of the existing habitat in the Manuherikia River.

4.2.3 Upper Manuherikia bird populations

The extent of effects on the threatened bird breeding populations is currently unknown as the response of black billed gulls to the impoundment enlargement and associated habitat reduction is not known. However, if the birds retain a presence in the upper Manuherikia River valley then a predator control programme in the vicinity of the nesting colony would provide some mitigation and aim to reduce chick and adult bird mortality during the breeding season. The area over which predator control is undertaken could also be designed to incorporate at least some of the black-fronted tern breeding area, extending some protection to these threatened birds too. However, prior to determining the size of such an operation it would be beneficial to understand the current predation impacts in the upper Manuherikia River so that control operations target the appropriate species be they black-backed gulls, mustelids, hedgehogs, feral cats or other predators.

Offset compensation may also be possible for the braided river birds with conservation management activities being undertaken to assist in the protection of populations or enhance breeding of threatened braided river birds elsewhere in the South Island. The exact nature of this offset would have to be determined via consultation with other parties. However, it is likely that predator and/or weed control at other braided river bird breeding sites would be the most feasible options.

4.3 Mt Ida Dam Impoundment

The Mt Ida dam and reservoir site has been assessed as having relatively low values and mitigation is considered limited or not necessary. If required it could be in the form of retirement of grazing of an area with good indigenous vegetation in the vicinity of the Ida Burn.

4.4 Command Area Mitigation and Environmental Management Options

4.4.1 On farm options

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. The LENZ analysis indicates that the Manuherikia Valley and Ida Valley are well developed for pastoral farming, and indigenous vegetation and ecosystems are rare. Therefore, it is expected that ecosystems with significant biodiversity values, which would benefit from protection will be rare on the farm properties. 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.

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.

4.4.2 Central Otago roundhead galaxias

The Central Otago roundhead galaxias is present in a number of streams within the command area. While some of these streams may not be subject to water abstraction, flows may currently be influenced by irrigation runoff. However, the Central Otago roundhead galaxias may still exist, as small remnant populations, in abstracted streams such as Thomsons Creek and Lauder Creek. 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. Possible management actions include:

- Riparian management with a goal to maintain a willow and woody weed free stream channel.
- Salmonid management to reduce the density of large predatory salmonids.
- Instream habitat management to ensure areas of shallow water (5 - 15 cm deep) are common during the low flow summer period.
- Reintroductions of Central Otago roundhead galaxias to areas they have been lost from.

4.4.3 Saline wetlands

The saline wetlands of the Manuherikia River valley are a rare ecosystem type that harbours a range of saline tolerant plants. Five saline sites are recognised in the Manuherikia catchment and these are included in the Otago Regional Plan as regionally significant wetlands (Figure 5). 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 changes in this area. Monitoring of water and salinity levels in the wetland, 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. Given the location (near the edge of the irrigated area) and the relatively small size of the Rockdale saline wetland it is expected that simple local measures including buffer zones will ensure the wetland is suitably protected.

5.0 CONCLUSIONS

The lowland areas of the catchment have been highly modified which has significantly reduced the ecological values that are present. Indigenous vegetation and intact indigenous ecosystems are essentially absent from the valley floors of both the Manuherikia and Ida valleys. Any remaining areas of indigenous vegetation in the valley floor are of high value due to their rarity and five regionally significant saline wetlands have been identified in the lower Manuherikia River catchment.

The upper parts of the catchment are substantially less modified and contain significant ecological values. 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.

The upper parts of the Manuherikia River catchment have in general excellent water quality and aquatic habitat value. However, in the lower reaches of the Manuherikia River at Galloway, the water quality has declined to ‘good’ and the habitat values are reduced. In the tributaries, water quality and habit values declines downstream as each stream flows across the Manuherikia or Ida valley floors.

Raising Falls Dam will create a larger reservoir thereby inundating some of the braided river system that enters the reservoir and some of the terrestrial vegetation around the dam the most notable of which is within the Home Hills covenant area. All three options for raising Falls Dam will cause varying degrees of inundation of the braided river system upstream of the reservoir and the Home Hills covenant. 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 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 Mt Ida dam and reservoir site has been assessed as having relatively low values and mitigation is considered limited or not necessary.

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APPENDIX A

Report Limitations

Report Limitations

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APPENDIX B

Ecological Data

The following sections summaries the ecological monitoring data collected during this project namely during field visits over the 2013 - 2014 summer. Relevant background data collected during earlier projects and discussed in the body of this report is also presented.

1.0 TERRESTRIAL ECOSYSTEMS IN THE MANUHERIKIA VALLEY

Site walkovers were conducted across the inundation areas at the Falls and Mt Ida dam sites to identify the vegetation communities, their state and their extent. A general botanical survey was conducted in March 2014 and a spring annual plant survey in October 2014 at the two dam sites. The location of individual plants or clusters of threatened plants were recorded using a GPS for mapping.

The following photos were taken during Golder field visits and show relevant terrestrial ecosystems and plant species which are discussed in the body of this report.

Figure B-1: Coral broom amongst browntop grasses.

Figure B-2: Sparsely vegetated scree slopes in one of the un-named gullies on Home Hills.

Figure B-3: Shrublands in the DOC covenant at Home Hills, southern most gully (left) and Johnstone Creek, north facing hillside (right).

Figure B-4: Browntop grass dominated area of vegetation at Falls Dam: Riverbed mosaic (top left); browntop grassland-fescus tussock (top right); browntop grassland (bottom left); looking across Falls Dam to the browntop grassland and copper tussock fen (bottom right).

1.1 Spring Annual Plants

Kate Wardle undertook a survey of spring annual plants in the potential inundation areas at Falls Dam and the Mount Ida Dam. A copy of the report (Wardle, 2015) is included in Appendix E.

2.0 BIRDS

Observation of the bird species utilising Falls Dam during the February to late April period were made by Golder field staff. Additional incidental records were made of birds observed at other times during the rest of the fauna and flora surveys undertaken by Golder. Birds observed at Falls Dam reservoir included pied stilts, Canada goose, paradise shelduck, and shoverler.

Wildlands (2015) undertook a detailed assessment of effects on river birds of increasing the height of Falls Dam. A copy of their report Wildlands (2015) is included in Appendix C.

3.0 REPTILES

Field investigations were conducted at the Falls and Mt Ida dam sites to provide up to date data on the lizard populations present in the inundation areas of the two dams. Surveys commenced in February 2014 and were conducted through to early April 2014 when cold weather appeared to curtail lizard activity. At Falls Dam the surveys were conducted around the full dam perimeter. At Mt Ida surveys were conducted in an area of the tussock vegetation along the north face slopes of the inundation area. Surveys were conducted via a number of methods:

- Visual observations were observers watch areas of lizard habitat such as rocky scree slopes and used binoculars to observed and identified lizards active in the survey area.
- Rock turning and searching where searchers lifted rocks and moved vegetation to uncover or disturb lizards so they could be observed and identified. When possible lizards were caught and photographed to provide permanent record for later identification. All lizards caught were carefully returned to their original locations once photographed.
- Gee minnow traps were placed in lizard habitat and baited with pear to attract and trap lizards. Traps were placed amongst rock scrubby vegetation habitat.

Skinks and geckos (Figure B-5, Figure B-6) were encountered at the Falls Dam site during Golder field visits with the majority of the individuals observed and photographed being of relatively common species, the Southern Alps gecko (*Woodworthia* sp. 'Southern Alps') and McCann's skink (*Oligosoma maccanni*). Survey findings indicated that the lizard populations are large and robust. Juvenile and adult skinks and geckos were observed. The presence of moulted gecko skins under rocks also provided good evidence of an abundant population. The proportion of lizards with regrown tails was low (< 30 %) indicating that predation is possibly low (or highly successful) as few lizards have experienced encounters that have led to tail dropping events to escape predators (Figure B-7). The dense grey scrub and abundance of crevices amongst the rock bluffs and scree slopes also provide good cover for the lizards.

Figure B-5: Geckos from: Johnstones Creek area (left), western side of the Falls Dam reservoir near the dam (right).

Figure B-6: McCann's skinks from Johnstones Creek (left), and from one of the un-names gullies (right).

The Home Hills pastoral lease tenure review conservation resources report (DOC 2006) reports lizard observations in the Falls Dam area. Five lizard species where reported: green skink, McCann's skink, common skink, cryptic skink and Southern Alps gecko. DOC (2002) reported the results of a 1996 survey of the Little Mt Ida pastoral lease and also reported the five lizard species present; two species of common skink, green skink, scree skink and common gecko. Scree skink was considered the most significant find as this was the rarest species observed. This species is still considered threatened with a ranking of nationally vulnerable (Hitchmough et al. 2012). This species occupies steep unstable scree slopes and was found at altitudes greater than 700 m on the southern flanks of the Hawkdun Range at sites above the altitudes potentially affected by the Manuherikia irrigation project.

Figure B-7: Juvenile gecko (top left), juvenile McCann's skink (top right), adult gecko with regrown tail (bottom left) and white moulted gecko skinks (bottom right).

Taxonomic issues

Since the DOC (2002, 2006) tenure review reports were written the skink and gecko taxonomy has been reviewed and additional species described so the exact species recorded in the DOC surveys is uncertain. This is of particular concern with regard to the green skink that is now likely to fall within the West Otago green skink range (Greaves et al 2007) and this taxon has been given a threat ranking of nationally vulnerable (Hitchmough et al. 2012). DOC (2006) also noted that the habitat around Falls Dam and its immediate tributaries is good lizard habitat with dense shrubbery, rocky outcrops and scree slopes that provides good feeding, sun basking and predator refuge areas. This habitat extends downstream through the Manuherikia Gorge from immediately below Falls Dam for approximately 1 km and includes the terrace slopes at Fiddlers Flat.

Additional distributional data

Lettink (2011) conducted lizard surveys in the upper Manuherikia Valley upstream of Falls Dam. This survey located two skink species, common (*Oligosoma polychroma*) and McCann's skinks. These species were common in the tussock grassland areas surveyed and were thought to be common in areas with good vegetation cover. It can be expected that these lizards are also present in the tussock areas around the proposed Ida Burn dam site.

Jewell (2006) provides a distribution guide for gecko of Otago. The distribution maps provided by Jewell (2006) show that two other gecko species occur in the Manuherikia Valley, the large Otago / Southland large gecko (*Woodworthia* sp. 'Otago large') and the Central Otago gecko (*Woodworthia* sp. 'Central Otago'). These latter two species are recorded downstream of the Falls Dam area and the Southern Alps gecko is restricted to the areas around Falls Dam and further north along the Hawkdun Range. Therefore, in rocky areas within the Manuherikia Valley the Central Otago and Otago large geckos will be the expected gecko species encountered.

4.0 WATER QUALITY

4.1 2014 water quality sampling

Water quality sampling was conducted monthly at eight sites (Table B-1 and Figure B-8) from February to May 2014. The pH, DO conductivity and salinity were measured in the field using a calibrated hand-held water quality meter and the mean values indicate these parameters where suitable for supporting a healthy stream flora and fauna (Table B-2). Concentrations of dissolved oxygen were high throughout the catchment (mean saturation >80 % at all sites), although values were generally lower in the Ida Burn site that elsewhere (mean 84 % saturation compared to >90 % for all other sites). The Ida Burn also had higher conductivity values than the other sites (mean 52 µS/cm). The pH values measured at all sites were near-neutral (7.3 - 7.7). Temperatures reflected ambient conditions (i.e., warmer on warm days, colder on cold days) and these data are not presented.

Table B-1: Monthly (Feb - May 2014) water quality monitoring sites.

Stream	Location	Map reference	Sample dates
Wether Burn	Athenaeum Rd bridge	CC15 635 072	13/2/14, 18/3/14, 23/4/14, 19/05/14
Manuherikia River	Loop Rd bridge	CB15 517 223	13/2/14, 18/3/14, 23/4/14, 19/05/14
Manuherikia River	Upstream of Ida Burn confluence	CC14 411 072	13/2/14, 18/3/14, 23/4/14, 19/05/14
Lower Ida Burn	Upstream of Manuherikia confluence	CC14 413 067	13/2/14, 18/3/14, 23/4/14, 19/05/14
Lauder Creek	SH 85 bridge	CC14 399 082	13/2/14, 18/3/14, 23/4/14, 19/05/14
Manuherikia River	Omakau Ophir Rd bridge	CC14 327 008	13/2/14, 18/3/14, 23/4/14, 19/05/14
Thompson Creek	Upstream of Manuherikia confluence	CC14 318 991	13/2/14, 18/3/14, 23/4/14, 19/05/14
Manuherikia River	Upstream of Chatto Creek confluence	CC14 287 971	13/2/14, 18/3/14,

Table B-2: Mean field measurements of DO, conductivity and salinity at eight sites in 2014.

Site	pH	DO (%)	DO (mg/L)	Conductivity (µmS/cm)
Wether Burn @ Athanaeum Rd	7.6 (7.3 - 7.7)	91 (82 - 101)	10.0 (9.5 - 10.4)	99 (68 - 148)
Manuherikia @ Loop Rd	7.4 (7.4 - 7.5)	100 (83 - 117)	10.6 (9.9 - 11.8)	44 (26 - 90)
Manuherikia u/s Ida Burn	7.6 (7.5 - 7.7)	100 (83 - 121)	10.5 (9.8 - 11.7)	52 (32 - 88)
Lower Ida Burn	7.6 (7.3 - 7.9)	84 (79 - 90)	9.1 (8.1- 10.2)	205 (113 - 291)
Lauder Ck @ SH85	7.5 (7.2 - 7.6)	97 (82 - 116)	10.2 (9.4 - 11.2)	72 (10 - 123)
Manuherikia @ Omakau	7.6 (7.5-7.7)	101 (83 - 121)	10.5 (9.8 - 11.5)	71 (44 - 99)
Thompson Creek	7.5 (7.4 - 7.6)	91 (81 - 104)	9.7 (9.0 - 10.2)	115 (88 - 146)
Manuherikia u/s Chatto Ck	7.6 (7.5 - 7.7)	101 (85 - 118)	10.5 (9.9 - 11.3)	79 (48 - 100)

Note: n=4 except for DO data (n=3, no data for April).

Water samples were send to Hill Laboratories in Christchurch for analysis for: pH, total nitrogen (TN), total Kjeldahl nitrogen (TKN), total ammoniacal nitrogen, nitrate-N, nitrite-N, nitrate-N + nitrite-N, total phosphorus (TP), dissolved reactive phosphorus (DRP), total suspended solids, turbidity, faecal coliforms and *E coli*.

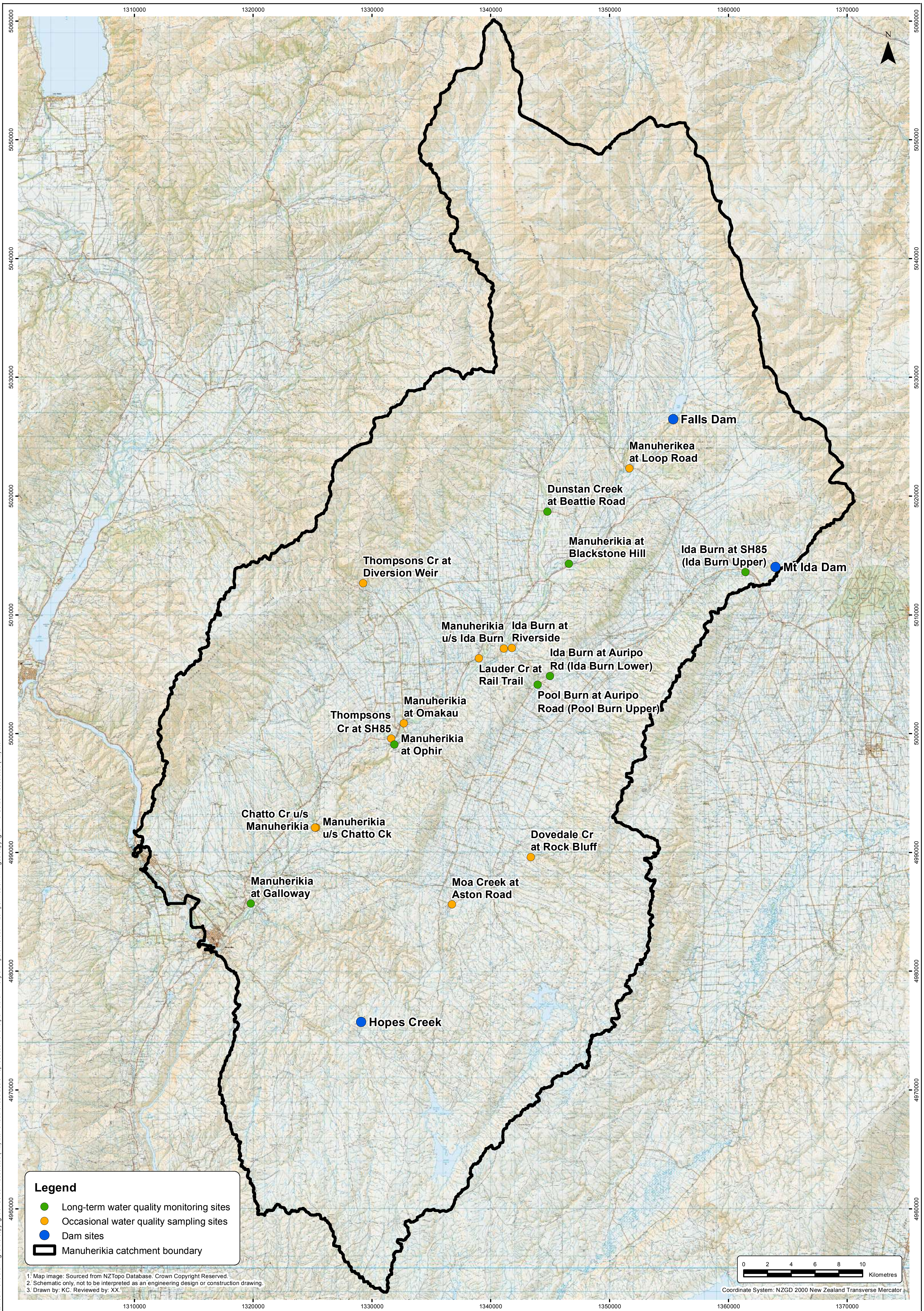
Results for laboratory analyses of nutrients (total ammoniacal nitrogen, nitrate-N, nitrite-N, total nitrogen (TN), dissolved reactive phosphorus (DRP), and total phosphorus (TP)) are presented in Table B-3. Data for total suspended solids, turbidity, faecal coliforms and E coli are presented in Table B-4. All data were analysed by Hill Laboratories.

The data presented indicate that the water quality of the Manuherikia River itself was relatively good, particularly in the upper reaches, but that the water quality of its tributaries was typically much poorer. Bacterial populations and nutrients in the tributaries were elevated, in particular the lower Ida Burn and Thompson's Creek.

Overall, the results of the 2014 survey were consistent with historical ORC monitoring data for the catchment (refer below). The gradual (relative) degradation in water quality from the upper to lower Manuherikia can be attributed to the substantial loads from the tributaries.

4.2 Previous investigations

Water quality sampling has been conducted by the ORC at long-term SOE monitoring sites and also less frequent as part of catchment management studies. Therefore, considerable data is available on water quality throughout the Manuherikia catchment rather than data being restricted to a few locations and occasions. This provides a relatively robust dataset to assess the current water quality status.



Golder Associates

TITLE ORC WATER QUALITY MONITORING SITES

AUGUST 2015

PROJECT 1378110270

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Table B-3: Results for nutrients in samples collected during the 2014 water quality survey.

Site	Ammoniacal nitrogen	Nitrite+nitrate	Total nitrogen	Dissolved reactive phosphorus	Total phosphorus
ORC "Good water quality"	**0.10**	**0.075**	-	**0.010**	-
Wether Burn at Athanaeum Rd	<0.010	0.009 (<0.002 - 0.03)	0.27 (0.20 - 0.38)	**0.010 (0.004 - 0.015)**	0.018 (0.010 - 0.028)
Manuherikia at Loop Rd	<0.010	0.004 (<0.002 - 0.006)	0.12 (0.055 - 0.18)	<0.004	0.006 (0.004 - 0.008)
Manuherikia u/s Ida Burn	<0.010	0.014 (0.004 - 0.037)	0.10 (0.055 - 0.15)	0.006 (<0.004 - 0.008)	0.011 (0.006 - 0.015)
Lower Ida Burn	0.013 (<0.010-0.035)	**0.25 (0.071 - 0.41)**	1.0 (0.43 - 1.8)	**0.054 (0.016 - 0.094)**	0.090 (0.028 - 0.015)
Lauder Creek at SH85	<0.010	0.014 (0.003 - 0.031)	0.35 (0.12 - 0.59)	**0.031 (0.006 - 0.051)**	0.088 (0.016 - 0.175)
Manuherikia at Omakau	<0.010	0.024 (<0.002 - 0.047)	0.16 (0.12 - 0.19)	**0.011 (0.006 - 0.017)**	0.020 (0.012 - 0.023)
Thompson Creek	0.033 (<0.010-0.12)	**0.23 (0.017 - 0.54)**	1.0 (0.32 - 2.4)	**0.082 (0.011 - 0.18)**	0.190 (0.018 - 0.48)
Manuherikia u/s Chatto Creek	<0.010	0.055 (<0.002 - 0.157)	0.30 (0.13 - 0.58)	**0.021 (0.006 - 0.044)**	0.039 (0.018 - 0.08)

Notes: Data are mean values (range in parentheses). All units g/m^3 element (i.e., g/m^3-N or g/m^3-P); n=4. Data marked in red and bold indicate historical averages greater than ORC "Good Quality Water" Limit. Data marked in blue is marginal with respect to limits.

Table B-4: Results for other parameters in samples collected during the 2014 water quality survey.

Site	Turbidity (NTU)	Total suspended solids (g/m^3)	*Escherichia coli* (cfu/100 mL)	Faecal coliforms (cfu/100 mL)
ORC "Good water quality"	**5**	-	**260**	-
Wether Burn at Athanaeum Rd	2.6 (1.7 - 3.6)	<3	**1,680 (100,4000)**	1,700 (130 - 4,000)
Manuherikia at Loop Rd	1.9 (0.67 - 2.5)	<3	23 (9 - 30)	23 (10 - 40)
Manuherikia u/s Ida Burn	**3.2 (1.1 - 9.1)**	5.1 (<3 - 16)	85 (20 - 230)	100 (30 - 260)
Lower Ida Burn	**5.9 (3.6 - 10)**	4.9 (<3 - 8)	**2,300 70 - 21,000)**	3,200 (70 - 23,000)
Lauder Creek at SH85	**6.7 (2.7 - 13)**	10 (5 - 21)	**730 (150 - 1,800)**	760 (170 - 2,400)
Manuherikia at Omakau	**3.5 (1.0 - 9.6)**	4.6 (<3 - 14)	120 (40 - 260)	150 (40 - 270)
Thompson Creek	**21 (3.6 - 69)**	50 (4 - 179)	**690 (100 - 21,000)**	890 (160 - 23,000)
Manuherikia u/s Chatto Creek	**4.9 (0.97 - 13)**	7.8 (<3 - 22)	**210 (110 - 1,000)**	250 (140 - 1,000)

Notes: Except for bacteria, mean data presented (range in parentheses), bacteria data are medians; n=4. Data marked in red and bold indicate historical averages greater than ORC "Good Quality Water" Limit. Data marked in blue is marginal with respect to limits.

Table B-5: Summary of ORC monitoring data for key water quality parameters

Waterway	Site	Ammoniacal-N	DRP	*E. coli* (MPN)	Nitrate + nitrite#	Turbidity (NTU)
Manuherikia	Blackstone Hill	0.012 ± 0.0017	0.0065 ± 0.0019	63 ± 22	0.018 ± 0.0066	**3.2 ± 1.5**
	Ophir	0.012 ± 0.0011	**0.018 ± 0.0038**	**190 ± 82**	**0.078 ± 0.028**	**6.9 ± 2.8**
	Galloway	0.012 ± 0.0013	**0.014 ± 0.002**	**260 ± 140**	**0.058 ± 0.018**	**6.9 ± 3.0**
Dunstan Creek	Beattie Road	0.011 ± 0.00068	0.0043 ± 0.0014	51 ± 28	0.039 ± 0.012	1.1 ± 0.26
Ida Burn	SH85	0.01 ± 0	0.0068 ± 0.002	53 ± 35	0.012 ± 0.0059	1.1 ± 0.98
	Auripo Rd	0.013 ± 0.0018	**0.035 ± 0.012**	**570 ± 320**	0.048 ± 0.024	**3.8 ± 1.7**
Pool Burn	Auripo Road	0.022 ± 0.018	**0.054 ± 0.013**	**200 ± 180**	0.046 ± 0.026	2 ± 1
ORC Plan Change 6A "Good Quality Water" Limits		**0.10**	**0.01**	**260***	**0.075**	**5**

Notes: Except where indicated otherwise, all units g/m^3. Data marked in red and bold indicate historical averages greater than ORC "Good Quality Water" Limit. Data marked in blue is marginal with respect to limits. *Limit as stated is for cfu (coliform forming units), not MPN (most probable number). #As nitrogen. DRP – dissolved reactive phosphorus.

The ORC regularly collects samples for water quality analysis from seven sites within the Manuherikia catchment, all downstream of Falls Dam. The locations of these sites are marked on Figure B-8. Three sites are on the main stem of the Manuherikia, and four are on major tributaries into the main stem. A summary of the data measured is provided in Table B-5, and compared, where available, to the “Good Quality Water” limits identified in the “Regional Plan: Water for Otago”.

In general, the sampled waters are typical of inland streams in rural catchments and at altitude. Water temperatures reflect climate and thus range from near freezing in winter, to greater than 20 °C in summer. Suspended sediment concentrations and conductivity are generally low, but occasionally spike, most likely the product of large volumes of run-off entering the catchment’s waterways during rainfall events after prolonged dry periods.

Historical concentrations of nitrogen species (i.e., ammoniacal nitrogen, nitrite and nitrate) are relatively low throughout the catchment, although concentrations of nitrate and nitrite approach the Regional Plan: Water for Otago (Plan Change 6A) limit in the lower part of the Manuherikia. Similarly, for the other three key parameters, the water quality of the upper catchment is better than that of the lower catchment. In particular, sites in the lower catchment contain concentrations of dissolved reactive phosphorus typically elevated above the ORC “Good Quality Water” limit, and relatively high turbidity.

It should be noted water quality limits identified in the Regional Plan: Water for Otago are intended to represent the upper 80th percentile value of data collected over five years, not averages, and only during periods of median or lower flows. Thus, comparison of these values with the historical data for the catchment is provided for context, rather than an assessment off compliance.

In the 2007 Otago Regional Councils State of the Environment (SOE) Report, ORC described the overall water quality in the Manuherikia catchment as “generally good” (ORC 2011). This is considered to be at least in part due to the existing low intensity farming practices in the catchment (ORC 2011).

More recently (2009 – 2010) and partially in response to the increasing likelihood for farming to intensify, the ORC initiated a sampling program specifically aimed at describing the current state of ecological health and water quality in the Manuherikia catchment. Thus, as part of this sampling program water was collected and analysed for a range of physical, chemical and microbial parameters, fortnightly from 17 stream sites throughout the catchment (Figure B-8).

The ORC findings and conclusions from their investigation (ORC 2011) were:

- Water quality results showed that overall the Manuherikia River main stem had ‘good’ water quality, with a change from ‘excellent’ water quality at the top of the catchment (at Loop Road), to ‘good’ at the bottom, (at Galloway).
- There were some tributaries of the main stem of the river that had degraded water quality during periods of low flow, and which was probably caused by run-off from irrigated pasture.
- Nitrogen was well below effects-based guideline values (Biggs 2000), especially during the high risk summer period when streams flows were low when algae can bloom to nuisance levels. Analysis suggests this catchment is nitrogen limited which is currently preventing algal proliferation.
- If nitrogen (nitrate, nitrite, and ammonia) concentrations increase, the lack of flushing flows during the summer could make the Manuherikia catchment at high risk of an increase in potentially prolific algal growth.
- DRP concentrations were above the guideline value (particularly for low flows) in many of the tributaries of the Manuherikia River, which contributed to the increase in DRP in the lower part of the Manuherikia River.

- E. coli levels were low for the upper catchment sites (e.g., Loop Rd) and most of the Manuherikia main stem, with the exception of downstream of Ophir, which is influenced by high E coli levels from Thomsons Creek.
- Elevated E. coli levels in Dovedale Creek were probably the result of deer accessing the stream.
- Suspended solids concentrations were below the ORC plan change 6A limits.
- Elevated DRP, TP, TN and E. coli in the lower Thomsons Creek, Pool Burn and Lauder Creek sites are consistent with what is to be expected from runoff from flood irrigation systems. It is possible that DRP levels in the streams increase downstream because all the DRP flushed into the streams cannot be fully utilised by plant growth, due to low NNN concentrations limiting algal growth.
- Elevated E. coli, TP and DRP in the Manuherikia at Ophir during low flows are possibly due to contributions from Thomson's Creek.

In the most recent ORC SOE report (ORC 2012b) it was noted that total nitrogen, E. coli and turbidity have all shown overall increasing trends in the Manuherikia River (at Ophir) since sampling begun in 2006.

5.0 PERIPHYTON

Periphyton cover at the eight water quality monitoring sites was noted on each site visit and also at the fisheries survey sites to provide an assessment of periphyton abundance in the Manuherikia River and the tributaries at different times during the summer and autumn.

There is one site in the Manuherikia catchment (Manuherikia River at Blackstone Hill) that is part of the SOE monitoring programme undertaken by the ORC. Periphyton communities were sampled on four occasions in the Manuherikia River at Blackstone Hill between 2009 and 2013. Periphyton communities have also been sampled once in 2010 at two other sites within the catchment, Dunstan Creek at Beattie Road and Ida Burn at SH85.

During aquatic surveys undertaken in late 2010, the ORC found that the majority of sites sampled within the Manuherikia catchment only had a thin layer of algae present on the bed substrates.

The Golder surveys at fish sampling and water quality monitoring also found algal abundance was generally low and thin and medium thickness algal mats were the common algal community. The exception was to the Loop Road site on the Manuherikia River where algae formed a thick mat with some additional filamentous algal and the algal community extended across all wadeable areas of the river. Upstream of Falls Dam didymo was present in some areas and in Johnstone Creek formed large continuous thick mats.

The presence of didymo upstream of Falls Dam means all reaches of the Manuherikia River downstream of Falls Dam and any tributaries that receive water from Falls Dam will be exposed to didymo. Local stream conditions will control the extent to which didymo growths are apparent.

The Manuherikia River downstream of the Dunstan Creek confluence had patchy algal communities. The most notable observation was the occurrence of medium to thick black mats at the Omakau Ophir bridge site. These mats covered less than 10 % of the river bed but were noteworthy as the algal is potentially the blue-green algae Phormidium that can at times release toxins to the water.

Periphyton taxa recorded at ORC sampling sites at Blackstone Hill (Table B-6) and in Dunstan Creek and Ida Burn (Table B-7).

Table B-6: Periphyton taxa and coded abundance recorded in the Manuherikia River at Blackstone Hill on four occasions.

	Year sampled			
Taxa	**2009**	**2011**	**2012**	**2013**
Filamentous Green Algae				
Cladophora		1		
Rhizoclonium			1	
Filamentous Red Algae				
Audouinella		2	3	
Cyanobacteria				
Nostoc				2
Oscillatoria			1	
Rivularia			2	
Diatoms				
Cymbella				1
Didymosphenia germinata	2			3
Epithemia				2
Frustulia	3			1
Gomphoneis	4		2	
Gomphonema				4
Hantzschia		1		
Melosira		2	3	3
Naviculoid	4			
Rhopalodia				2
Stauroneis	3			
Synedra		1		
Tabellaria	5			
Phytoplankton				
Asterionella	5			
Cosmarium	1			
Scenedesmus	1			

Note: Data provided by ORC. No sampling was undertaken in 2010. Coded abundance where 1 = rare, 2 = rare-occasional, 3 = occasional, 4 = occasional-common, 5 = common, 6 = common-abundant, 7 = abundant, 8 = dominant, after Biggs and Kilroy (2000).

Table B-7: Periphyton taxa and coded abundance recorded in Dunstan Creek and Ida Burn in 2010.

Taxa	Dunstan Ck at Beattie Rd	Ida Burn at SH85
GREEN FILAMENTS		
Bulbochaete spp.		3
Microspora spp.	8	7
Mougeotia spp.		3
Oedogonium sp.		3
Spirogyra spp.		3
GREEN (NON-FILAMENTOUS)		
Ankistrodesmus spp	2	2
Cosmarium spp.	2	2
Pediastrum spp.		2
Scenedesmus spp.	2	
DIATOMS		
Achnanthidium spp. (small)	3	4
Brachysira spp.	2	
Cocconeis placentula	5	1
Cymbella aspera	1	1
Cymbella kappii		6
Cymbella cf. *tumida*	1	
Diatoma hiemale	2	
Didymosphenia geminata	3	
Encyonema cf. *minutum*	5	4
Epithemia sorex		4
Fragilaria spp. (small. cf. *vaucheriae*)	5	4
Frustulia vulgaris		2
Gomphoneis minuta var. *cassieae*	3	4
Gomphonema cf. *minutum* (15 µm)	4	4
Gomphonema cf. *parvulum*	6	
Gomphonema cf. *berggrenii?*		4
Gomphonema spp. (small)	2	
Melosira varians	4	
Meridion circulare	1	
Navicula cf. *margilithi*	3	
Navicula cf. *gregaria*		3
Nitzschia acicularis	1	
Nitzschia spp.(small)	3	
Nitzschia (skinny) 20 - 30x5µm		4

Taxa	Dunstan Ck at Beattie Rd	Ida Burn at SH85
Nitzschia cf. *linearis*		1
Pinnularia cf. *viridis*		3
Pinnularia cf. *subcapitata*		1
Rhopalodia novae-zealandiae		2
Rossithidium linearis		3
Synedra ulna cf. *ramesi*	6	
Synedra spp. cf. *rumpens*		2
Tabellaria flocculosa	1	4
CYANOBACTERIA		
cf. *Phormidium* spp.	4	8

Note: Data provided by ORC. Coded abundance where: 1 = rare, 2 = rare-occasional, 3 = occasional, 4 = occasional-common, 5 = common, 6 = common-abundant, 7 = abundant, 8 = dominant, after Biggs and Kilroy (2000).

6.0 AQUATIC MACROINVERTEBRATES

6.1 Introduction

The following ecological indices were calculated from macroinvertebrate data and used to assist in the assessment of stream health of each site.

- **Macroinvertebrate abundance** measures the total number, or density of individuals found in each sample. The number is presented as the mean number of individuals per 0.1 m^2. Abundance can be a useful measure for comparison between sites but can also be highly variable.
- **Taxa richness** is the number of macroinvertebrate taxa (e.g., species, genera, families) present in each sample (expressed per unit area of river bed sampled). In general, a stream which has a diverse range of habitat and/or high water quality will support a variety of different taxa, and numbers recorded will be higher. However, one issue with taxa richness is that higher taxa richness does not always automatically equal ‘better’, and can occur in streams that are slightly enriched (e.g., from farmland runoff), rather than in streams that are in ‘pristine’ condition. Benthic macroinvertebrate taxa richness can also be influenced by flow regime, for example, taxa richness is often reduced immediately following high flow events.
- **Macroinvertebrate Community Index (MCI)** is an assessment of the water quality within a stream using benthic macroinvertebrates (Stark 1985). The MCI is a presence/absence based index score approach and can be used to describe the ‘health’ of a stream using the formula:

$$MCI = 20\sum \frac{a_i}{S}$$

Where: a_i = the sum of individual taxon scores in a sample, S = total number of taxa.

- **Quantitative Macroinvertebrate Community Index (QMCI)** is similar to the MCI but utilises quantitative data (Stark 1985, 1993). The QMCI is based on the relative sensitivity of different taxa in a sample to changes in water quality. The QMCI is designed to be particularly sensitive to changes in the relative abundance of individual taxa within a community. The QMCI is calculated as follows:

$$QMCI = \sum \frac{(n_i a_i)}{N}$$

Where: a_i = the sum of individual taxon scores in a sample, n_i = the number of individuals in the *ith* taxon and N = total number of individuals

The MCI and QMCI were designed to detect organic pollution in waterways, and are based on scores between 1 and 10 assigned to each taxon, with low scores indicating high tolerance to organic pollution and high scores indicating low tolerance to organic pollution. Using the equations above, the MCI and QMCI values are calculated, with higher scores indicating higher water quality (Stark 1993). Scores for all replicate samples collected were averaged and interpreted in the context of national guidelines for water and habitat quality (Table B-8).

Table B-8: Interpretation of MCI and QMCI biotic index values.

Water Quality Class	Description	MCI	QMCI
Excellent	Clean water	>120	>6
Good	Doubtful quality or possible mild degradation	100 - 120	5 – 6
Fair	Probable moderate degradation	80 – 100	4 – 5
Poor	Probable severe degradation	<80	<4

Note: Water quality classes after Stark & Maxted (2007) and descriptions after Stark (1998).

6.2 2014 macroinvertebrate samples

Macroinvertebrates were sampled at the eight water quality monitoring sits and two additional sites in the upper reaches of the water quality monitoring tributaries (Thompsons Creek and Lauder Creek) on 17 - 18 March 2014. At each site three Surber samples (500 µm; 0.1 m^2) were collected from each site from riffle habitats as these are generally the most productive. Macroinvertebrates were identified and counted to a level suitable for calculating standard macroinvertebrate indices used for assessing stream ecological health by following protocols outlined in Stark et al. (2001).

The macroinvertebrates communities at most sites were dominated by mayflies (*Deleatidium*) and caddis flies (e.g., *Aoteaphyche, Pycnocentria* or *Hudsonema*), true flies (Orthocladiinae and Tanytarsini) and oligochates (worms) (see Appendix D). Macroinvertebrate abundance ranged from 8 individuals / m^2 to 1,162 individuals / m^2 (Figure B-9). Thompson Creek u/s was considered atypical and it was thought this site had only recently been rewetted after a dry period in the summer.

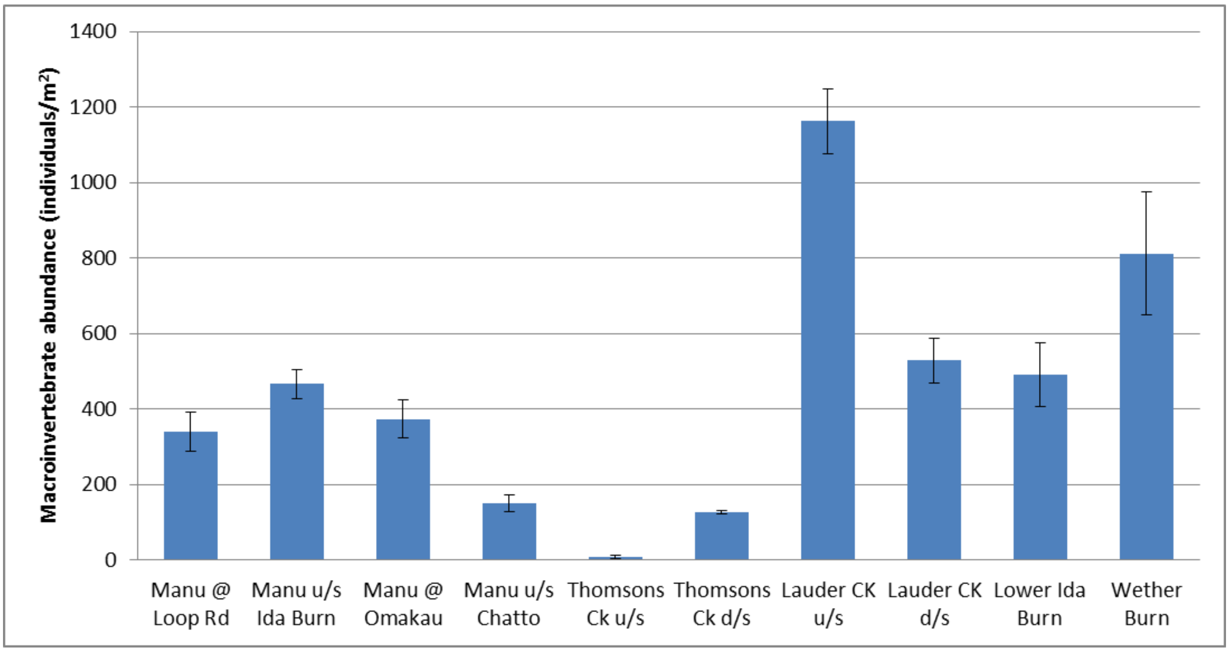


Figure B-9: Macroinvertebrate abundance (±1 standard error) at sites in the Manuherikia study area.

The mean number of taxa present at the sample sites ranged from 4.5 to 23.3 taxa (Figure B-10). Again Thomson Creek U/s was an outlier having a low taxa count. MCI scores range from 68.3 to 104 with tributary sites generally having a lower MCI score than the main stem of the Manuherikia River (Figure B-11). The upper Thomson Creek site again has the lowest score, and the downstream Thompson Creek and the lower Ida Burn also having MCI scores that indicate poorer water quality. The MCI score for the Manuherikia River at Loop Road is lower than the sites further downstream and this is attributed to the high algal biomass at this site leading to a degraded macroinvertebrate community.

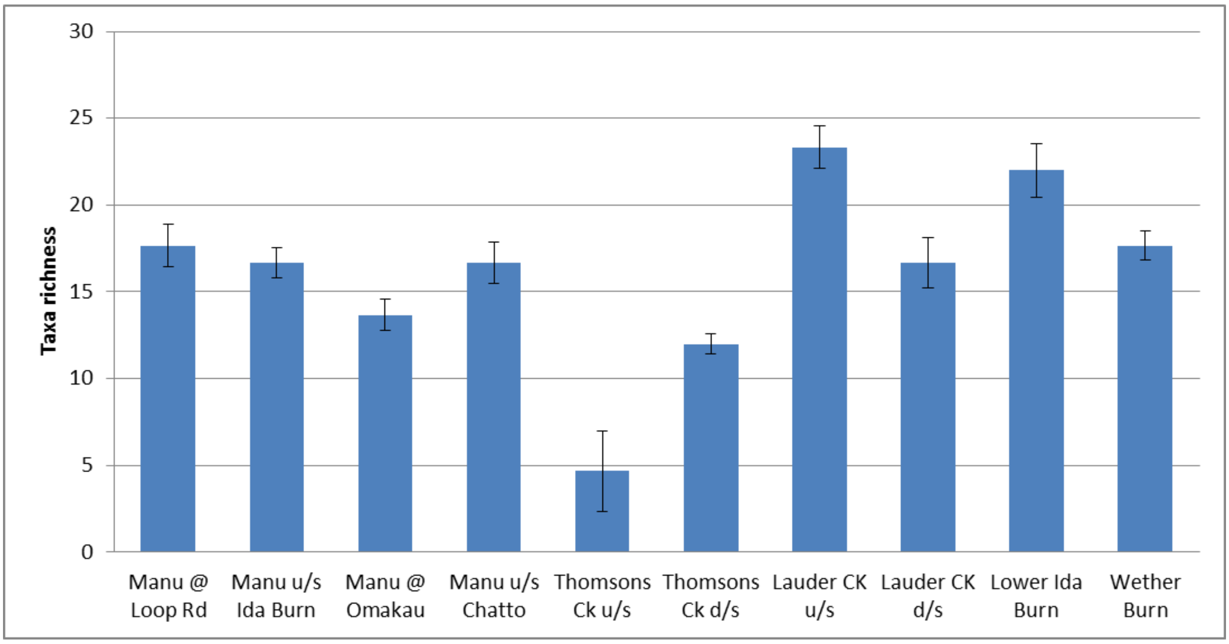


Figure B-10: Macroinvertebrate taxa richness (±1 standard error) at sites in the Manuherikia study area.

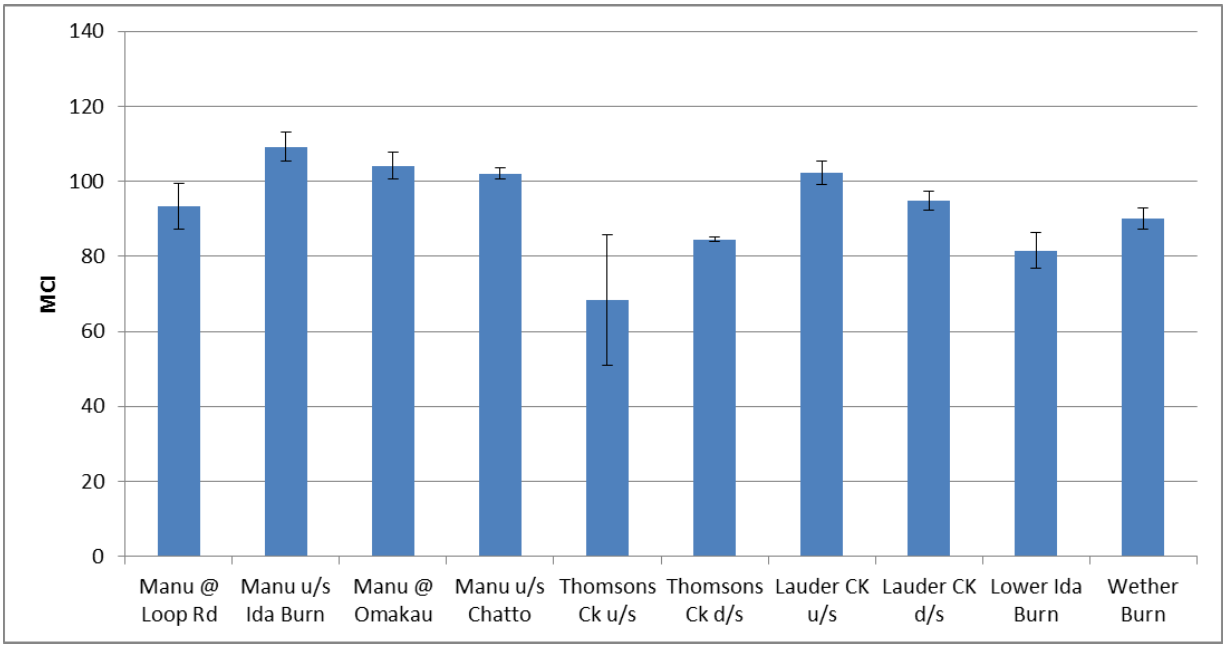


Figure B-11: MCI scores (±1 standard error) at sites in the Manuherikia study area.

The QMCI scores (Figure B-12) for the sites differ to the MCI scores in that a number of tributary sites including the Lauder Creek sites, lower Thomson Creek and Whether Burn scores indicate good water quality. However, upper Thomson Creek and lower Ida Burn and the Manuherikia River at Loop Road continue to score poorly.

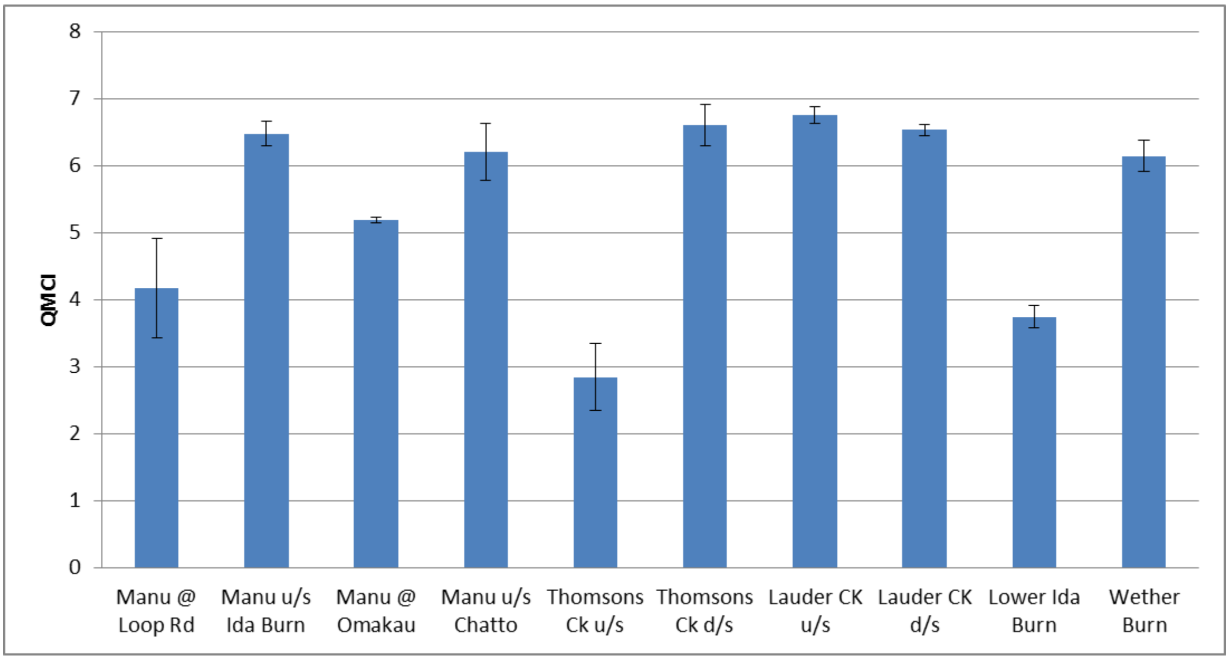


Figure B-12: QMCI scores (±1 standard error) at sites in the Manuherikia study area.

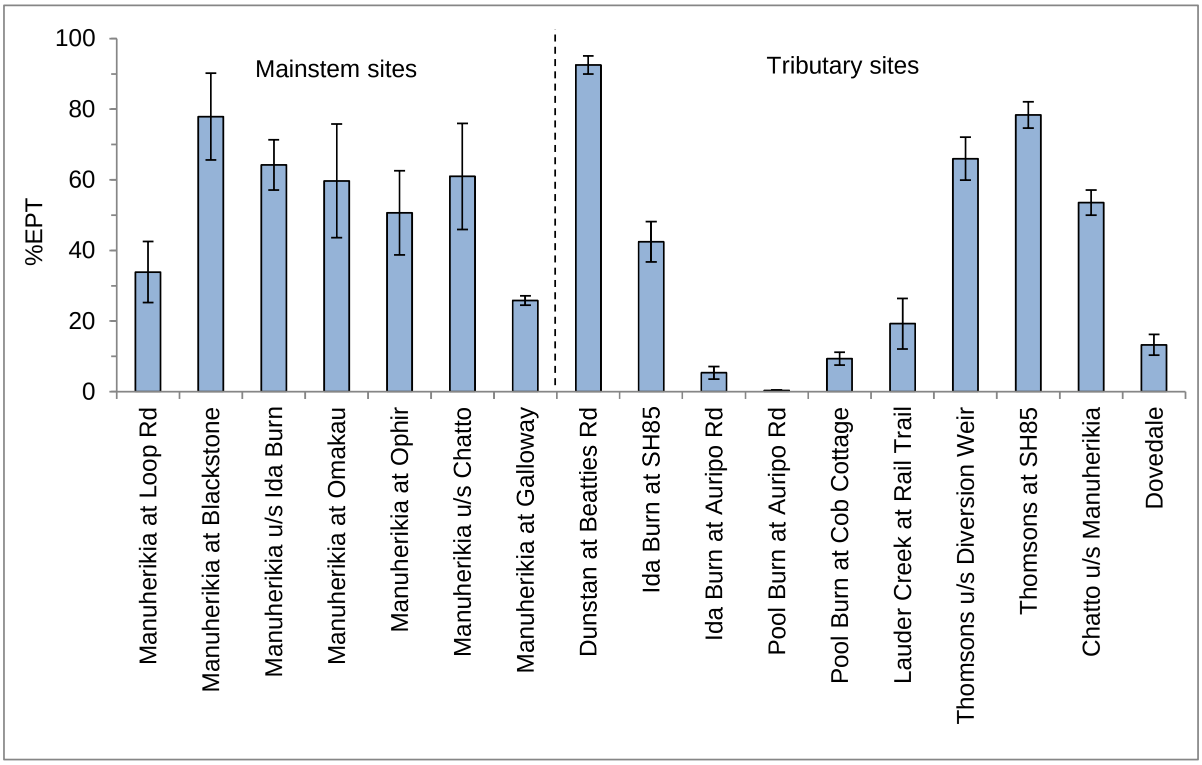
6.3 Historic Manuherikia macroinvertebrate surveys

As mentioned above, the ORC monitor one site in the Manuherikia Catchment (i.e., Manuherikia River at Blackstone Hill) annually since 2009 as part of the State of the Environment (SOE) monitoring programme. Additional sampling was conducted by the ORC in the Manuherikia catchment at 17 stream sites under baseflow conditions in December 2010. No invertebrate sampling appears to have been conducted in the upper Manuherikia River upstream of Falls Dam.

In 2010, the percentage of the macroinvertebrate community consisting of sensitive Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa was highly variable between sampling sites. Some of the more upstream sampling sites had the highest EPT percentages and include Dunstan Creek at Beatties Road (92 %EPT), followed by Thomsons Creek lower (78 %EPT) and Manuherikia River at Blackstone (78 %EPT) (Figure B-13). The lowest EPT percentage (0.4 %) was recorded in the Pool Burn upper site. ORC control sites on Lower Ida Burn and Dovedale Creek had macroinvertebrate communities consisting of 42 % and 13 % EPT, respectively.

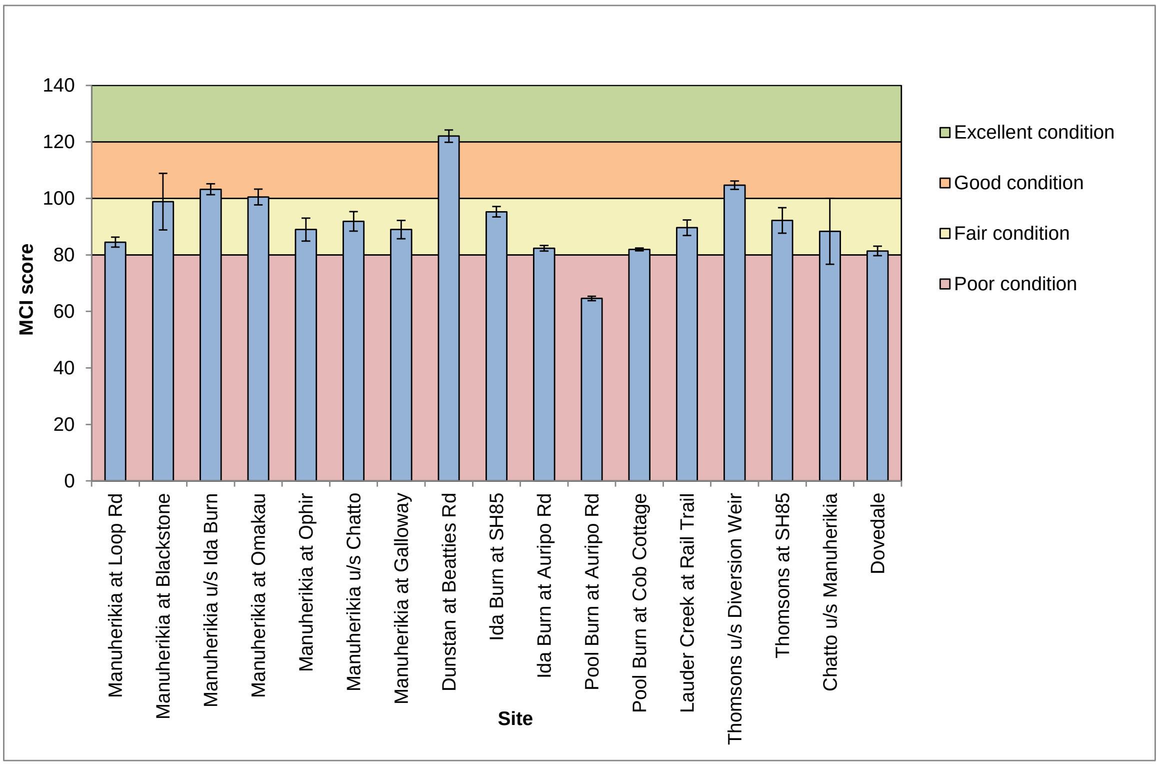
Mean macroinvertebrate Community Index (MCI) scores recorded in 2010 were highest in Dunstan Creek at Beatties Road, which was the only site to achieve a MCI score >120 and was indicative of "excellent" instream habitat or water quality conditions (Figure B-14). The macroinvertebrate community in Dunstan Creek at Beattie Road was dominated by sensitive taxa primarily the mayfly *Deleatidium*, and cased caddisflies (especially *Pycnocentrodes* and *Olinga* species). The Pool Burn upper site (at Auripo Road) was the only site that had a mean MCI score that was indicative of 'poor' instream habitat or water quality conditions. Upper Pool Burn was dominated by tolerant taxa in particular worms and snails (*Potamopyrgus antipodarum*). Manuherikia upstream of the Ida Burn confluence and the upstream Thomsons Creek site (upstream of diversion weir) had MCI scores in the 'good' category, while the remaining sites fell into the 'fair' category. These latter sites were dominated by the cased caddisfly *Pycnocentrodes* and the mayfly *Deleatidium*.

Quantitative Macroinvertebrate Community Index (QMCI) scores recorded during the ORC survey in 2010 were highest in Dunstan Creek at Beatties Road, which was classified as being in 'excellent' condition and is not surprising given that this site had the highest percentage of sensitive EPT present (Figure B-13; Figure B-15). This was followed by Chatto Creek and the Manuherikia at Blackstone, which had QMCI scores categorising them as being in 'good' condition. The two sampling sites on Thomsons Creek were also classified as being indicative of 'good' habitat or water quality. The downstream Ida Burn site at Auripo Road achieved the lowest QMCI score, followed by the upstream Pool Burn site, also at Auripo Road. Overall, out of the 17 sites sampled in the Manhuherikia Catchment, a total of eight sites had mean QMCI scores <4 and were indicative of "poor" habitat and/or water quality (ORC 2011).



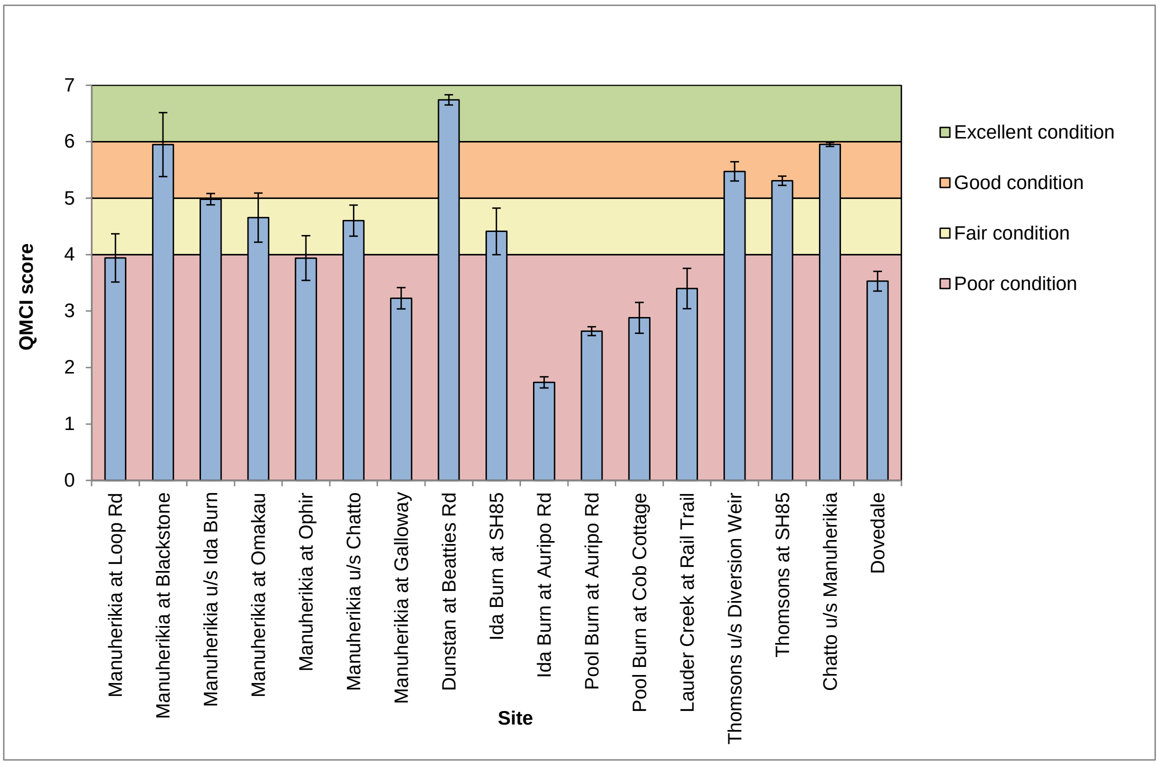
Note: Data provided by ORC.

Figure B-13: Mean (±1SE) %EPT recorded in the Manuherikia River mainstem and tributaries.



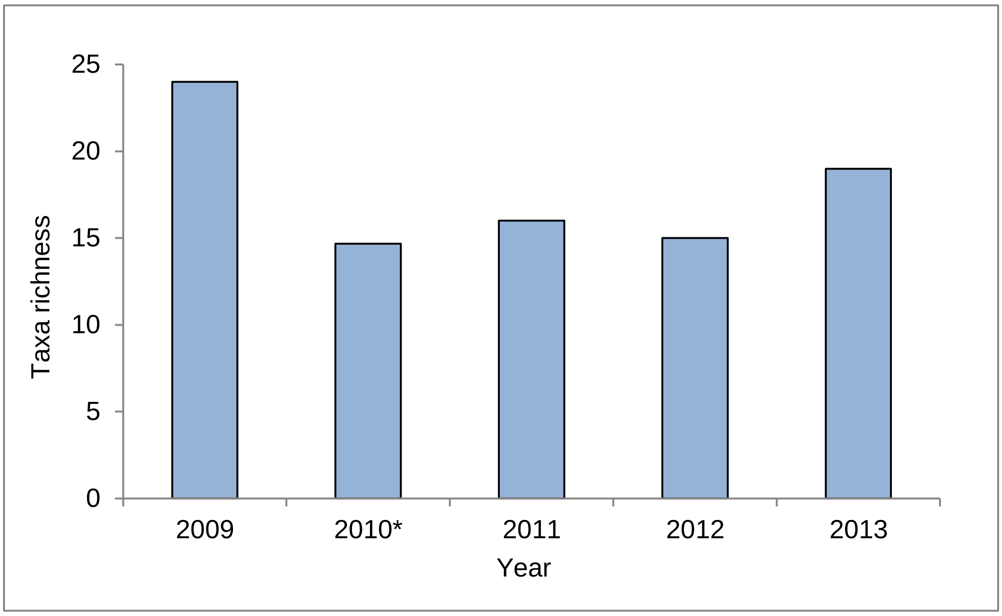
Note: Data provided by ORC.

Figure B-14: Mean MCI (±1SE) scores recorded in the Manuherikia River main stem and tributaries.



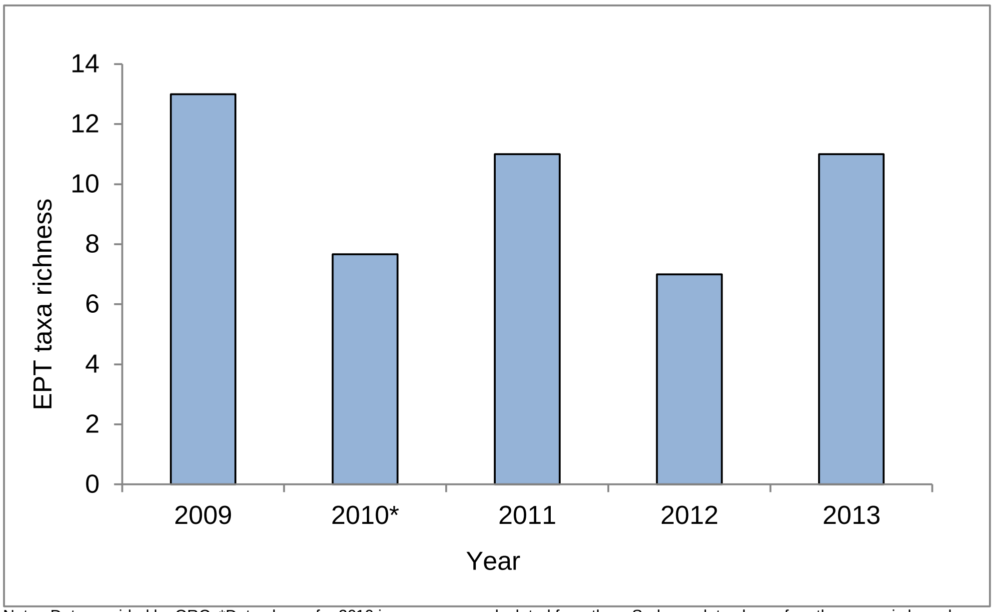
Note: Data provided by ORC.

Figure B-15: Mean QMCI (±1SE) scores recorded in the Manuherikia River mainstem and tributaries.



Note: Data provided by ORC. *Data shown for 2010 is an average calculated from three Surbers, data shown for other years is based on one kick-net sample.

Figure B-16: Taxa richness recorded in the Manuherikia River at Blackstone from 2009 - 2013.

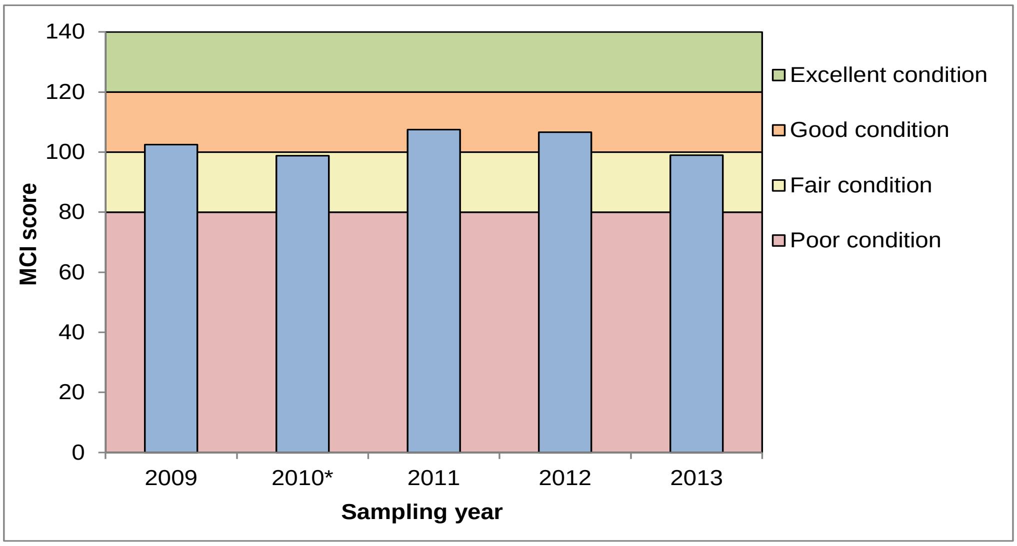


Note: Data provided by ORC. *Data shown for 2010 is an average calculated from three Surbers, data shown for other years is based on one kick-net sample. EPT richness excludes Hydroptilid caddisflies.

Figure B-17: EPT taxa richness recorded in the Manuherikia River at Blackstone from 2009 - 2013.

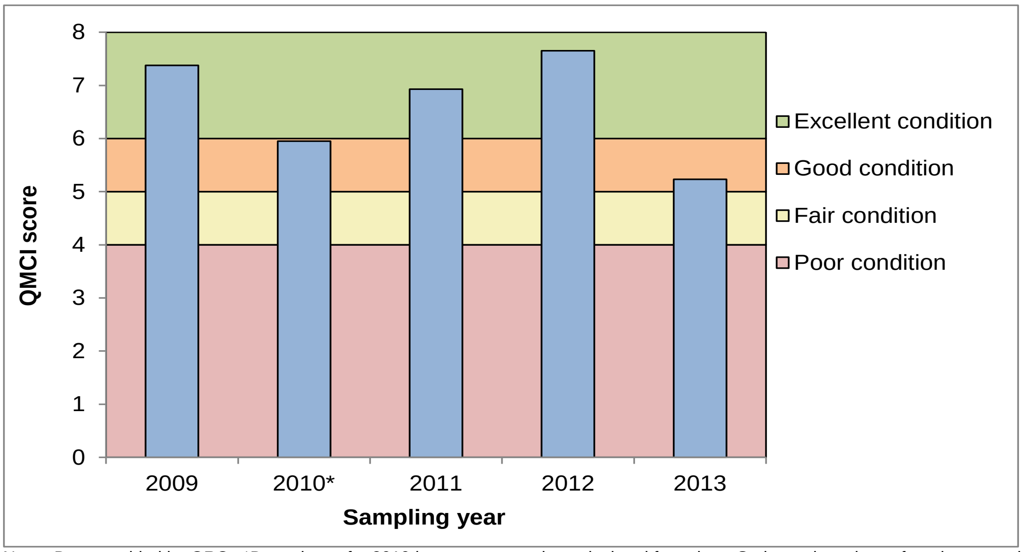
SQMCI scores recorded in the Manuherikia River at Blackstone Hill have ranged from 5.2 to 7.7, with scores being indicative of water and/or habitat quality in the “good” to “excellent” category (Figure B-19). SQMCI recorded in 2013 indicated a decline in “health” compared to previous years. However, this decline is likely to reflect the increased abundance of orthoclad midge larvae recorded in 2013. In previous years the mayfly *Deleatidium* was typically the most abundant and dominant species present. Notably, the presence of the invasive alga didymo was recorded in periphyton samples collected at this site in 2013, whilst didymo had not been recorded during surveys undertaken in the preceding two years.

Studies on the impact of didymo in waterways it invades have indicated that it can significantly alter the composition of benthic macroinvertebrate communities (Kilroy et al. 2009; Gillis & Chalifour 2010). For example, a recent New Zealand study found that the presence of didymo typically resulted in increases in algal biomass, increased macroinvertebrate abundances and shifted community composition from sensitive taxa to more tolerant taxa, such as oligochaetes and chironomid larvae (Kilroy et al. 2009).



Note: Data provided by ORC. *Data shown for 2010 is an average calculated from three Surbers, data shown for other years is based on one kick-net sample.

Figure B-18: MCI scores recorded in the Manuherikia River at Blackstone from 2009 - 2013. Water quality categories "Excellent – Poor" are also shown.



Note: Data provided by ORC. *Data shown for 2010 is an average value calculated from three Surbers, data shown for other years is based on one kick-net sample.

SQMCI scores calculated using coded abundance has been provided for all years, except for 2010 where a QMCI score based on count data has been provided.

Figure B-19: SQMCI scores recorded in the Manuherikia River at Blackstone from 2009 - 2013. Water quality categories "Excellent – Poor" are also shown

6.4 Macroinvertebrate species of potential conservation interest

The largest macroinvertebrate that is known to be present in the Manuherikia catchment is the freshwater crayfish or koura (*Paranephrops zealandicus*). However, koura are restricted to a few sites in the Pool Burn sub-catchment and a short reach of the Ida Burn. No koura have been reported from the streams in the Manuherikia Valley (see Figure D6 in Appendix D) and none were observed during Golder field investigations. Koura has been classified as being in a declining species by the Department of Conservation (Grainger et al 2014).

6.5 Summary of Macroinvertebrate Monitoring

Macroinvertebrate taxa richness recorded in the Manuherikia River at Blackstone Hill between late 2009 and late 2013 has ranged from 15 taxa to 24 taxa (Figure B-16). The number of “pollution-sensitive” Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa has varied between years, ranging from 7 EPT taxa to 13 EPT taxa, and consequently there has been no clear trend in either increasing or decreasing EPT taxa richness over time (Figure B-17).

MCI scores recorded over time have ranged from 99 to 108 and have been indicative of “fair” to “good” water and / or habitat quality (Figure B-18).

The macroinvertebrate indices determined from samples collected in 2014 indicate that tributary sites are more likely to indicate water and/or habitat quality issues are present.

7.0 FISH

Fisheries surveys were undertaken using an EFM300 back-pack electric fishing machine. Reaches were fished using a single pass along 20 - 50 m of the stream. Fishing was conducted in a downstream direction fishing towards a 1.5 m wide pole net. All fish caught were retained, identified and measured before being released back to the stream when fishing was completed.

In the upper Manuherikia River above Falls Dam three transects where fished across the braided river with all braids / channels large enough to fish being sampled. At the Mt Ida dam site streams in the inundation area where sampled in the upper reaches of the inundation area and at sites close to the proposed dam site. A further 18 sites, including the water quality monitoring sites, were fished in streams around the Manuherikia and Ida Valleys sampling fish faunas of the streams in the irrigation command areas. Particular attention was made to sample areas where threatened fish species had previously been reported to confirm the current state of populations.

The Manuherikia River supports a total of 11 fish species (Table 9, (NZFFD; ORC records). Currently five of these species are classified as threatened (Goodman et al 2014) including the Clutha flathead that is ranking 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 (see Appendix D for distribution maps). Data from Golder Fisheries surveys is provided in Table 10.

Table 9: Fish species present within the Manuherikia catchment (Sources: New Zealand Freshwater Fish Database, ORC records and Fish & Game Otago records).

Common name	Species name	DOC threat classification*
Clutha flathead	*Galaxias* SpD	Nationally critical
Alpine galaxiid	*Galaxias paucispondylus* aff. *manuherikia*	Nationally endangered
Central Otago roundhead galaxiid	*Galaxias anomalus*	Nationally endangered
Longfin eel	*Anguilla dieffenbachii*	Declining
Koaro	*Galaxias brevipinnis*	Declining
Common bully	*Gobiomorphus cotidianus*	Not threatened
Upland bully	*Gobiomorphus breviceps*	Not threatened
Rainbow trout	*Oncorhynchus mykiss*	Introduced and naturalised
Brown trout	*Salmo trutta*	Introduced and naturalised
Brook char	*Salvelinus fontinalis*	Introduced and naturalised
Perch	*Perca fluviatilis*	Introduced and naturalised

Note: *threat rankings from Goodman et al (2014).

The most widespread fish in the Manuherikia catchment is the introduced species, brown trout (*Salmo trutta*) and the most widespread native fish is the upland bully (*Gobiomorphus breviceps*). It is also understood that the common bully (*Gobiomorphus cotidianus*), while a native species, has been introduced to many Central Otago reservoirs generally as forage food and bait fish for the trout fisheries.

Table 10: Fishing data.

Site	Location NZTM Easting, Northing	Date	Area Fished (≈ m^2)	Species	No of fish	Length (mm)	Comment
1	Johnstones Creek 1356400:5027700	12/02/14	160	Brown Trout	17	60 - 250	
				Upland Bully	16	30 - 75	
2	Manuherikia braid 1350549:5028752	12/02/14	60	Brown Trout	45	60 - 145	1 individual greater than 100 mm
				Upland Bully	1	57	
3	Manuherikia braid 1356492:5028756	12/02/14	7.5	Brown Trout	3	100 - 200	
				Upland Bully	50	20 - 80	mainly small juveniles
4	Manuherikia braid 1356437:5028742	12/02/14	160	Brown Trout	11	62 - 85	
				Upland Bully	7	20 - 80	many larval fish
				Manu alpine	1	47	
5	Manuherikia braid 1356308:5028729	12/02/14	60	Brown Trout	10	60 - 180	large trout in side pools
				Upland Bully	8	20 - 80	
				Manu alpine	1	54	
6	Manuherikia braid 1356598:5030828	12/02/14	20	Brown Trout	8	52 - 90	recently cut channel
				Upland Bully	5	40 - 76	
				Manu alpine	12	42 - 50	
7	Manuherikia braid 1356600:5030830	12/02/14		Brown Trout	5	70 - 85	
				Upland Bully			
				Manu alpine	17	46 -77	
8	Manuherikia braid 1356791:5032000	14/02/14	20	Brown Trout	1	145	
				Upland Bully	2	55 - 57	
				Manu alpine	24	58 - 95	
9	Manuherikia braid 1356700:5032100	14/02/14	60	Brown Trout	7	54 -1 84	
				Upland Bully	3	44 - 50	
				Brook char	2	181 - 210	
10	Manuherikia braid 1356300:5032100	14/02/14		Brown Trout	5	75 - 87	
				Upland Bully	9	53 - 81	
11	Moa Creek at Webster Lane 1337050:4988956	16/04/14	40	CO roundhead	21	37 - 61	intermittent reach, pools, no flow during survey
12	Wedder Burn at Anthearum road 1363565:5007194	17/04/14		Brown trout	2	87 - 107	
13	Hills Creek 1356503:5018556	17/04/14		undi Salmonid	2	180150	
				brown trout	4	158 - 224	
14	Ida Burn at Auripo Rd 1344993:5004829	17/04/14		Co roundhead	6	60 - 72	
15	Spain Creek at Auripo Rd 1344689:5004555	17/04/14		nil			
16	Maori Creek 1340903:4990520	17/04/14		nil			
17	Un-named stream A 1332816:5000142	17/04/14		nil			

Site	Location NZTM Easting, Northing	Date	Area Fished (≈ m²)	Species	No of fish	Length (mm)	Comment
18	Un-named stream B 1332855:5000074	17/04/14		nil			
19	Thompson off Gorge Rd 1330008:5012084	15/04/14		nil			
20	Cemetery Creek 1333285:5003745	15/04/14		nil			
21	Thompson at Donnohy Rd 1331769:5002541	15/04/14		upland bully	22	19 - 90	
				longfin eel	1	700	observed not caught
				undi Salmonid	2	140, 120	
22	Trib of Thompson Creek off Clausen Rd 1329961:5003053	15/04/14		nil			
23	Young Hill Creek 1322200:4997739	15/04/14		nil			
24	Chatto at Disputed Spurs Rd 1325833:5003934	15/04/14		Upland Bully	28	30 - 68	
25	Un-named trib Thompson Creek 1332638:5005767	15/04/14		nil			
26	Hills Creek u/s Gorge Creek 1356848:5012605	16/04/14		nil			
27	Lauder Creek u/s Beck's School Rd 1338852:5012821	16/04/14		longfin eel	2	400	second underbank not seen
				Upland Bully	12	30 - 77	
28	Dunstan Creek at Loop Rd 1346622:5026152	16/04/14		Rainbow Trout	9	80 - 117	
				Upland bully	8	34 - 80	
				CO roundhead	11	53 - 77	10 CORGs in tributary, 1 in Dunstan Creek
29	Dunstan Creek at Barkers Rd 1344762:5018661	16/04/14		Rainbow Trout	3	100 - 123	
				Upland bully	13	33 - 86	
				CO roundhead	4	53 - 58	
30	Pool Burn at Rutherford Lane 1338646:4994583	16/04/14		nil			Eels observed by farmer (years ago??)
31	Ida Burn 1366064:5015475	13/02/13		brook char	1	138	stream with little flow, isolated pools and flowing sections
32	Ida Burn 1365125:5016085	13/02/13					dry grassy channel
33	Ida Burn 1364895:5016106	13/02/13					dry grassy channel
34	Ida Burn	13/02/13		brook char	common		spot fishing along 300 m of stream inluding inflowing very small tribs, main trib and Ida Burn main channel, only just got continuous flow
				Brown trout	common		

8.0 AQUATIC HABITAT MODELLING

Aquatic habitat models are used to assess the change in habitat available to fish, aquatic invertebrates and algal as flow changes in a reach river. Any habitat modelling process and flow setting decision requires information on the physical habitat in the river (e.g., water depth, water velocity, stream width, stream bed substrate) and how these parameters change with change in flow. Flow setting also requires information on river flow preferably over a period of years so that flow statistics such as mean flow and the 7 day mean annual low flow (7dMALF) have been calculated from sufficient data to have robust estimates.

The most common habitat modelling process used in New Zealand is the River Hydraulics and Habitat Simulation program (RHYHABSIM) (Jowett 2010). This method creates habitat models for reaches of a river that have similar habitat characteristics. For instance a model can be developed for a gentle gradient reach with runs, riffles and pools but this cannot be used to model habitat in a higher gradient gorge with rapids and plunge pools. It should also be noted that while this model is commonly used in New Zealand, other flow setting process are available and there is considerable debate on the use of models and methods for flow setting (e.g., Hudson et al. 2003).

For the Manuherikia River two RHYHABSIM models are available to assess the changes in aquatic habitat with changes in flow. Jowett & Wilding (2003) developed a model for the lower Manuherikia River at Galloway and Golder (2008) developed a model for Dunstan Creek. Both models have been developed on gentle gradient reaches with riffle run pool habitat and stream bed substrates dominated by cobble and gravel. These models are appropriate for the majority of the Manuherikia River as this is predominately a cobble gravel bed river. These models cannot be used to assess habitat availability in the gorge sections of the Manuherikia River. The ORC has been collecting flow data for the main stem of the Manuherikia River and good estimates of mean flow and 7dMALF are available. This data does need to be correct to account for irrigation abstractions and additions to the Manuherikia River to change the measured flows to natural flows.

For the tributaries of the Manuherikia River (except Dunstan Creek) limited flow data is available and no habitat models have been developed.

APPENDIX C

Assessment of Effects on River Birds (Wildlands 2015)

ASSESSMENT OF EFFECTS ON RIVER BIRDS OF INCREASING THE HEIGHT OF FALLS DAM, MANUHERIKIA RIVER, CENTRAL OTAGO

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R3510a

Assessment of effects on river birds of increasing the height of Falls Dam, Manuherikia River, Central Otago

Contract Report No. 3510

January 2015

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1. INTRODUCTION

The Manuherikia River is a tributary of the Clutha River/Mata-Au, which it joins at Alexandra. The river, hereafter referred to as the Manuherikia, has a braided section in its upper reaches which runs in a southerly direction between the St Bathans Range and the Hawkdun Range. This braided reach, approximately 11 km in length, stops at the lake formed by Falls Dam. The dam was built in 1935 as part of a wider irrigation scheme to provide water to the wider Manuherikia catchment downstream of the dam (LAWA 2014).

A historical report described wrybill *Anarhynchus frontalis* (Threatened-Nationally Vulnerable) as a regular visitor to the upper Manuherikia, and also recorded the presence of black stilt (Threatened-Nationally Critical; McEwen 1987). Recent surveys indicate that a further three threatened bird species breed regularly on the river; black-billed gull *Larus bulleri* (Threatened-Nationally Critical), black-fronted tern *Chlidonias albostriatus* (Threatened-Nationally Endangered), and banded dotterel *Charadrius bicinctus bicinctus* (Threatened-Nationally Vulnerable; Wildland Consultants 2010, 2011, 2012).

Investigations are underway to evaluate various potential projects to increase the irrigation capacity within the Manuherikia catchment. Most of these relate to increasing the height of Falls Dam. Wildland Consultants has been commissioned to undertake a further river bird survey of the Manuherikia, and assess potential effects on the river bird community of increasing the height of Falls Dam by 27 m (the scenario whereby the height of Falls Dam would be raised by the greatest amount).

Under this scenario, modelling indicates that the lake will extend a further 2.64 km upstream from its present maximum extent. This equates to a potential maximum loss of 24.3% of existing riverbed habitat.

2. METHODS

In 2010, three river bird surveys were carried out in the period late October to early November, approximately one week apart: 24 October, and 8 and 19 November. In 2011, flooding postponed surveys, and resulted in only two surveys being undertaken on 14 November and 1 December. In 2012, a single survey was undertaken on 30 October (Wildland Consultants 2012). In 2014, a single survey was undertaken on 17 October.

Approximately 10.5-11.0 km of river was surveyed in each survey, from upstream of Falls Dam to the point where the river valley narrows and the river becomes a single channel. In 2010-2012, only a small section of the river could be walked, due to access issues. The remainder of the river was observed using a spotting scope from the road, which varies from 50 to 400 m from the river. In 2014, the riverbed was able to be accessed but high flow levels permitted only limited river crossings.

Weather during the surveys in 2010, 2011 and 2012 was fine and warm, but with heat haze which may have decreased long range visibility. Northwest gales affected the 2014 survey, making the use of binoculars and spotting scope somewhat difficult.

3. SURVEY RESULTS

Overview

In 2010 and 2011 the same fourteen species of birds were seen during surveys (Table 1). In 2012 and 2014, the same species were observed again, except for grey teal and little shag. Three Nationally Threatened species were observed in all surveys (including repeat surveys within the same season): black-billed gull, black-fronted tern, and banded dotterel. Two At Risk species were found in all surveys: pied oystercatcher and pied stilt (counts are provided in Appendix 1).

Table 1: River birds observed during four years of surveys of the Manuherikia River, 2010, 2011, 2012, and 2014, and their national threat status (threat classifications are from Robertson *et al.* 2013).

Species	Scientific Name	Threat Classification
Black-billed gull	*Larus bulleri*	Threatened-Nationally Critical
Black-fronted tern	*Chlidonias albostriatus*	Threatened-Nationally Endangered
Banded dotterel	*Charadrius bicinctus bicinctus*	Threatened-Nationally Vulnerable
South Island pied oystercatcher	*Haematopus finschi*	At Risk-Declining
Pied stilt	*Himantopus himantopus leucocephalus*	At Risk-Declining
Black shag	*Phalacrocorax carbo novaehollandiae*	At Risk-Naturally Uncommon
Little shag	*Phalacrocorax melanoleucos brevirostris*	At Risk-Naturally Uncommon
Black-backed gull	*Larus dominicanus dominicanus*	Not Threatened
Grey teal	*Anas gracilis*	Not Threatened
Paradise shelduck	*Tadorna variegata*	Not Threatened
White-faced heron	*Ardea novaehollandiae*	Not Threatened
Canada goose	*Branta canadensis*	Introduced and Naturalised
Mallard	*Anas platyrhynchos*	Introduced and Naturalised
Spur-winged plover	*Vanellus miles novaehollandiae*	Introduced and Naturalised

Survey findings for key species of interest are set out below.

Black-billed gull

Black-billed gull is classified as Nationally Critical, and is the most threatened species found on the Manuherikia. In 2010, a large breeding colony (highest number counted = 285 birds) was found breeding just above the lake (Figure 1). In 2011, the colony was in the same location, but was significantly smaller (maximum counted = 40); in 2012, the colony was also in the same place and numbered 275 birds, but colony behaviour indicated that breeding was not occurring (birds may have commenced breeding after this survey). In 2014, only very small numbers were observed (total = 18 birds), and no breeding was observed, although small numbers were seen on the ground within the river, about mid-way up the reach.

Black-fronted tern

Black-fronted tern is classified as Nationally Endangered. Tern colonies have been found throughout the Manuherikia. Three colony locations are shown on Figure 1. Numbers present at colony sites were approximately 30 terns in 2010, and 15 and 12 terns in 2014. In 2010, three additional pairs were thought to be holding territories above the bridge, but no breeding was seen. In 2011, 5-6 nests were observed downstream of the black-backed gull colony. In 2012, approximately 20 black-fronted terns and five nests were observed above and below the bridge. A further colony was also observed approximately 4 km upstream of the lake.

Numbers observed in association with colonies is generally significantly less than the number of terns observed overall along the length of the river. For example, in 2014, 27 birds were seen in association with two colonies, but 111 birds were sighted flying and foraging along and adjacent to the river. Foraging terns were regularly sighted feeding over adjacent rough pasture. Observations made in 2011 and 2012 indicated that some food items consisted of lizards.

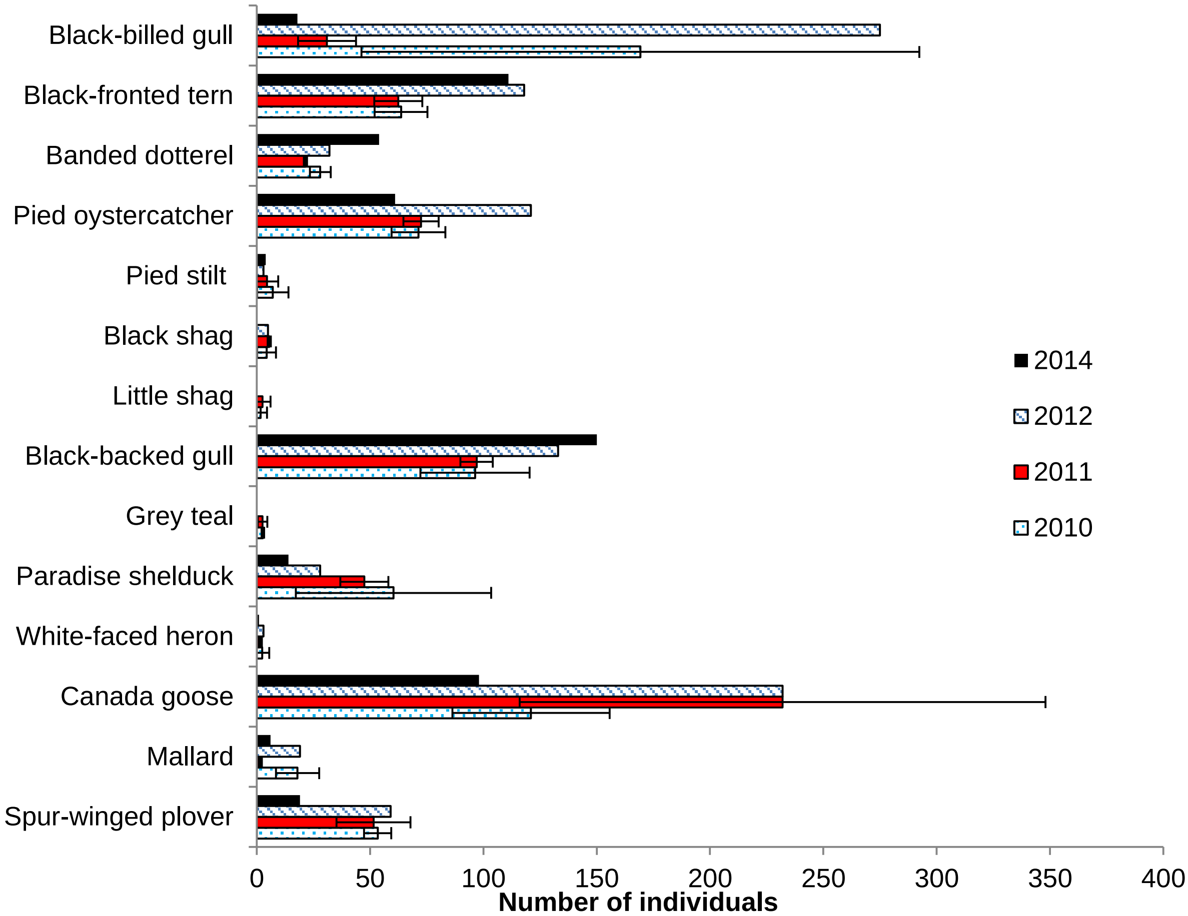
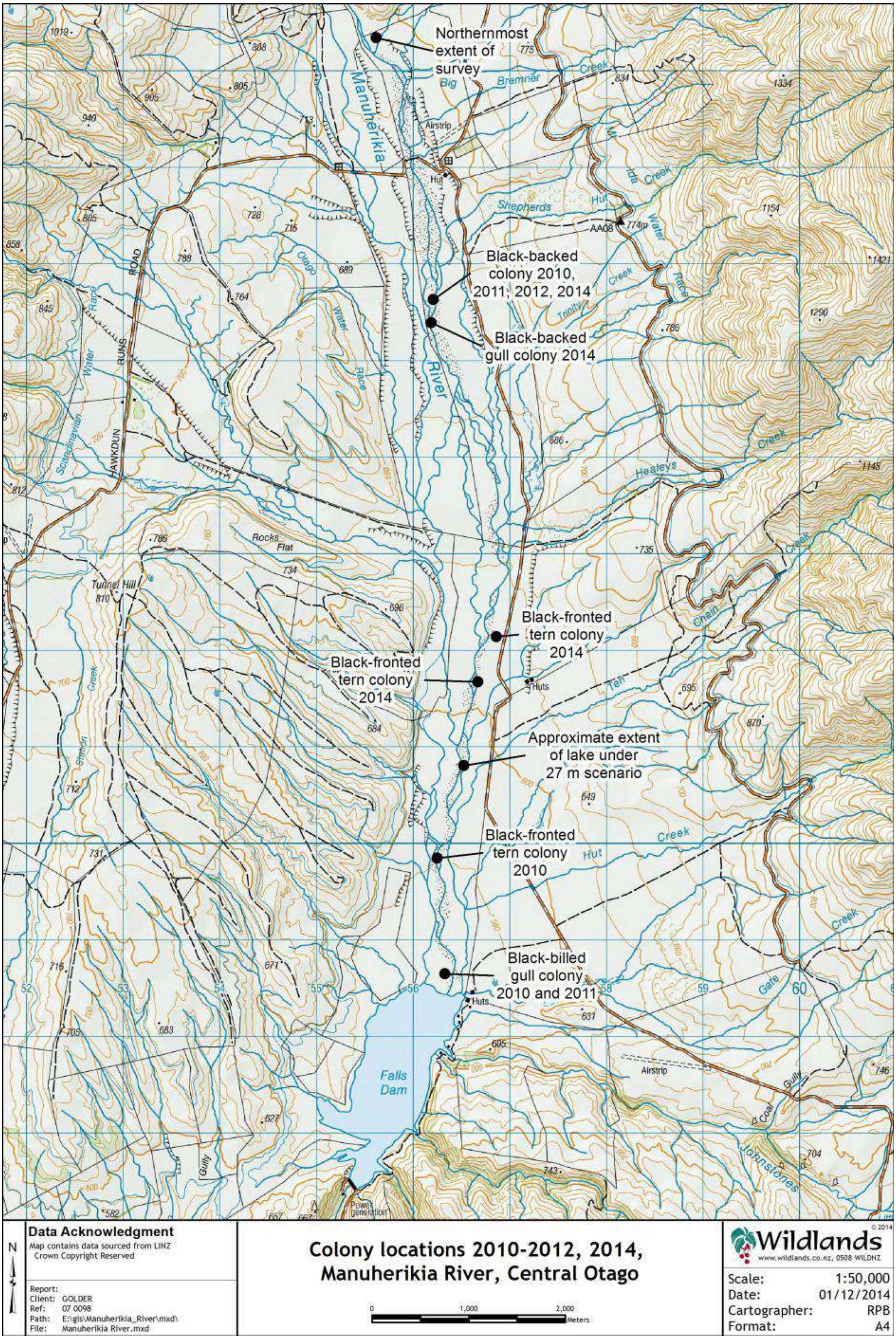


Figure 2: Mean number of birds observed on the braided section of the Manuherikia River, 2010-2014. Error bars indicate one standard deviation (only single counts were completed in 2012 and 2014).


Northernmost extent of survey
Black-backed colony 2010, 2011, 2012, 2014
Black-backed gull colony 2014
Black-fronted tern colony 2014
Black-fronted tern colony 2014
Approximate extent of lake under 27 m scenario
Black-fronted tern colony 2010
Black-billed gull colony 2010 and 2011
Manuherikia River
Falls Dam
Rocks Flat
Tunnel Hill
HAWKDUN RUNS ROAD
Airstrip
Huts
Data Acknowledgment
Map contains data sourced from LINZ
Crown Copyright Reserved
Report:
Client: GOLDER
Ref: 07 0098
Path: E:\gis\Manuherikia_River\mxd\
File: Manuherikia River.mxd
Colony locations 2010-2012, 2014, Manuherikia River, Central Otago
0 1,000 2,000 Meters
Wildlands
www.wildlands.co.nz, 0508 WILDNZ
Scale: 1:50,000
Date: 01/12/2014
Cartographer: RPB
Format: A4

Banded dotterel

Observations of banded dotterels made in 2010, 2011, and 2012 were mostly undertaken from the adjacent road, and as such, were thought to be an underestimation. In 2012, the survey was carried out along the river itself, and recorded the most dotterel to date. In the 2014 survey, dotterel territories were found to be very evenly distributed throughout the entire river.

Pied oystercatcher

Like banded dotterel, pied oystercatcher are also found throughout the river, at slightly higher densities than the dotterel. The higher numbers recorded in 2012 appear to have been bolstered by a group of 40 birds feeding in a paddock above the lake.

Black-backed gull

The species is highlighted due to its predatory nature on other braided river birds. Black-backed gulls appear to have nested in exactly the same location in all four years, although in 2014, a second colony (or sub-colony) was located immediately south of the usual location. Numbers have been relatively consistent from year to year.

Other species

Other At Risk species - pied stilt, black shag and little shag - are uncommon on the Manuherikia. Pied stilt breed on the river in small numbers. In 2010-2012, the only birds observed were immediately above the lake. In 2014, the only pied stilts observed were within the mid reaches of the river.

In December 2014, a Department of Conservation team undertaking fish surveys observed four wrybill at a location just inside the modelled 2.64 km inundation zone. It was not observed whether these birds were paired or breeding. Previous surveys undertaken by Wildlands did not locate wrybill, but were mostly undertaken from the road, reducing the ability to observe highly cryptic species such as wrybill (as for banded dotterel). Small numbers of wrybill may well have been present in all years.

4. ECOLOGICAL SIGNIFICANCE FOR BRAIDED RIVER BIRDS

Black-billed gull

The national population of black-billed gulls has been estimated at 90,000 mature individuals (McClellan 2009) and, as such, numbers on the Manuherikia are not internationally or nationally significant[1]. Stronghold rivers for the species are largely restricted to Southland, but also include the Ashburton River, in south Canterbury. Otago rivers are not known to have historically supported significant numbers of

[1] This estimate of the national population is likely to be revised after a comprehensive South Island survey that was completed by the end of November 2014.

black-billed gulls; colony sizes rarely exceeded a thousand birds in the 1960s and 1970s (Department of Conservation, unpublished data).

The South Island aerial survey of black-billed gulls is presently underway, and the Otago flight has been completed. This survey has obtained the most comprehensive, synchronised coverage of Otago Region to date (completed within one day). Rivers covered were the Clutha, Taieri, Kye Burn, Manuherikia, Shotover, Dart, Rees, Matukituki, Wilkin, Makarora, Hunter, Ahuriri, Hopkins, and Dobson. Only one colony, numbering *c.*150 gulls, was found, located on the Clutha/Mata-Au[1]. Observers noted black-billed gulls on the wing in the Manuherikia but, like the survey described in this report, observed no colonies. This regional survey suggests an extremely small population of black-billed gulls in the Otago region. However, it should be noted that numbers of black-billed gulls can show significant regional fluctuations between years (pers. obs.), and further consecutive surveys within Otago and the South Island are tentatively planned to examine this possible variation, and may detect greater numbers in following years. Nevertheless, given the Manuherikia has supported up to 280 gulls in previous years, it is likely to be regionally significant for this species.

The braided section of the Manuherikia runs between the St Bathans Ecological District and the Hawkdun Ecological District. It is unlikely that any other waterway in these Ecological Districts supports gulls, and therefore the Manuherikia is significant for its black-billed gull population within these Ecological Districts.

<u>Black-fronted tern</u>

The national population of black-fronted terns has been estimated at less than 5,000 mature individuals (Robertson *et al.* 2013), but also up to 10,000 (O'Donnell and Hoare 2011). Numbers on the Manuherikia have varied between 51-118 birds (mean = 88.8). Criterion 6 of the Ramsar Convention (Convention on Wetlands of International Importance, Ramsar, Iran, 1971) states that "a wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird" (Ramsar 2011). The most recent international publication providing an authoritative basis for Criterion 6 levels is Wetlands International (2006). This report gives the 1% level for black-fronted tern as 60 birds, based on an analysis by BirdLife International. On this basis, the braided section of the Manuherikia is internationally significant for black-fronted terns.

Additionally, O'Donnell and Hoare (2011) provide the most recent counts of black-fronted terns for 84 South Island rivers in which surveys have been undertaken. An analysis of these counts gives a mean of 99.1 terns per river (standard deviation = 227.7, indicating high variability between rivers)[2]. No terns were found on 33 of the rivers, compared to the largest count of 1,617 on the Wairau. The highly skewed

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1 The flight was undertaken on November 7 2014. The Clutha colony was observed at Beaumont Bridge, but another group of birds (*c.*30) was seen on the Clutha at Roxburgh, though they were not breeding. By December 3, this group had swelled to *c.*1,000 birds and were breeding (B. McKinlay, Department of Conservation, pers. comm.). This is one of the largest colonies reported in Otago for many years; however, it should be noted that the Clutha appears to have rarely been surveyed over the last 50 years.

2 Appendix 1 of O'Donnell and Hoare 2011 separates three of the largest rivers into reaches. These have been combined for this analysis.

nature of the data means that a more useful analysis of the data is to separate the data into quartiles. The third quartile is 87.5 terns, that is, only 25% of the 84 rivers supported more than 88 terns during the most recent count. These data suggest that the Manuherikia River can be considered nationally important for black-fronted tern.

The river is also likely to be significant for black-fronted tern within both the St Bathans and Hawkdun Ecological Districts.

Banded dotterel

The national population of banded dotterel is estimated to be approximately 50,000 birds, though this may be a significant overestimate (Southey 2009). The Manuherikia River does not, therefore, meet the international 1% criterion for wetland significance, and is unlikely to be regionally or nationally significant. However, as the main waterway within the St Bathans and Hawkdun Ecological Districts, the river is significant within these Ecological Districts for this species.

South Island pied oystercatcher

The national population of South Island pied oystercatcher has varied markedly over the last few decades. In 1970, the population was estimated at *c.*49,000 birds (Baker 1973). However, by 1983-1994, the population was estimated to number *c.*112,000 individuals (Sagar *et al.* 1999), representing a major increase since their formal protection in 1940. Further counts from 1994 to 2003 indicated a somewhat mixed picture of slight declines, increases, and stabilisations at key sites; the conclusion being that a continuing increase was no longer clear (Southey 2009). However, the species is now considered to be in general decline (Robertson *et al.* 2013) and Sagar (2014) contends that the species is now at levels recorded in 1988.

The Manuherikia population has varied between 61 and 121 since 2010; while this is a sizeable population, it is not nationally significant and is unlikely to be regionally significant. However, it will likely be significant within the St Bathans and Hawkdun Ecological Districts.

Wrybill

The national population of wrybill is 5,000-5,500, and is based on winter counts, as counts on braided rivers are considered impractical given the cryptic nature of the species, and the dispersal of breeding territories (Dowding 2014). The species is thought to be in gradual decline, and the breeding distribution has contracted significantly in past decades. Birds primarily breed on braided rivers in Canterbury, but small populations are known from four alpine Otago rivers; the Matukituki, Makarora, Dart and Hunter (Dowding 2014).

The numbers of wrybill observed on the Manuherikia are not nationally significant. However, the Manuherikia is well outside of the main recognised breeding distribution (BirdLife International and NatureServe 2014). It is possible that small numbers of wrybill are regularly present on the river, but have not been observed during surveys. Riegen and Dowding (2003) noted that preliminary analysis of banding re-sightings indicated strong natal site fidelity in the wrybill – most young returning to the same river to breed. This further suggests that the Manuherikia may regularly support a small population. If even small numbers of birds regularly occur on the upper Manuherikia, it could be considered ecologically significant given its outlying distribution.

5. POTENTIAL EFFECTS ON BRAIDED RIVER BIRDS

Increasing the height of Falls Dam by 27 m has been modelled to result in the loss of approximately a quarter of the braided river habitat of the Manuherikia when the dam is at its most full. The lake is likely to reach its maximum during spring when the snow melt increases water flow within the river, coinciding with the start of the breeding season for braided river birds. The primary effect of the increase will be the loss of breeding habitat for all braided river species that breed on the river. The impact of this loss may vary between species.

Birds that breed on braided riverbeds must be adaptable to a changing environment, particularly, breeding sites that are modified between seasons by floods or encroaching vegetation. These species are often forced to change nesting sites from year-to-year because previous nesting sites are no longer suitable. The availability of nearby food sources may also influence nest site selection, as may other factors. However, the relative influence of such factors including the physical characteristics of nest sites on nest site selection is poorly understood.

The most mobile of these species is probably black-billed gull, meaning that this species may be the least affected by loss of breeding habitat. In Southland, the stronghold for black-billed gull, colonies were rarely found to re-establish in previously-used colony sites over a three-year period (McClellan 2009; unpublished data). However, there are also anecdotal, unpublished observations of colonies establishing, irregularly, in the same site for decades (a recent and relatively well-known example is the colony that regularly establishes near the State Highway 1 road bridge on the Ashburton River, Ashburton).

Interestingly, a black-billed gull colony was observed at the same location on the Manuherikia in 2010 and 2011, and in 2012 breeding may also have commenced at the same site after the survey was completed. However, in 2014, no black-billed gulls were seen close to the lake; the small numbers observed were all in the mid reaches of the river. Breeding habitat suitable for black-billed gulls consists of areas of relatively vegetation-free gravel. On this basis, breeding habitat is not limiting, as habitat sufficient for numerous black-billed gull colonies is clearly available on the Manuherikia (although the river supported extensive areas of vegetation in 2014). Black-billed gulls can travel tens of kilometres to feed, and therefore there is no obvious reason why a gull colony could not establish successfully further up the river. However, one or more factors are leading to relatively regular colony establishment immediately upstream of the lake, and it is possible that the ‘delta’ above the lake provides more attractive breeding habitat for black-billed gulls. The loss of it could therefore reduce the chance of the birds using the river to breed. However, presumably a delta will re-form above the new lake level, so this loss may not be permanent.

Black-fronted terns are also a relatively mobile species that require only small areas of clear gravel to establish colonies (see Plate 1). Colony sites can change between years, and surveys on the Manuherikia have shown that tern colonies can establish throughout the river. Like black-billed gull, the availability of breeding habitat is unlikely to be a limiting factor on the Manuherikia, and therefore the species is likely to nest elsewhere on the river once the lower section has been inundated.

Plate 1: Black-fronted tern colony site, 2014. Arrow indicates location of colony (4-5 nests).

Banded dotterels and pied oystercatchers are solitary, territorial breeders. On the Manuherikia, their nesting sites are spread relatively evenly throughout the river, from its upper reaches above the bridge downstream to the delta. The effect of the loss of approximately one quarter of the available nesting habitat is difficult to predict; a conservative assessment is that the permanent loss of nesting habitat would result in an equivalent, proportional loss in the breeding populations of both species. However, the population trends of both species in the Manuherikia are not known, but could be assumed to be in decline given their respective national population trends. Therefore it is possible that the carrying capacity of the river for both species is not met, and the unaffected reach of the river can support a greater number of breeding dotterels and oystercatchers than has been observed in recent years.

Nesting densities of both species in certain habitats/locations have been examined e.g. Hughey (1998); Maloney *et al.* (1997); Morgan (2001). However, insufficient information exists to be able to predict with confidence whether the remaining *c.*75% of the Manuherikia will be able to support the existing dotterel and oystercatcher populations (combined possibly with weed control). Because of this, it is appropriate to consider the nesting habitat loss as resulting in a reduction in the breeding population of both species.

Wrybill are another solitary, territorial breeder. The Manuherikia is likely to be able to support a great many more breeding pairs than the tiny numbers observed at present. Wrybill are also likely to be able to move their nesting territories should the lower section of the river be flooded.

An increase in the height of the dam will also affect the availability of foraging habitat: river habitat will be significantly reduced, lake habitat will be increased, and there will also be a loss of terrestrial habitat through inundation by the extension of the lake. The lack of in-depth studies about the foraging behaviour of black-billed gulls, black-fronted terns, and pied oystercatchers – specifically the amount of time birds spend foraging over terrestrial habitats versus aquatic habitats – makes it difficult to evaluate the possible effects of the loss of terrestrial and river habitat and the increase in lake habitat. All four key species are known to forage in terrestrial habitats; this habitat can be very important for black-billed gulls (pers. obs., unpublished data) and black-fronted terns (e.g. O'Donnell and Hoare 2009). For example, O'Donnell and Hoare (2009) showed that terns made extensive use of adjacent valley floor grasslands for feeding on skinks and this behaviour has been observed elsewhere, including the Manuherikia.

While the terrestrial area that will be inundated is a small percentage of what is available to braided river birds, the lower valley floor habitats may provide relatively better quality foraging habitat than hill slope habitats. However, the terrestrial foraging behaviours of these species are insufficiently known to be able to predict the impact of this loss. The overall effect is a decrease in the availability of foraging habitat, which may affect the carrying capacity of the environment.

6. POTENTIAL OPTIONS FOR MITIGATION/COMPENSATION

6.1 Predator control

Predation is almost certainly the greatest threat to successful nesting for black-billed gull, black-fronted tern, banded dotterel, pied oystercatcher and wrybill on the Manuherikia. Predation by introduced mammals such as cats, stoats, ferrets, rats, and hedgehogs has been well documented e.g. Keedwell and Sanders (2002); McClellan (2009); Murphy *et al.* (2004); Sanders and Maloney (2002).

Predation by indigenous aerial predators such as Australasian harrier (*Circus approximans*) and southern black-backed gull may also be a key threat. Human activities have allowed black-backed gull numbers to increase well beyond levels known at European settlement and, as such, they now present a largely novel threat to braided river birds. The gulls are known to prey on eggs and chicks of a number of threatened bird species, including black-billed gull and black-fronted tern. However, the extent of their impact on braided river bird species is largely unstudied. Nevertheless, the regular presence of a substantial colony of black-backed gulls on the braided section of the Manuherikia may be a threat to bird species nesting in this location.

Harriers have also increased in numbers since the arrival of humans in New Zealand, having benefitted from the increase in open habitats resulting from deforestation. They have been shown to have significant impacts on braided river birds in parts of the country; e.g. black-fronted terns on the Wairau River, Marlborough (Steffens *et al.* 2012).

Predator control has the potential to improve productivity of all four key species (as well as others such as wrybill and pied stilt), and to reduce deaths of adult birds. However, there are serious limitations in our understanding of predator control regimes on braided rivers, and few examples of successful management programmes that have benefited a range of species. As such, the development of cost-effective, efficient strategies for predator control is considered to be the highest priority for braided river research (O'Donnell *et al.* in prep.). Because of the unknowns, a predator control operation focused on the upper Manuherikia valley to protect braided river bird populations could not be guaranteed to improve productivity of any of the key bird species present.

Nevertheless, recent adaptive management focused on a single, large black-fronted tern colony in the Ohau River, in the upper Waitaki, has had excellent, consistent results; but at great financial cost. In contrast, some species such as black-billed gulls have never been the focus of intensive management. Any proposal for predator control within the upper Manuherikia would need to be very well designed, and developed within an adaptive management framework, requiring thorough monitoring and expert involvement.

An additional benefit of intensive pest control (for example, a regime that would also enhance local lizard populations), would likely be a significant increase in food sources for black-fronted terns. O'Donnell and Hoare (2009) noted that the extensive, long-term pest control in the Eglinton Valley combined with stock removal had resulted in significant increases in the lizard fauna, and that this was being utilised by the terns; they estimated that the black-fronted tern colony was taking approximately 800 skinks every 12 hours.

6.2 Stock exclusion

The river is unfenced, and cattle can roam across the riverbed. Cattle will enter noisy black-billed gull colonies (R. McClellan, pers. obs.), and were observed within the black-billed gull colony on the Manuherikia on 14 November 2011. The animals can trample nests containing eggs and chicks of any species breeding on the riverbed. Cattle waste lowers water quality, and banks can be damaged by cattle movement.

Fencing of the riverbed will reduce the risk of trampling of nests, and may increase water quality. Alternative water sources would have to be provided for stock, however.

6.3 Weed control

Many braided river bird species tend to nest in areas with very low vegetation coverage, particularly black-billed gulls and black-fronted terns. In 2014, the Manuherikia had significant levels of vegetation (compared to *c.*20 rivers surveyed in Canterbury by the author in the same season). Weeds were present on the riverbed, but also indigenous plant species. Weed control can create further areas of clear gravel suitable for nesting by the four key bird species. Such control should be focused on island habitats within the river; this is likely to reduce access by terrestrial predators (see McClellan 2009). The creation of additional nesting habitat will help to offset the loss of nesting habitat resulting from increasing the height of Falls Dam.

7. CONCLUSION

The Manuherikia River above Falls Dam regularly supports substantial breeding populations of three Nationally Threatened bird species, black-billed gull, black-fronted tern, and banded dotterel, and one At Risk species, South Island pied oystercatcher. There may also be a tiny, remnant population of wrybill present on the river. The Manuherikia also supports a substantial population of southern black-backed gull, a species known to prey on the eggs and chicks of braided river birds. Populations of all species, particularly black-billed gulls, demonstrate natural fluctuations in numbers from year-to-year.

The Manuherikia can be considered to be internationally and nationally significant for black-fronted tern, and regionally significant for black-billed gull. The river is the only major waterway of its kind within the St Bathans and Hawkdun Ecological Districts, and the populations of all four breeding species are therefore significant within these Ecological Districts.

Increasing the height of Falls Dam by 27 m will result in the loss of about one quarter of the available breeding habitat for the four key species. Black-billed gull and black-fronted tern are likely to be the least affected by this reduction because they nest in colonies, and therefore require only small areas of suitable habitat, and because they are highly mobile and can shift colony sites between years under normal circumstances. In contrast, banded dotterel and pied oystercatcher are solitary nesters, and a conservative assessment is that the loss of braided river nesting habitat may lead to a similar reduction in the breeding population on the river. This effect will be less if the river can support a greater number of breeding pairs than it does at present, and could potentially be offset by creation of further habitat through weed control, and predator control.

A terrestrial pest control regime and control of black-backed gulls has the potential to offset the loss of productivity of banded dotterel and pied oystercatcher caused through an assumed reduction in the breeding population. Pest control could also be considered to provide compensation for overall effects on braided river birds. This could be achieved by increasing the productivity of black-billed gull and black-fronted tern (and other species such as wrybill and pied stilt), which are likely to be less affected by nesting habitat loss. Intensive predator control that augments local lizard populations also has the potential to provide an improved food source for black-fronted terns.

Habitat creation through weed control will assist to offset nesting habitat loss.

The effects of the losses in the availability of riverine and terrestrial foraging habitat on the populations of river birds is difficult to evaluate; but is likely to result in an overall loss. It is not feasible to offset the loss of foraging habitat.

The project, overall, will require very careful evaluation of adverse effects on fauna including braided river birds, and potential mitigation/compensation for those effects. However, it is clear at this stage that a comprehensive package of works would be required to address potential adverse effects on river-breeding birds associated with the scenario evaluated in this assessment.

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APPENDIX 1

SPECIES COUNTS AT THE MANUHERIKIA RIVER, 2010-2012, 2014

Species	2010				2011			2012	2014
	24 Oct	8 Nov	19 Nov	Mean (SD)	14 Nov	1 Dec	Mean (SD)	30 Oct	17 Oct
Black-billed gull	40	183	285	169 (123)	40	22	31 (13)	275	18
Black-fronted tern	51	66	74	64 (12)	55	70	63 (11)	118	111
Banded dotterel	27	33	24	28 (5)	22	21	22 (1)	32	54
Pied oystercatcher	65	64	85	71 (12)	78	67	73 (8)	121	61
Pied stilt	3	3	15	7 (7)	1	8	5 (5)	3	4
Black shag	3	1	9	4 (4)	5	6	6 (1)	5	0
Little shag	0	0	5	2 (3)	5	0	3 (4)	0	0
Black-backed gull	80	85	124	96 (24)	92	102	97 (7)	133	150
Grey teal	2	3	3	3 (1)	4	1	3 (2)	0	0
Paradise shelduck	37	34	110	60 (43)	55	40	48 (11)	28	14
White-faced heron	0	6	1	2 (3)	2	1	2 (1)	3	1
Canada goose	113	91	159	121 (35)	150	314	232 (116)	232	98
Mallard	13	12	29	18 (10)	1	2	2 (1)	19	6
Spur-winged plover	54	47	59	53 (6)	63	40	52 (16)	59	19

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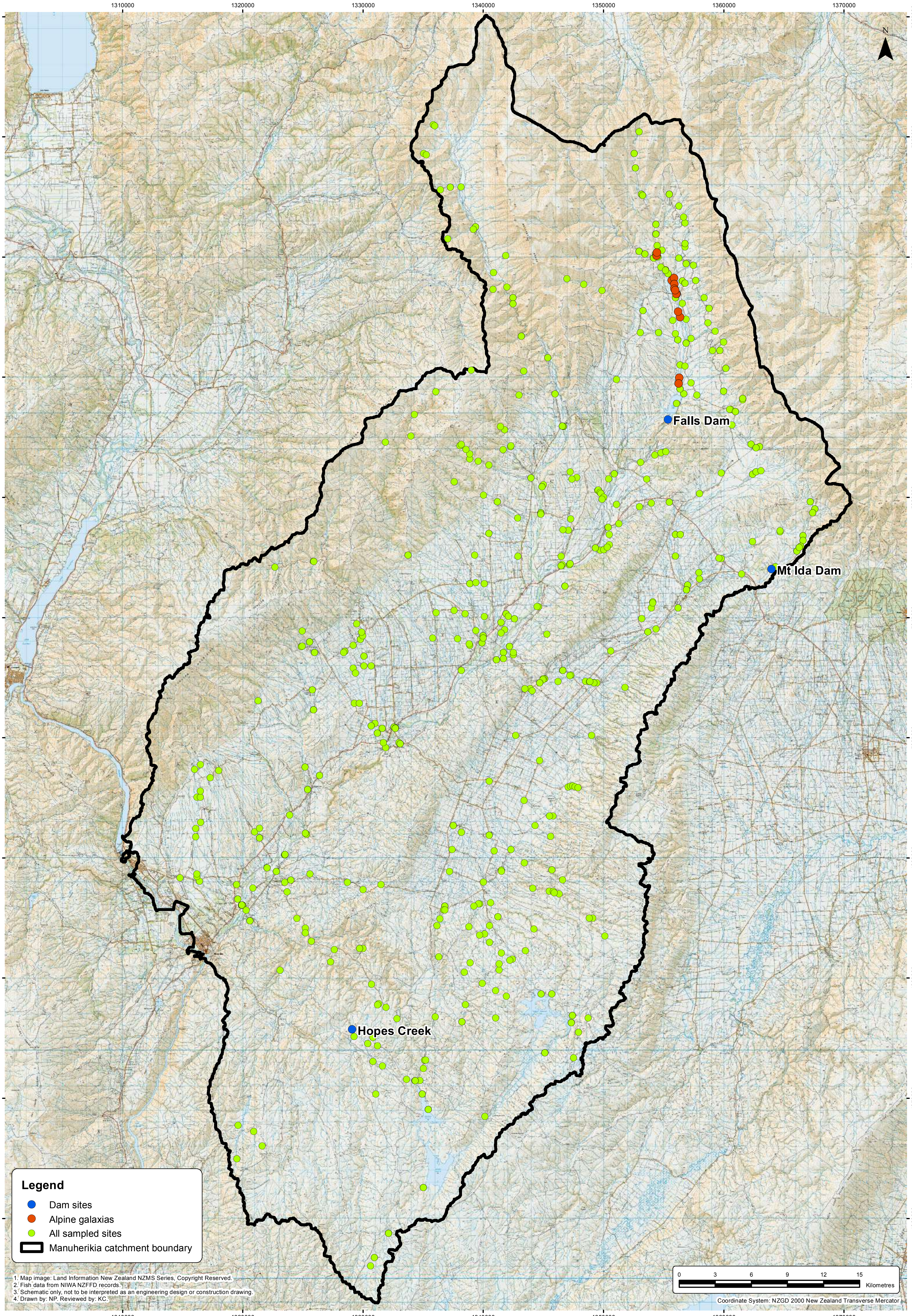
APPENDIX D

Native Fish Distribution (Freshwater Fish Database)



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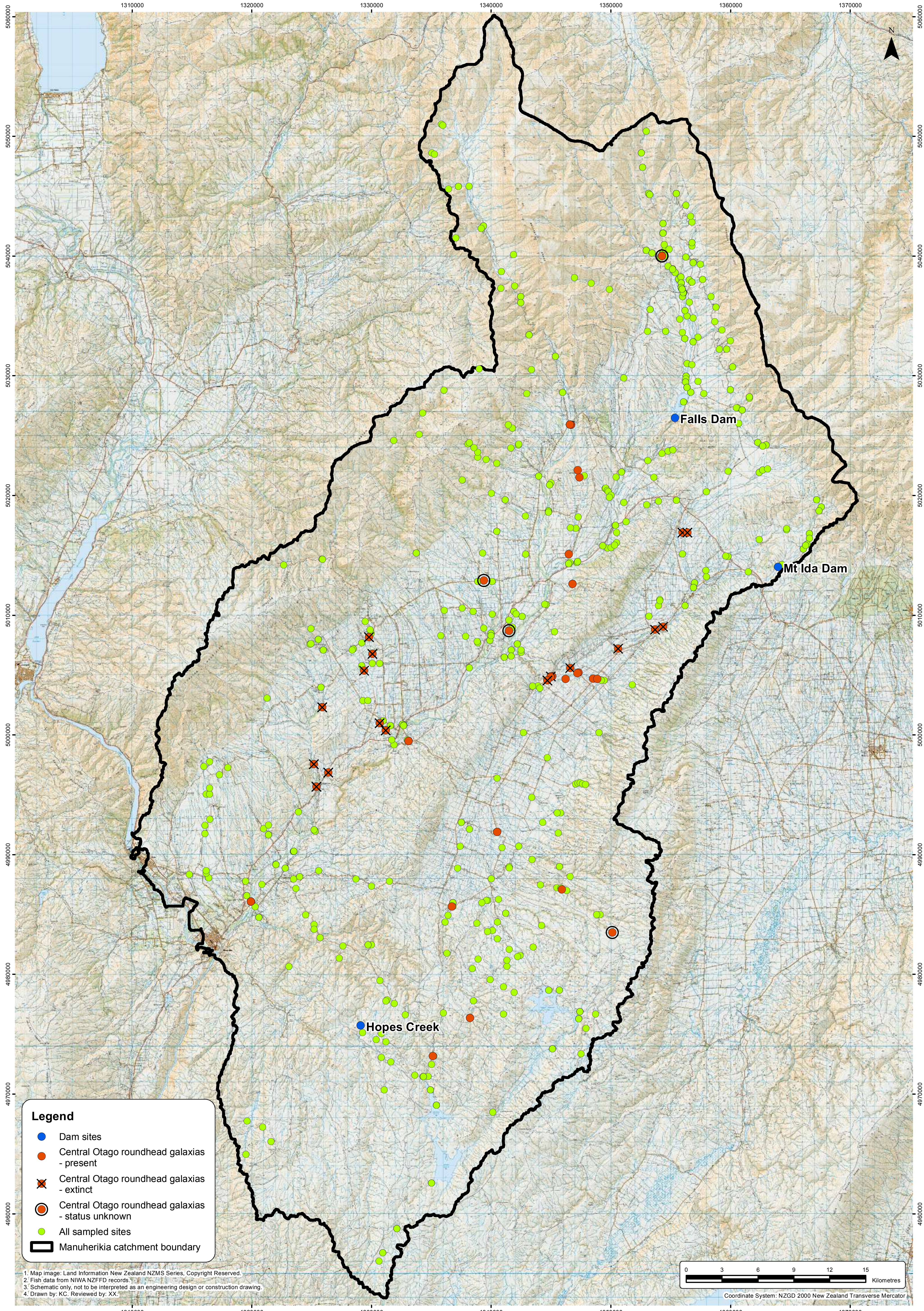

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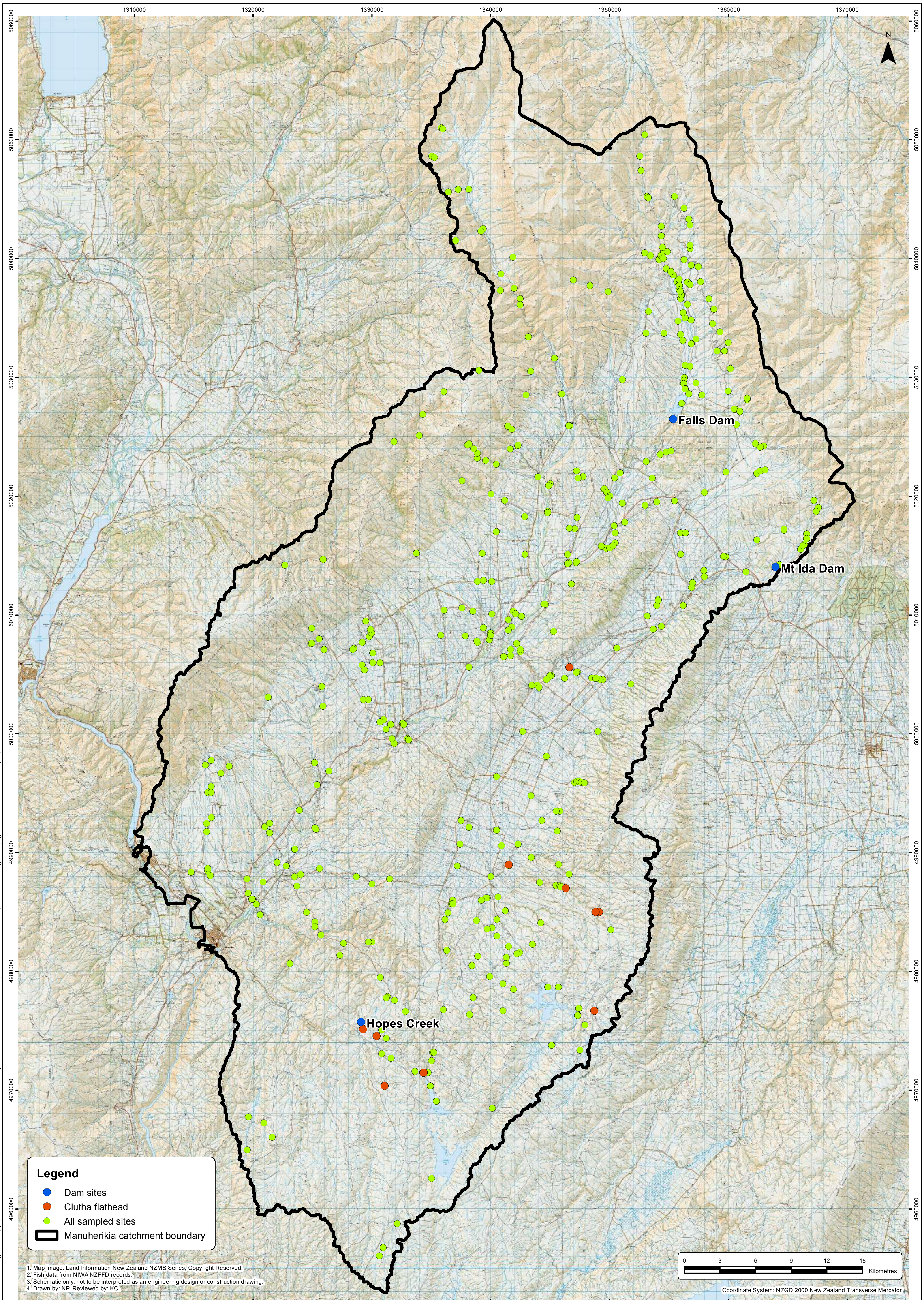

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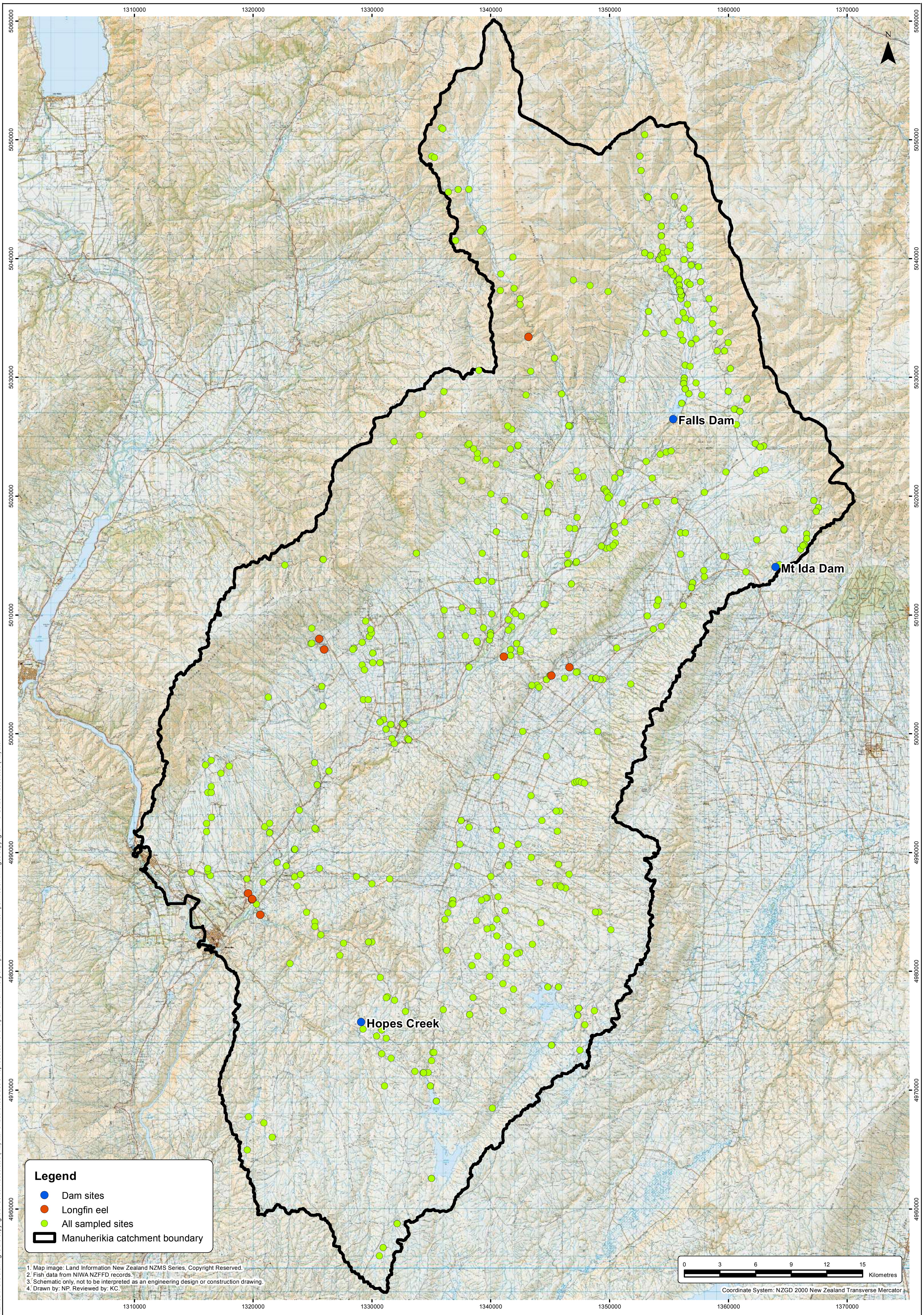

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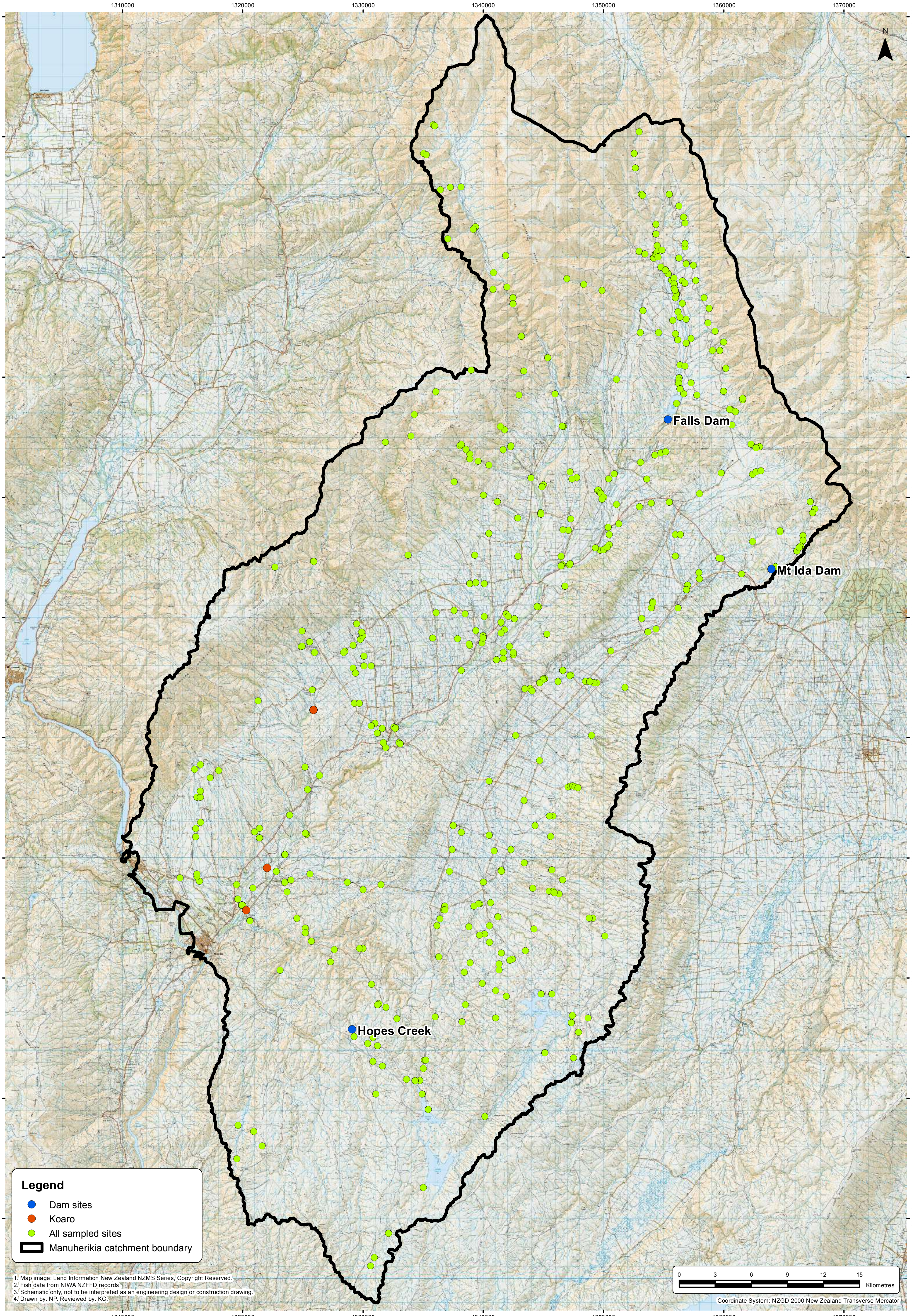

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3. Schematic only, not to be interpreted as an engineering design or construction drawing.
4. Drawn by: NP. Reviewed by: KC.

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TITLE KOARO SITES REPORTED IN THE NZFFD

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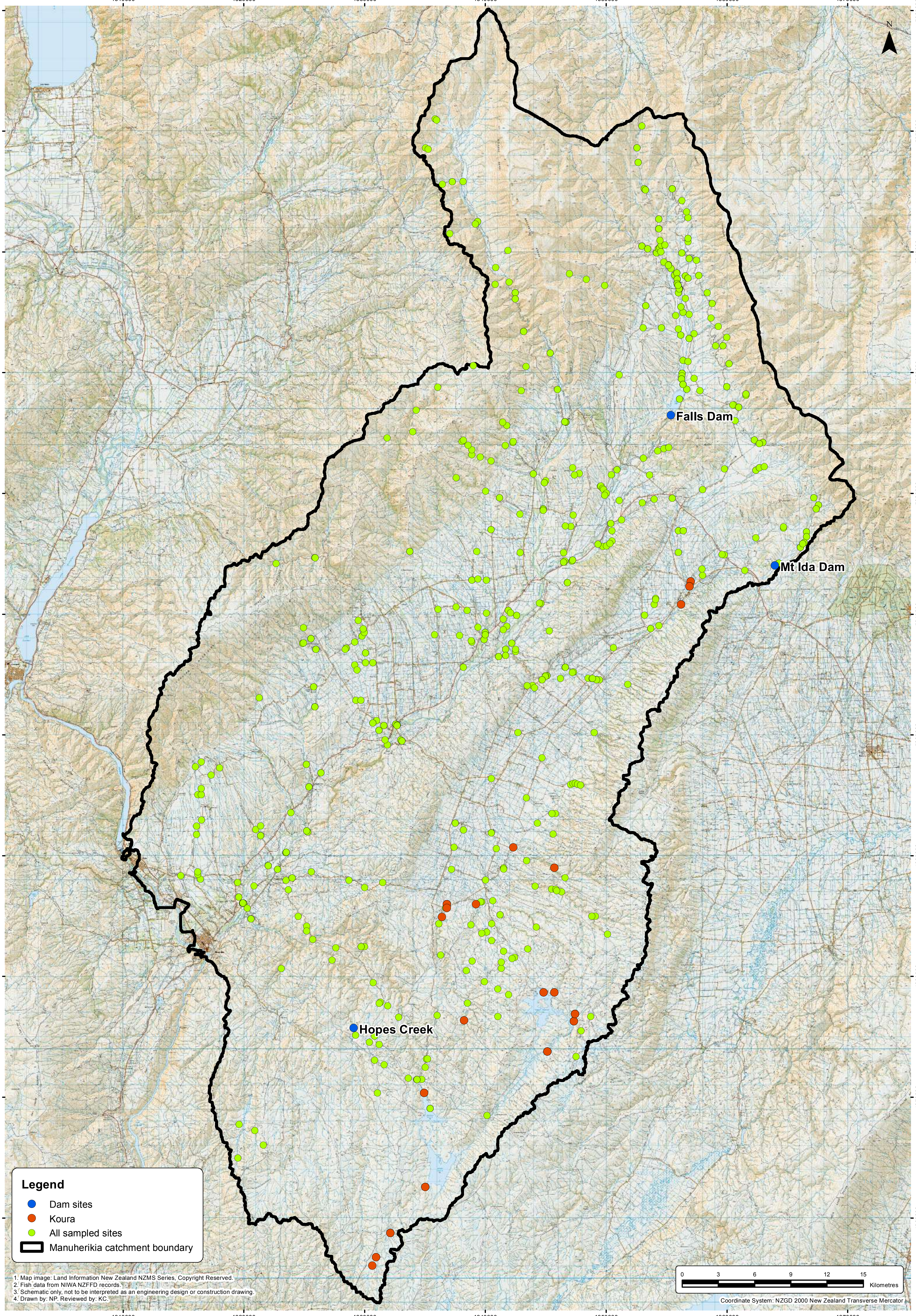

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AUGUST 2015

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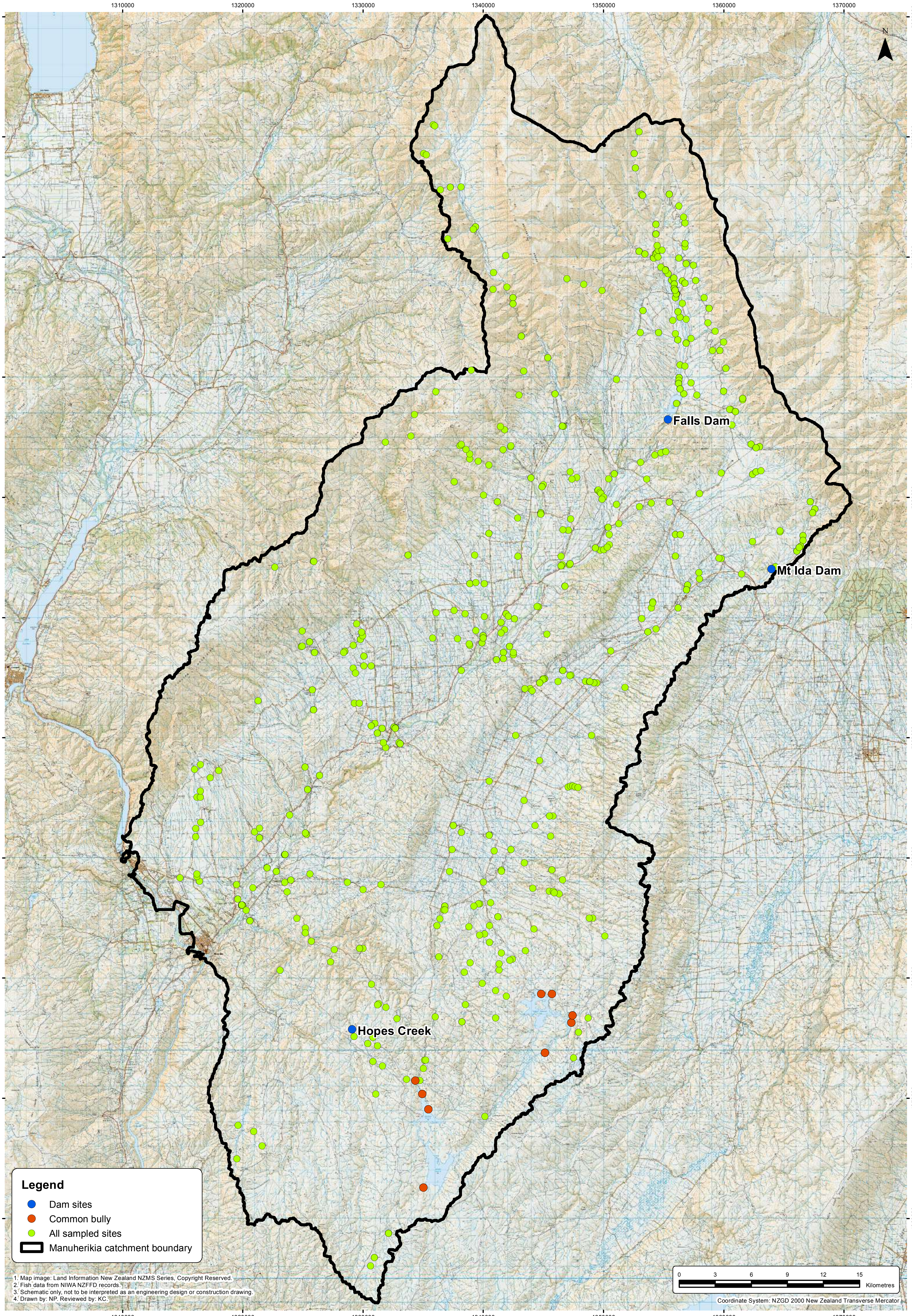

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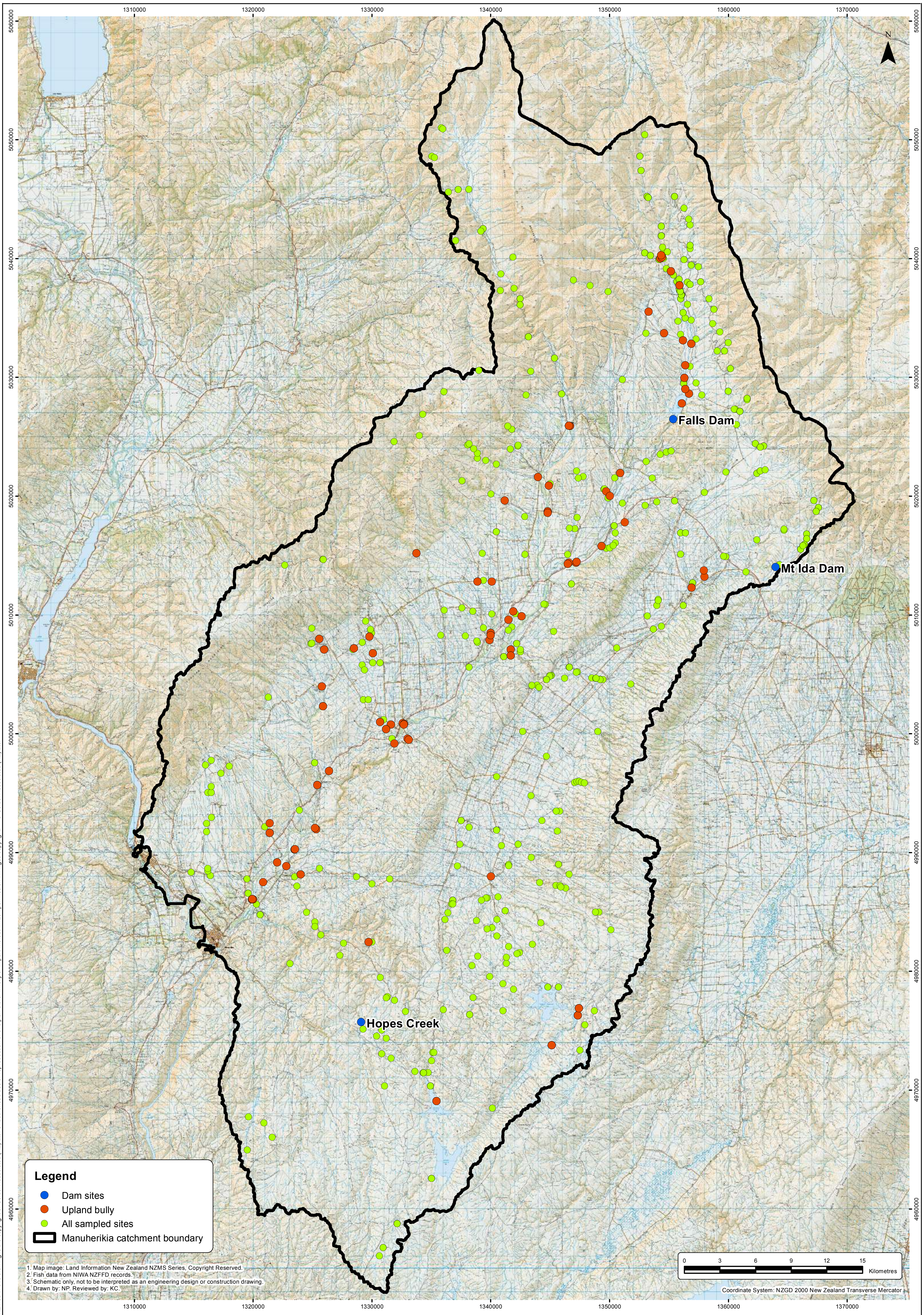

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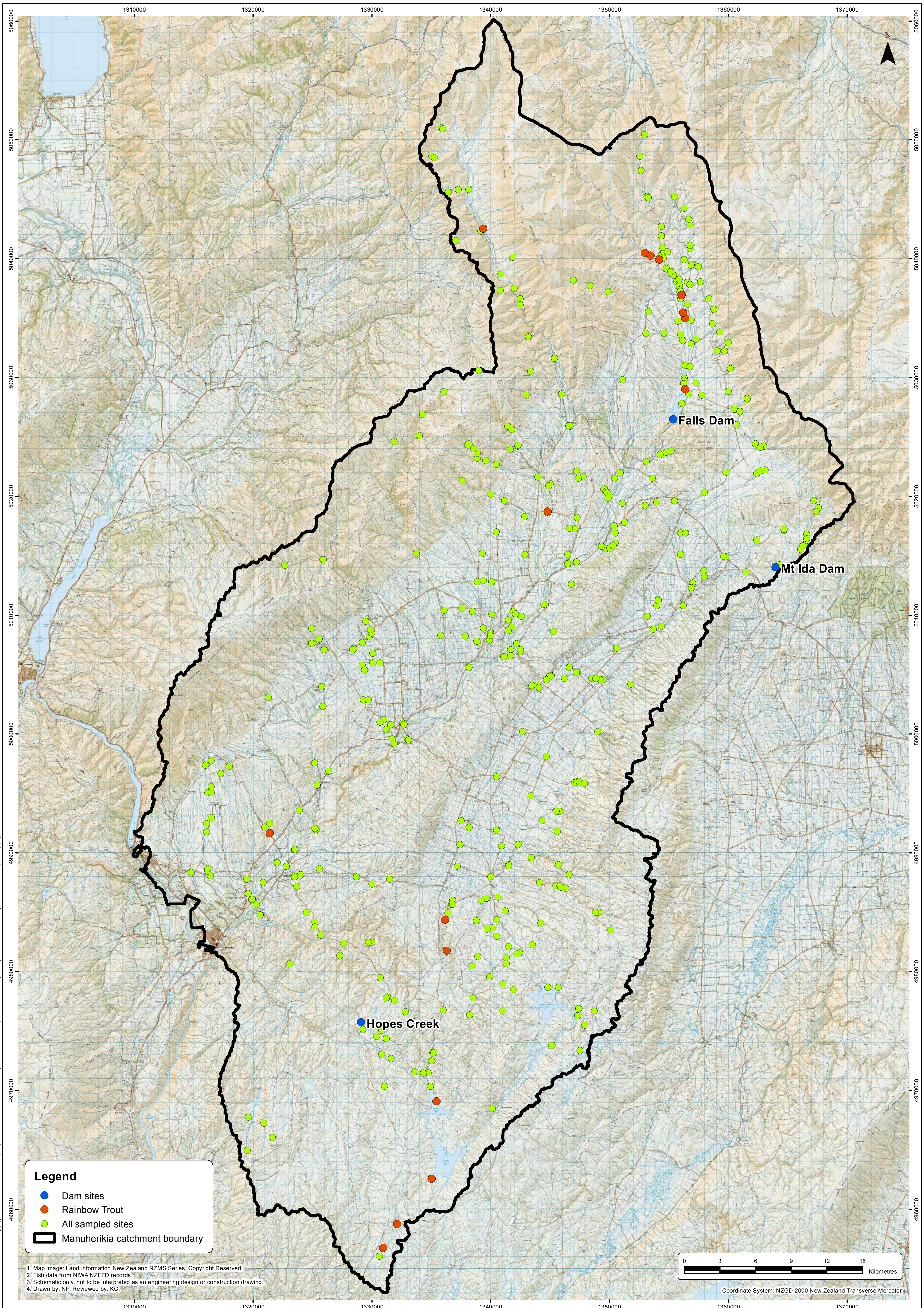

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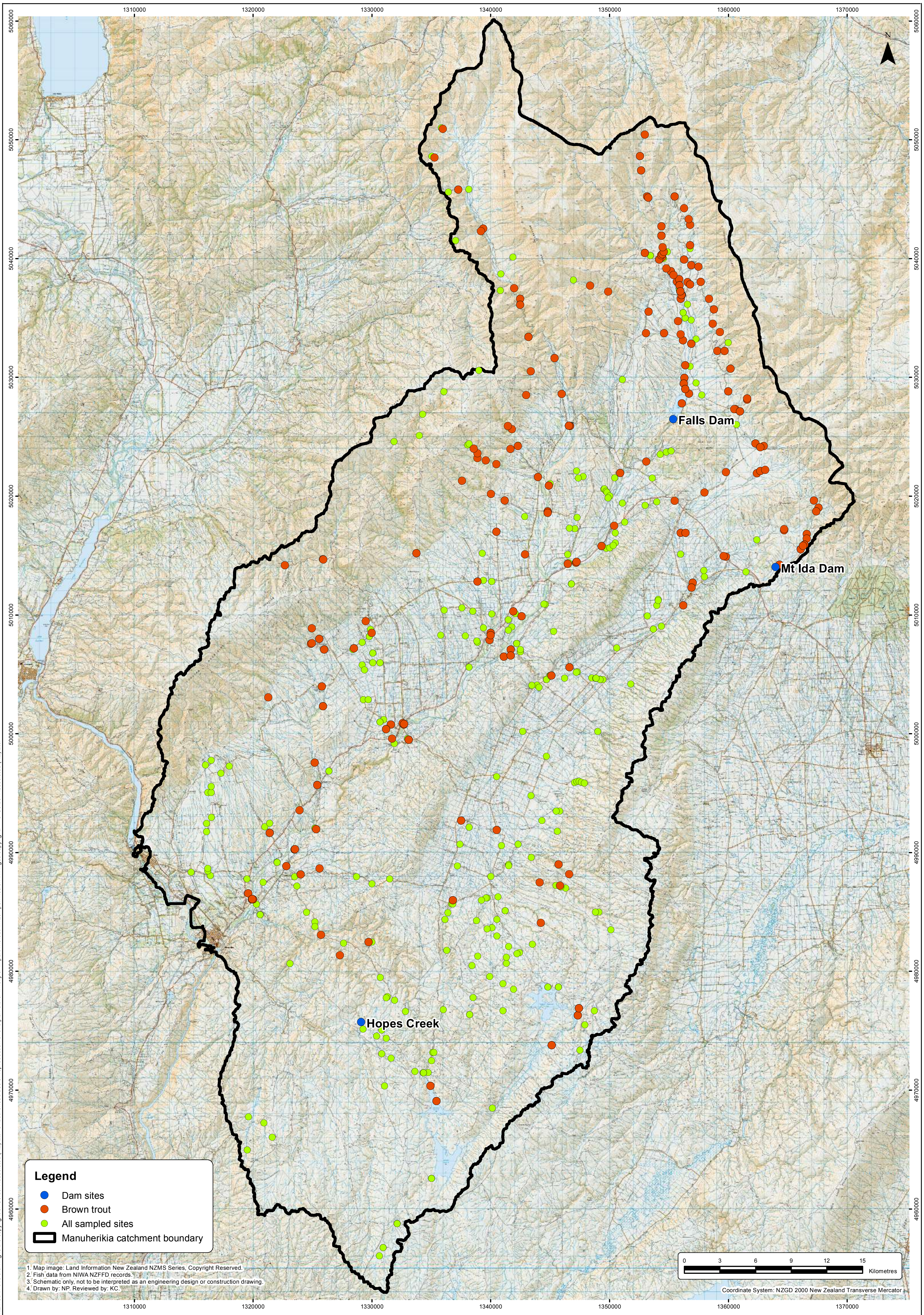

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AUGUST 2015

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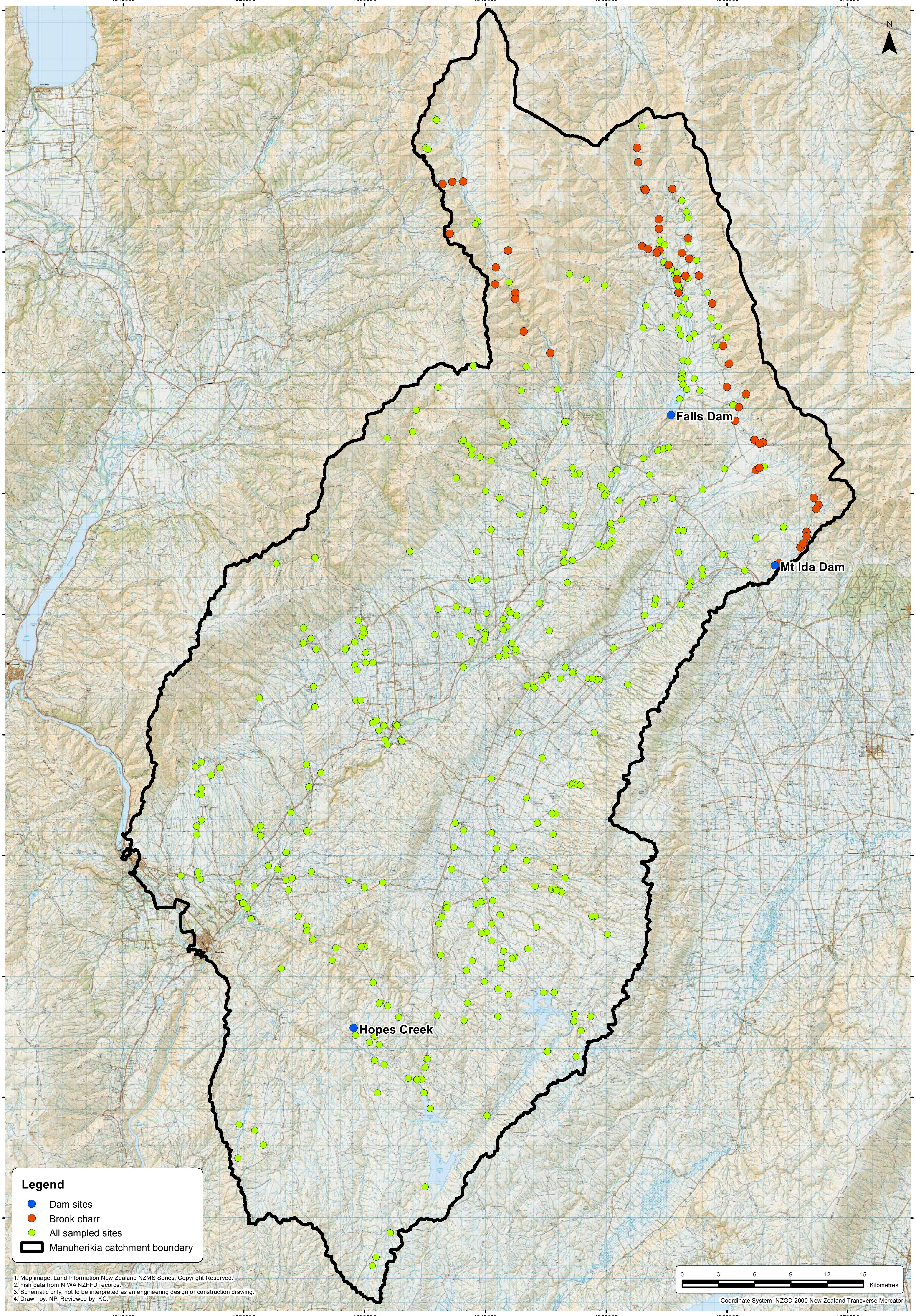

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2. Fish data from NIWA NZFFD records.
3. Schematic only, not to be interpreted as an engineering design or construction drawing.
4. Drawn by: NP. Reviewed by: KC.

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AUGUST 2015

PROJECT 1378110270

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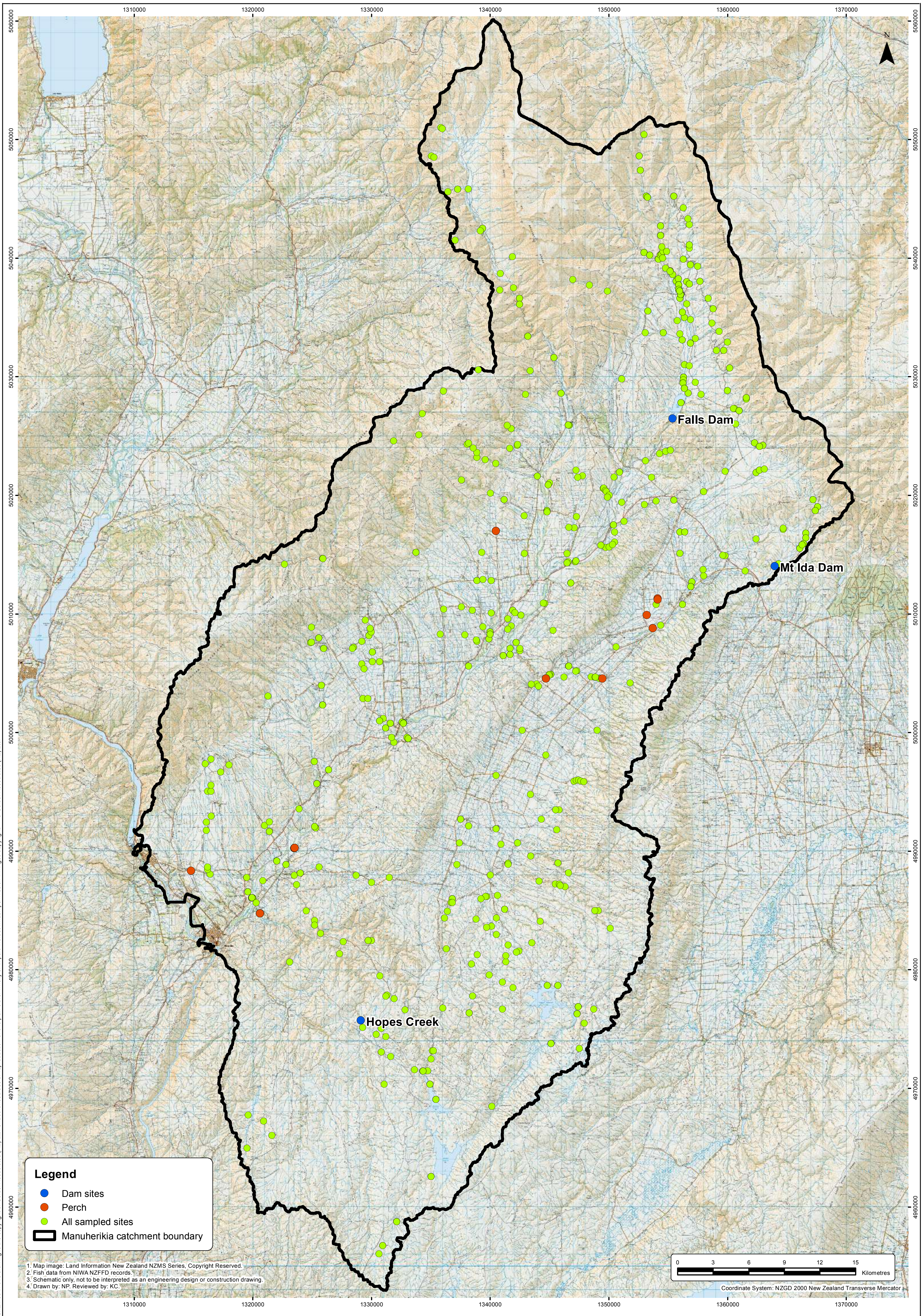

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APPENDIX E

Spring Annual Plant Survey (Wardle 2015)

SPRING ANNUAL SURVEY AT FALLS DAM AND THE PROPOSED IDA BURN DAM SITES

September 2014

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1. INTRODUCTION

The Manuherikia Water Catchment Strategy Group (MWCSG) is undertaking ecological assessments of the dam footprints that would result from the proposed raising of the Falls Dam, and the building of a dam at Ida Burn. A general botanical survey was conducted in March 2014. The need to survey for a suite of tiny threatened annual herbs that are best surveyed for in Spring was highlighted. This report outlines the results of these surveys that were done in September 2014.

2. SPRING ANNUAL SPECIES

Four species of Spring annual herbs were surveyed for: New Zealand mousetail (*Myosurus mimimus* subsp *novae-zelandiae*); *Ceratacephala pungens*, a diminutive member of the buttercup family; *Myosotis brevis*, a tiny native forget-me-not; and *Crassula multicaulis*. The latter two species are usually annual, but can be short-lived perennials. The descriptions that follow are based on information provided by New Zealand Plant Conservation Network.

2.1 Myosurus minimus subsp. *novae-zelandiae* New Zealand mousetail

Description
This spring to summer green annual herb forms tufts 10-80mm tall, comprised of 5-20 fleshy linear or spathulate leaves that are bright to dark green, yellow-green, red-green or red. A single greenish-yellow flower is borne on each fleshy, hairless stem (10-80 mm tall including receptacle). This lacks petals but has 5 minute green sepals that can drop off as the flower matures. The receptacle elongates with maturity, with 20-50 hairless, boat-shaped, dull, pale brown, yellow-brown or dark brown achenes (0.9-1.6 mm long). It usually flowers between August and November, while fruiting takes place between September and February.

Threat Category: Nationally Endangered

Habitat
New Zealand mousetail grows in damp and slightly salty depressions in pastures and short tussock grassland; on the margins of tarn and kettle holes; in damp gravel flats and alluvium; and on sunny stock camps in lowland to upland environments.

Plate 1: New Zealand mousetail coming into flower (*Kate Wardle*)

2.2 Ceratocephala pungens

Description

This small (1-5-2 cm tall) tufted annual herb has yellow-green leaves that are 3 lobed, but spoon-shaped in outline. All leaves originate from the crown. Each lobe is again divided into 2 or 3 oblong segments. The leaves are finely woolly-hairy (4-8 x 3-10 mm) with a flattened stalk (8-10 mm long). It has solitary yellow flowers that are unstalked or on short stalks (2-5 mm long). Sepals 4-5 mm long are linear-oblanceolate in shape, and woolly beneath. The yellow petals are as long as the sepals, and similar in shape. narrow. It produces 20-30 woolly-hairy triangular fruit (3-4 x 1.5 mm) with straight, erect, spiny beaks. It usually flowers between September and December, and fruits between November and March.

Threat Category: Nationally Critical

Habitat

Ceratocephala pungens grows on dry open ground associated with depleted tussock grassland and sunny hillsides of dry inland basins and river valleys. It often grows amongst scabweed (*Raoulia* spp.) mats, and on stock/rabbit camps where close-cropped grazing maintains a low-growing turf. It is usually found between 200-500m asl. but has been recorded at 850m asl. on the Cairnmuir Range in the Cromwell Gorge (*pers. obs*).

Plate 2: *Ceratocephala pungens* showing the yellow-green woolly flowers (*Mike Thorsen from NZPCN*)

2.3 Myosotis brevis Tiny-flowered forget-me-not

Description

This small annual or rarely short-lived perennial herb forms small circular patches on open ground. It forms compact rosettes with short lateral branches that are densely to sparsely leafy. Leaves are green, dark green, bronze green to brown-green, sometimes a variety of colour on the same plant; narrow-oblong/egg-shaped to spoon-shaped, 5 - 7 mm long; 1 - 3 cm wide. The leaves have unequal sides arranged in 2 opposite rows that overlap. The upper leaf surface is covered with copious stiff to coarse, spreading straight hairs, while the undersides are almost hairless. Broad leaf stalks.

Tiny (0.5 - 1 mm diam.) unstalked flowers that are white, cream or pale yellow, sometimes striped with blue; hairy calyx. Produces brown-black to grey-black ovate to ovate-elliptic nutlets (0.9 - 1.1 x 0.6 - 0.8 mm), that are distinctly keeled on the front surface. This forget-me-not usually flowers between September and April, and fruits between October and August.

Plate 3: Tiny forget-me-not, showing geen and bronze coloured leaves on same plant, and tiny flower. (*John Barkla from NZPCN*)

Threat Category: Nationally Vulnerable

Habitat

Found in turf on tarn margins and around the edges of lakes and lagoons; in open and more or less shingly places from coastal to alpine environments

2.4 Crassula multicaulis

Crassula multicaulis is an annual to short-lived perennial small herb that forms dark red, pink or green, moss-like mats or open patches to 3cm tall; stems initially decumbent, soon ascending, rooting at nodes, much-branched from base, branches reaching up to 60 mm tall. Leaves are fused at base, 1 - 3 x 0.6 - 0.7 mm, 0.3 - 0.4 mm thick, triangular-lanceolate, flattened above, strongly convex and keeled below; usually with sharp point. It has solitary flowers that are located in upper leaf axils; fragrant, star shaped, in groups of 4, 3.5 - 5 mm diam.; pedicels 2(-5) mm long, elongating at fruiting. Calyx lobes 0.5 - 0.8 x 0.5 - 0.6 mm, triangular, acute, usually with abrupt sharp point. Petals 1.6 - 1.8 x 1.3 mm, broadly elliptic-ovate, white or pink, or pink-flushed, apex rounded, much > calyx. Scales 0.7 mm long, oblanceolate. Follicles smooth. Seed 0.5 mm long. It usually flowers between November and April, and fruits between November and May.

Plate 4: *Crassula multicaulis* showing its pink coloration and straggly habit (*Joy Comrie*)

Threat Category: Nationally Endangered

Habitat

Coastal, lowland to alpine (0- 1800 m asl.) in open, seasonally damp ground, such as clay or salt plans or around tarn margins; braided riverbeds.

3. METHODS

The survey was undertaken on foot on 9th, 17th and 23rd September 2014 by Kate and Rob Wardle. Sites that had been identified as potential Spring annual habitat during the main botanical assessment in March 2014 were visited first, followed by a more extensive search.

Potential Spring annual habitats surveyed included seasonally-wet depressions favoured by New Zealand mousetail; depleted tussock grassland and dry sunny hillsides including stock camps dominated by mouse-eared hawkweed (*Pilosella officinarum*) and exotic grass turf (favoured by New Zealand mousetail and *Ceratocephala pungens*); and gravelly habitats (for tiny native forget-me-not and *Crassula multicaulis*).

When these habitats were found, they were examined closely. Where the habitat was extensive, this was done by systematically walking across the habitat in a zig-zag fashion until a Spring annual species was identified. A detailed inspection at closer range was then made of the habitat within a 1 m radius of the threatened plant, radiating out from that point until no further plants were found.

The habit of *Ceratocepahala pungens* and *Myositis brevis* i.e. forming discrete tufts or rosettes mean it is possible to make an accurate assessment of population size by counting the number of plants at each site.

New Zealand mousetail and *Crassula multicaulis* form dense patches of very small plants, or interweaving plants so for these plants, an accurate population count is not feasible. Instead, an assessment of the approximate number of plants present, and the extent of a population was made.

At each spring annual location a brief description of the habitat and species composition was made. A GPS was used to record the location of clusters of plants; these waypoints were used to map the location and extent of each spring annual population recorded.

4. STUDY SITES

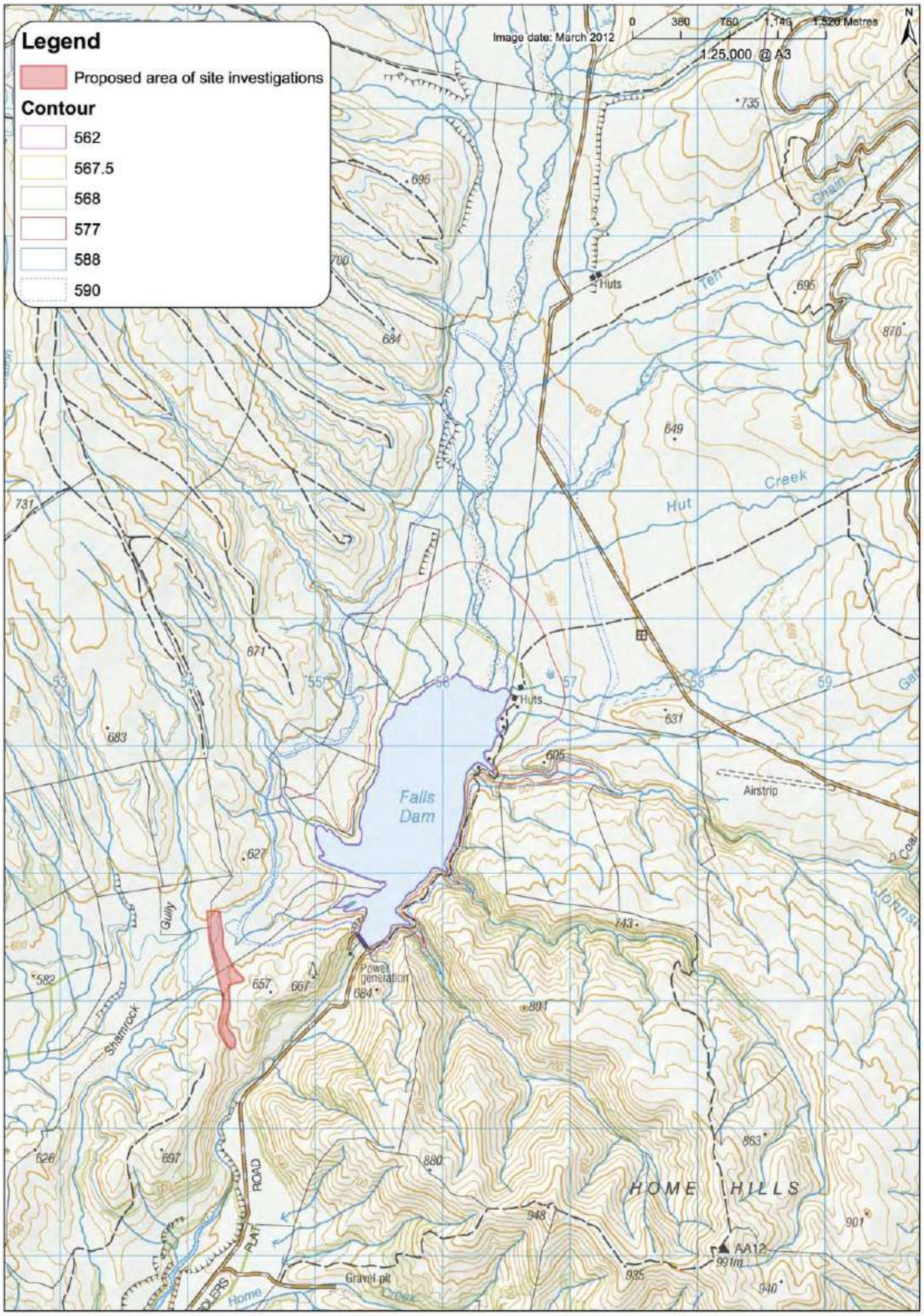
4.1 Falls Dam Site

The Spring Annual plant survey area was conducted within the footprint of the proposed maximum increase in dam height (i.e. the 27-m level) (Figure 1). This land occupies the zone between the existing dam shore and the 590 m asl contour.

The site mostly comprises cultivated pasture, with large areas of degraded hawkweed-short tussock grassland, mixed grey shrublands, rocklands, copper tussock peatland fen, and within upper Manuherikia River braided river valley there is a mosaic of exotic pasture vegetation, short tussock, hawkweed herbfield, matagouri shrubland and boulderfield communities.

The Spring Annual survey focused on those areas within the dam footprint that were potential habitat for these threatened herbs i.e. gravelly habitats associated with the gold mining sluicings behind the huts and river flats; seasonally wet depressions, and stock camps.

Figure 1: Location Map of Falls Dam. Spring annual survey was conducted between the existing dam shore and the 27m-rise option at Falls Dam (588m asl).



4.2 Proposed Ida Burn Dam Site

The Spring annual survey was conducted within the dam footprint of the highest proposed flood level, equating to the 680m asl contour (Figure 2).

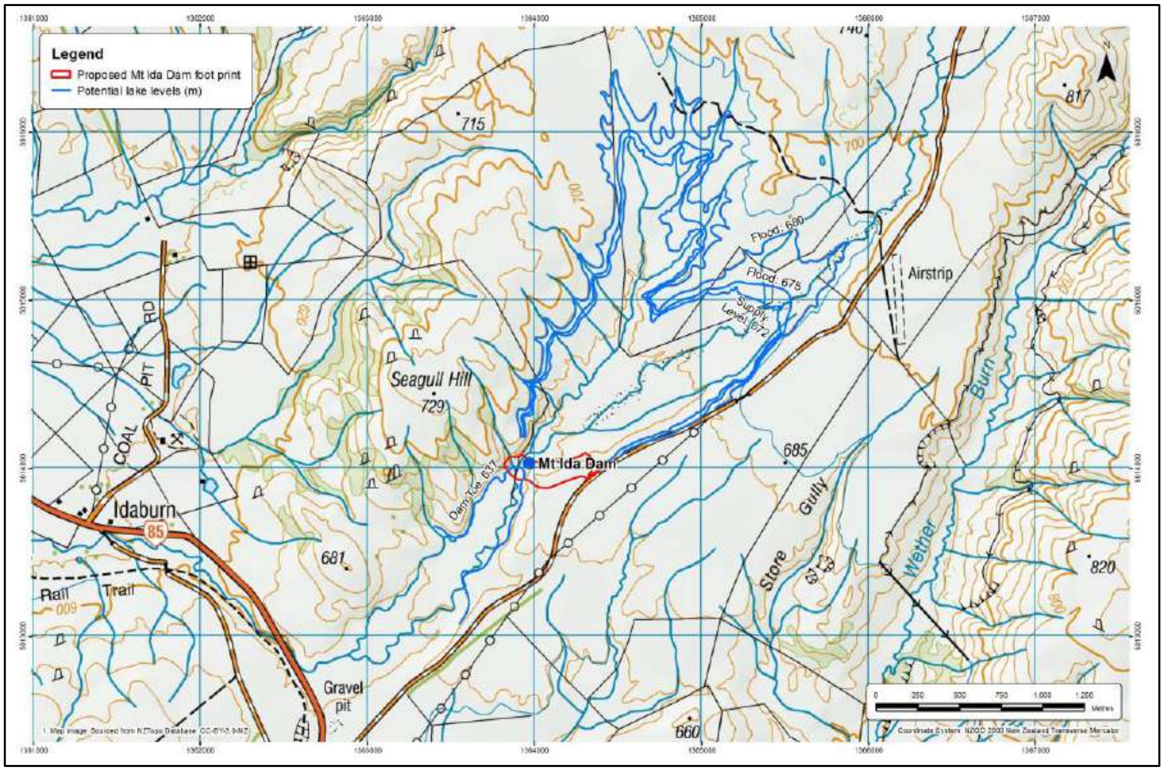


Figure 2: Location map of Ida Burn proposed dam footprint

The site comprises tall tussock grasslands, short tussock grasslands, degraded hawkweed herbfields on sunny faces, matagouri shrubland, wetlands and a mosaic of riverbed communities within the Ida Burn riverbed that include exotic grassland, shrubland, wetland, boulderfield and gravelly habitats.

The Spring annual survey focused on those areas within the dam footprint that were potential habitat for these threatened herbs i.e. seasonally wet depressions within any of the communities present, degraded sunny faces dominated by mouse-eared hawkweed where stock camp, and gravelly habitats associated with the Ida Burn riverbed.

5. RESULTS

5.1 Falls Dam Site

No Spring annuals were recorded at the Falls Dam site. There was only limited suitable habitat present, and much of the gravelly habitat associated with the upper Manuherikia River flats has been invaded by tall exotic grass species, making much of this habitat unsuitable.

5.2 Proposed Ida Burn Dam Site

There are extensive areas of suitable habitat within the Ida Burn dam footprint, comprised largely of degraded sunny north-north-east to north-west facing hillslopes dominated by low growing mouse-eared hawkweed herbfield-exotic grass turf, and used as stock and geese camps. In addition, there are seasonally wet depressions scattered within the footprint area, and large areas of gravelly habitat associated with the terraces and old river braids of the Ida Burn itself.

New Zealand mousetail was the only Spring annual species recorded at the Ida Burn site. It is associated with stock camps on the sunny faces of the longest and highest ridge located immediately to the west side of the Ida Burn. None were found on any of the other smaller ridges that had similar habitat located further to the west. While not recorded, all these sites were also considered suitable habitat for *Ceratocephala pungens.*

153 patches of New Zealand mousetail were recorded, comprising an average of at least 100 plants per patch. It is highly likely that more patches are present, especially within the 'core' population. This means that over 15300 plants are present on the sunny faces along the length of the ridge. Most of the plants are concentrated on two spurs, with a further 5 outlying populations present, extending the population along a 1 km length of the ridge (see Figure 3; Plate 5).

Plants within the core site are distributed as finite patches within an area that extends some 90 m upslope. The population is located between approximately 675 m and 690 m asl. The most obvious patches of New Zealand mousetail are growing near bare ground, Chewing's fescue *(Festuca rubra)*, brown top (*Agrostis capillaris)* and Kentucky blue grass (*Poa pratensis)*. Native species include moss, *Geranium sessiliflorum,* blue wheatgrass (*Elymus* sp.), and an occasional fescue tussock (*Festuca novae-zelandiae)* or patch of button daisy (*Leptinella pusila),* or turf coprosma (*Coprosma petriei).* The site is characterised by 80% vegetation cover, 15% litter (mostly dung) and 5% bare ground.

New Zealand mousetail is distributed along spurs just north of the core site, with many plants forming a dense patch. However, plants are also growing in amongst other vegetation, which is largely exotic. Species include mouse-eared hawkweed, white clover (*Trifolium repens*), harefoot's trefoil (*Trifolium arvense)*, sheep's sorrel (*Rumex acetosella*), grassland forget-me-not (*Myosotis stricta*), and parsley piert (*Aphanes arvensis).*

The middle outlier is located beside cushions of the At Risk-Declining dwarf broom *(Carmichaelia nana*).

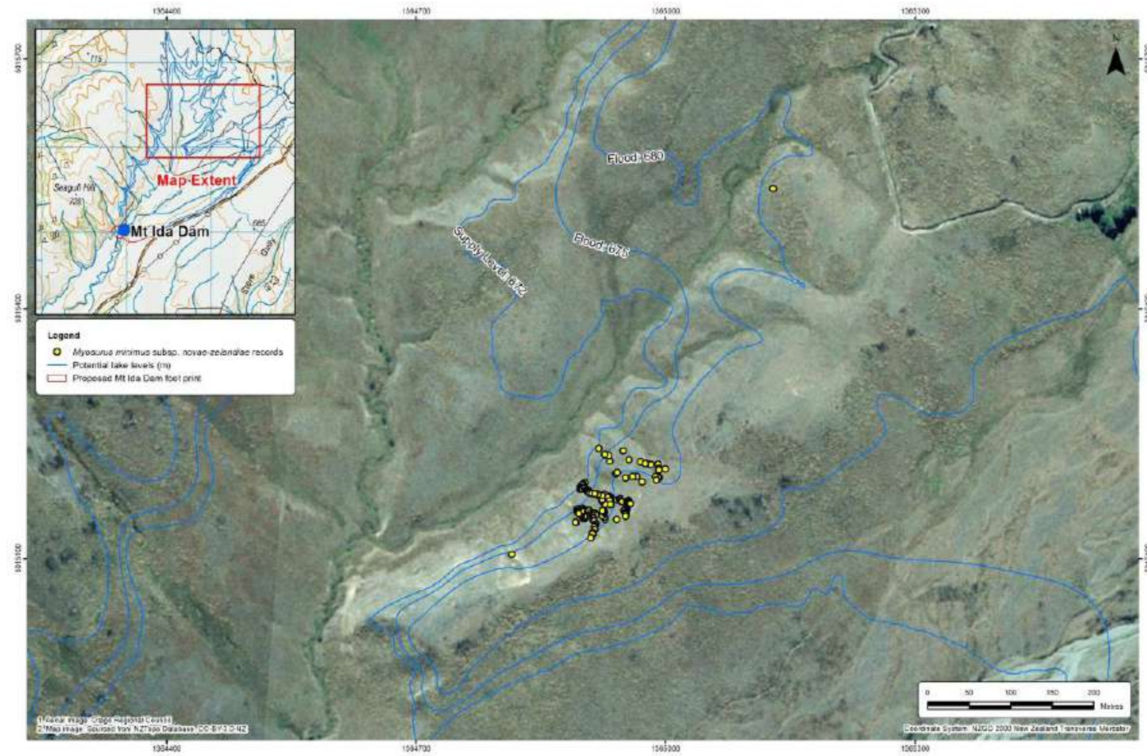


Figure 3: Location Map of New Zealand mousetail population within the highest proposed dam footprint (680m asl.)

Plate 5: Panorama of sunny faces that support New Zealand mousetail- plants extend beyond the right side of the photo

The northernmost site is a much more localized stock camp within a snow tussock grassland at approximately 680 m asl. Just a few small patches of New Zealand mousetail are present within 50 cm of each other. Several patches occupy a depression formed by a stock track. The site is characterised by 50% vegetation cover, 20% dead vegetation (mainly grass), 15% litter (mostly dung) and 15% bare ground. This site is locally dominated by exotic herb and grass species including haresfoot trefoil sheep's sorrel, Chewing's fescue, field speedwell (*Veronica arvensis),* browntop (*Agrostis capilaris*)*,* and mouse-eared chickweed *(Cerastium fontanum).* Native species present include moss, turfy coprosma (*Coprosma petriei)* blue wheat grass (*Elymus* sp.) and *Colobanthus strictus.*

The southernmost sites have a northwest aspect and are located towards the toe of the slope at 670m asl. A few hundred plants are present at each site, present as individual plants and discrete patches growing within moss and grazed browntop, with mouse-eared hawkweed, haresfoot trefoil and exotic grassland forget-me-not also present. These sites are stock and geese camps.

It is likely that the outlier populations present have established from seed carried by stock, especially the northernmost site, where it is present on a stock track.

Photos of the habitat and plants are included in Appendix 1.

6. SIGNIFICANCE OF VALUES

6.1 Falls Dam Site

Although there was limited Spring annual habitat present, no plants were recorded. In particular, there was limited suitable gravelly habitat for *Mysotis brevis* on the quartz sluicing fans behind the huts, and gravel riverbed habitats along Johnstone Creek and upper Manuherikia River, but much of the river bed habitat has been invaded by tall exotic grasses, thereby reducing the extent of potential habitat.

Only limited areas of sunny stock camp faces that provide suitable potential habitat for New Zealand mousetail and *Ceratocephala pungens* is present, but no plants were recorded.

No Spring annual species were recorded during the ecological survey on Home Hills pastoral lease during its tenure review inspection (DOC, 2006); or further up the Manuherikia valley on Mt St Bathans Station and adjoining conservation land during a threatened plant and Spring annual survey conducted as part of a feasibility study of coal mining at the Hawkdun lignite field for L&M Lignite Hawkdun Ltd (Wildlands, 2011).

6.2 Proposed Ida Burn Dam Site

No Spring annual plants were previously recorded on nearby Little Mt Ida pastoral lease during its tenure review inspection (DOC, 2010).

There are extensive areas of suitable stock camp habitat for New Zealand mousetail and *Ceratocephala pungens* present within the proposed dam footprint, but only New Zealand mousetail was recorded, and only on the longest and highest ridge present. While ephemeral wetland depressions were found, none of these supported New Zealand mousetail.

The population of New Zealand mousetail is estimated to be around 15000 plants. When compared with other populations, usually associated with ephemeral wetlands where New Zealand mousetail forms a dense extensive sward, this population is dispersed, smaller, and the associated vegetation is dominated by exotic species.

The New Zealand mousetail plants are located between 675 and 690m asl, so it will be the habitat below 680m that will be lost if the maximum dam height was built. New Zealand mousetail is an annual, so it is the loss of the seed bank and habitat that is of concern rather than the loss of the plants recorded during this survey.

While the higher part of the ridge will not be inundated, its extent will be limited to a narrow sliver extending into the proposed dam footprint. This habitat will likely be affected by wave action that would further erode away the soil. In addition there is likely to be a change in grazing pressure as stock may not concentrate on the tongue of land remaining. This would result in an increase in groundcover and biomass present, and a loss of the turf/mat herbfield community currently maintained by high grazing pressure. The other potential stock camp habitat found within the dam footprint would be inundated.

While no survey was made in the immediate surroundings to the proposed dam site, there may be potential sites on e.g. Seagull Hill for seed collected within the dam footprint, to be dispersed, thus establishing new populations.

Significance of Values

New Zealand mousetail is a threatened plant, ranked Nationally Endangered on the latest threat classification (de Lange *et al.* 2012)). It is endemic to New Zealand, and restricted to the eastern part of South Island. Its small size, and short time in which it is readily visible has probably contributed to it being overlooked.

It is more commonly found in ephemeral wetlands and depressions, where it can form an almost 100% dense cover, but also grows in turfs around e.g. kettleholes.

Threats to New Zealand mousetail nationally include loss of habitat through invasion by faster growing taller, or turf forming plants, including *Plantago coronopus*, broom and wilding pines. Changes in land use from mixed sheep/cattle and sheep farms to intensive cattle grazing, especially in Otago and Canterbury, is resulting in cultivation and increased demand for irrigation water. The use of bore water, and establishment of canals has reduced the number and extent of ephemeral wetlands, kettleholes and tarns once colonized by New Zealand mousetail and other marginal turf plants.

Its presence at Ida Burn on a hillslope growing amongst weedy competitive species such as mouse-eared hawkweed, browntop and Chewing's fescue is therefore an interesting finding. The exotic grasses are kept low by hard grazing by sheep, cattle, hares and geese. It is possible that this highly modified stock camp habitat is a substitute for a nutrient rich turf habitat once maintained by now extinct birds.

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APPENDIX 1: Photos of New Zealand mousetail plants and habitat at Ida Burn dam site.

Plate 6 & 7: NZ mousetail scattered amongst mouse-eared hawkweed and turf coprosma and dung.

Plate 8: NZ mousetail in dense exotic grass sward.

Plate 9: Stock camp habitat – toe slope.

Plate 10: Main NZ mousetail population growing on mouse-eared hawkweed dominated stock camp.

Plate 11 & 12: Northernmost record found in depression (Plate 12) on this stock track in localized stock camp area within snow tussock grassland.

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