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*.

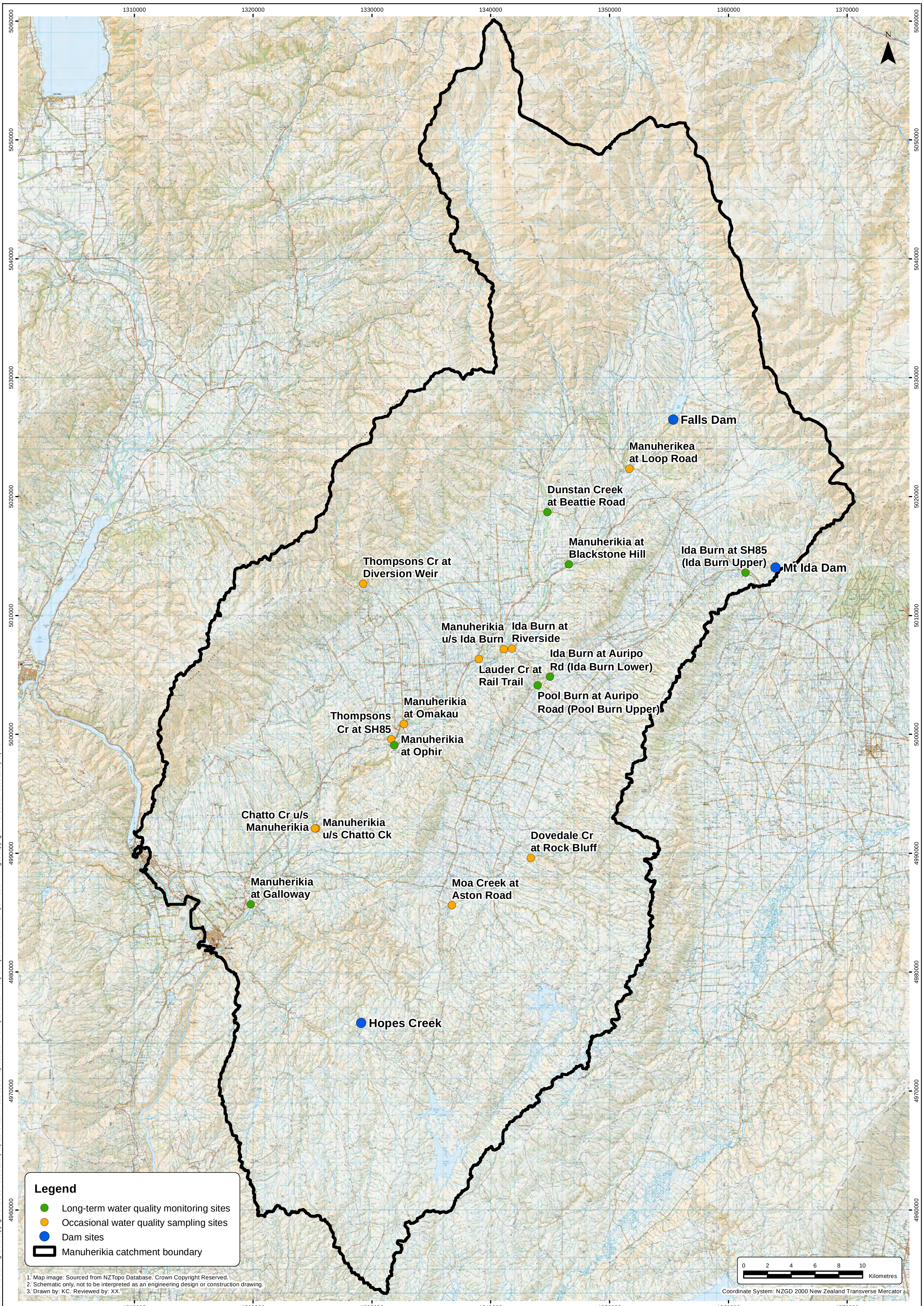
Results for laboratory analyses of nutrients (total ammoniacal nitrogen, nitrate-N, nitrite-N, total nitrogen (TN), dissolved reactive phosphorus (DRP), and total phosphorus (TP)) are presented in Table B-3. Data for total suspended solids, turbidity, faecal coliforms and E coli are presented in Table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

JUNE 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 m². 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 m²) 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.

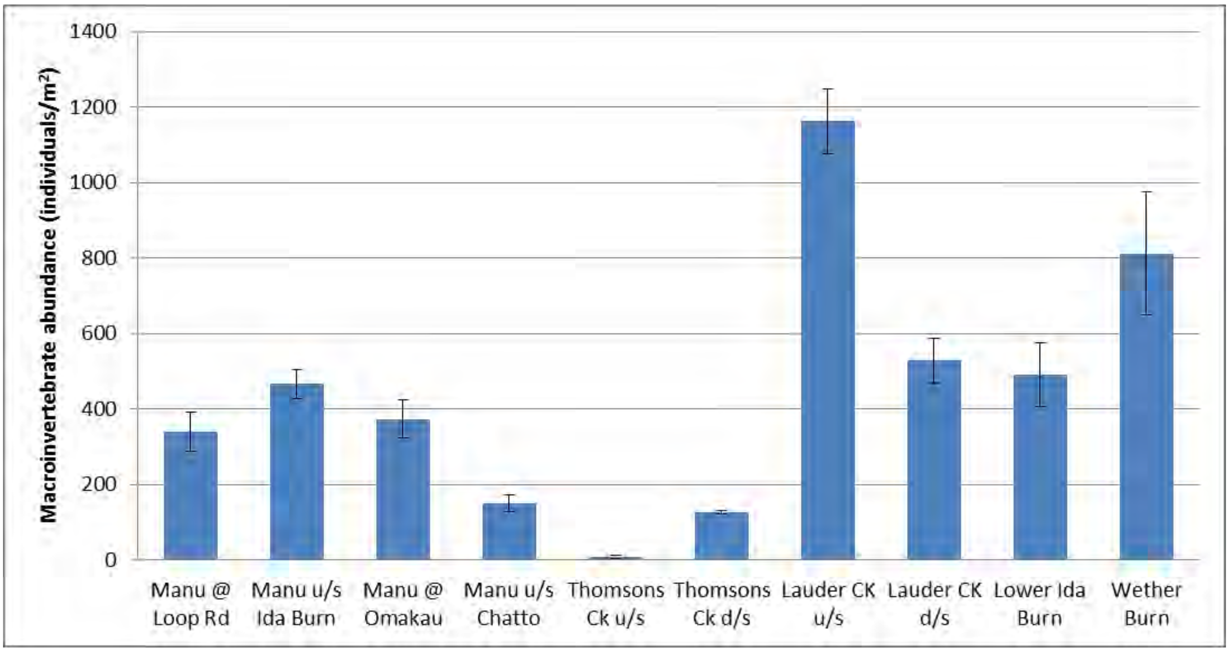


Figure B-9: Macroinvertebrate abundance (±1 standard error) at sites in the Manuherikia study area.

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.

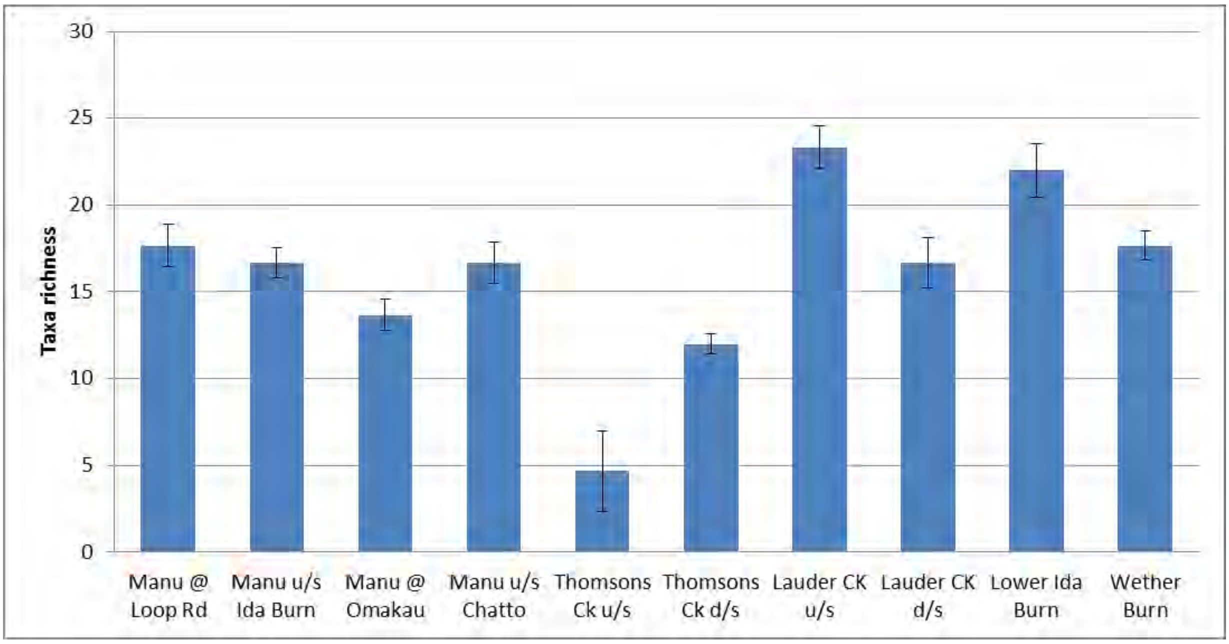


Figure B-10: Macroinvertebrate taxa richness (±1 standard error) at sites in the Manuherikia study area.

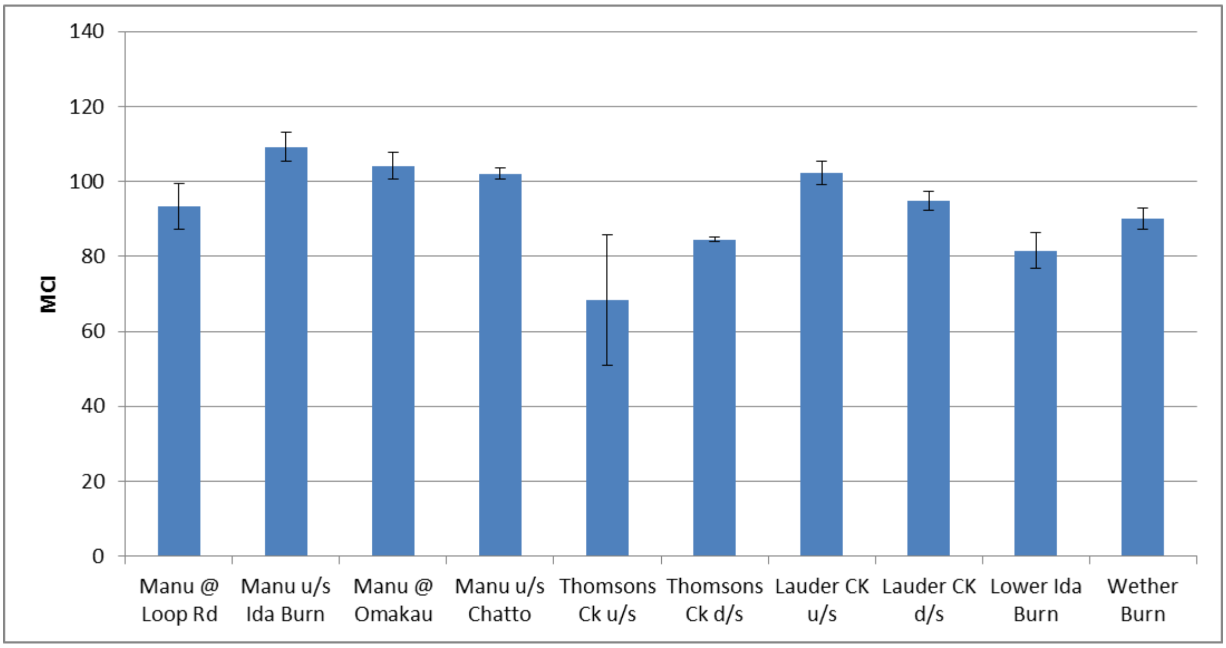


Figure B-11: MCI scores (±1 standard error) at sites in the Manuherikia study area.

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.

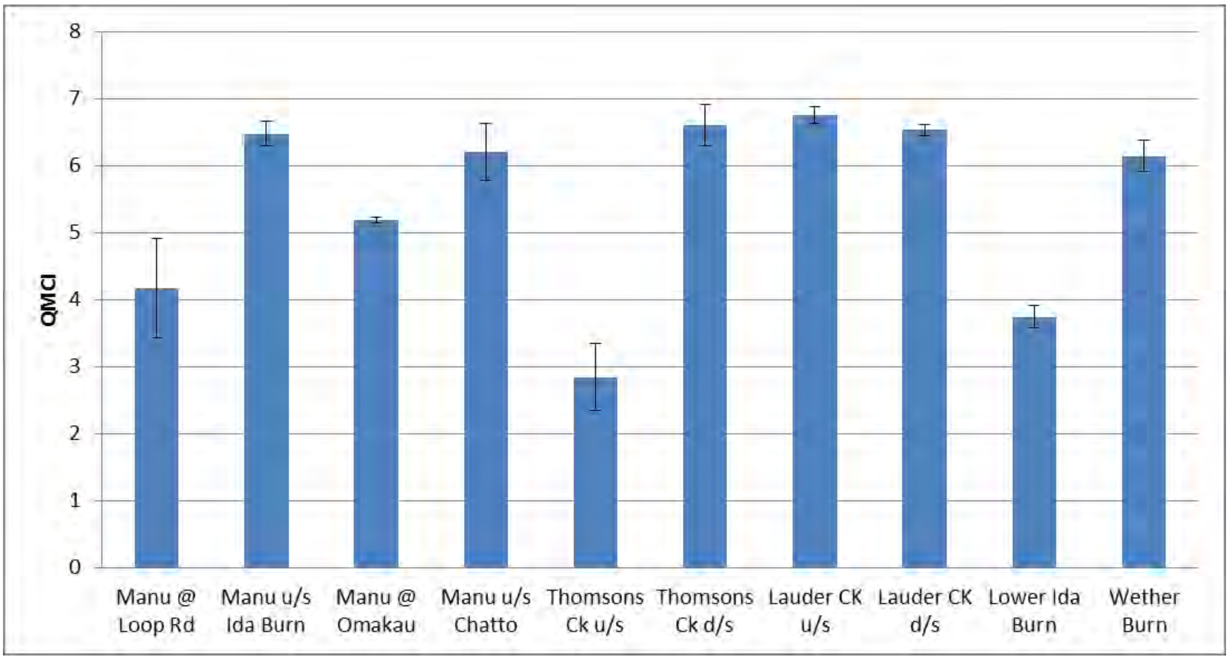


Figure B-12: QMCI scores (±1 standard error) at sites in the Manuherikia study area.

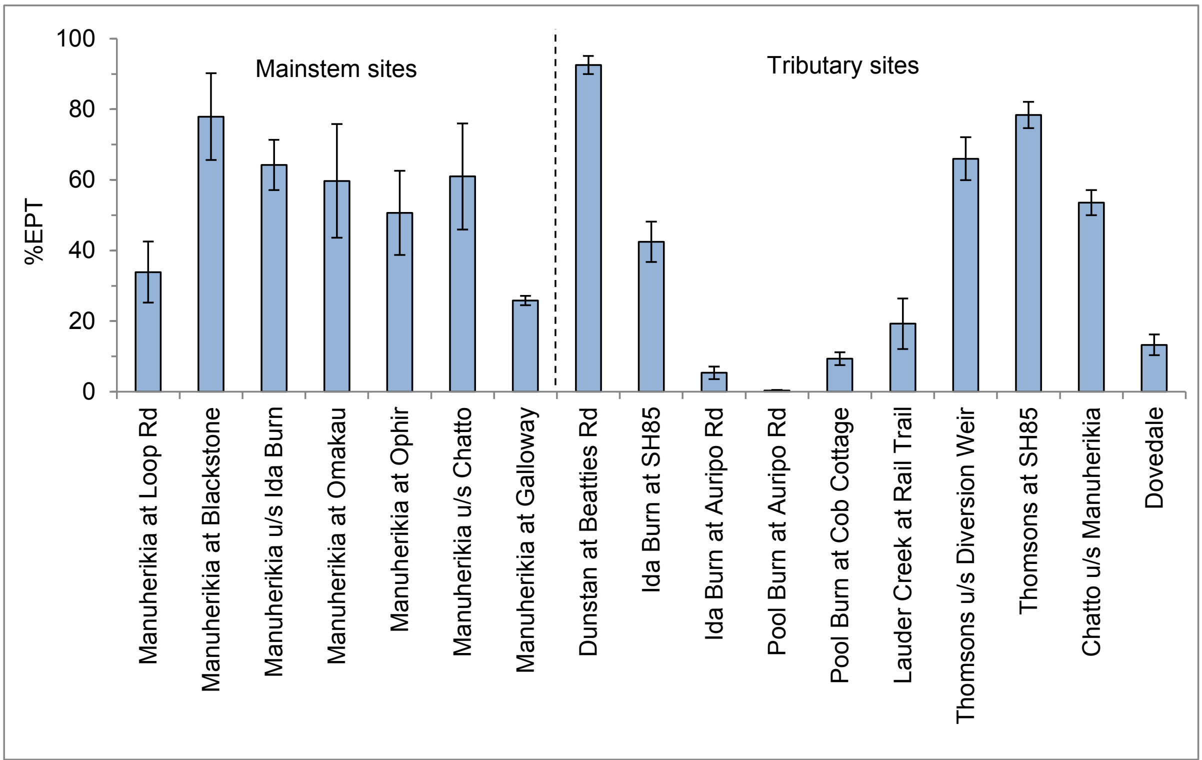
6.3 Historic Manuherikia macroinvertebrate surveys

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.

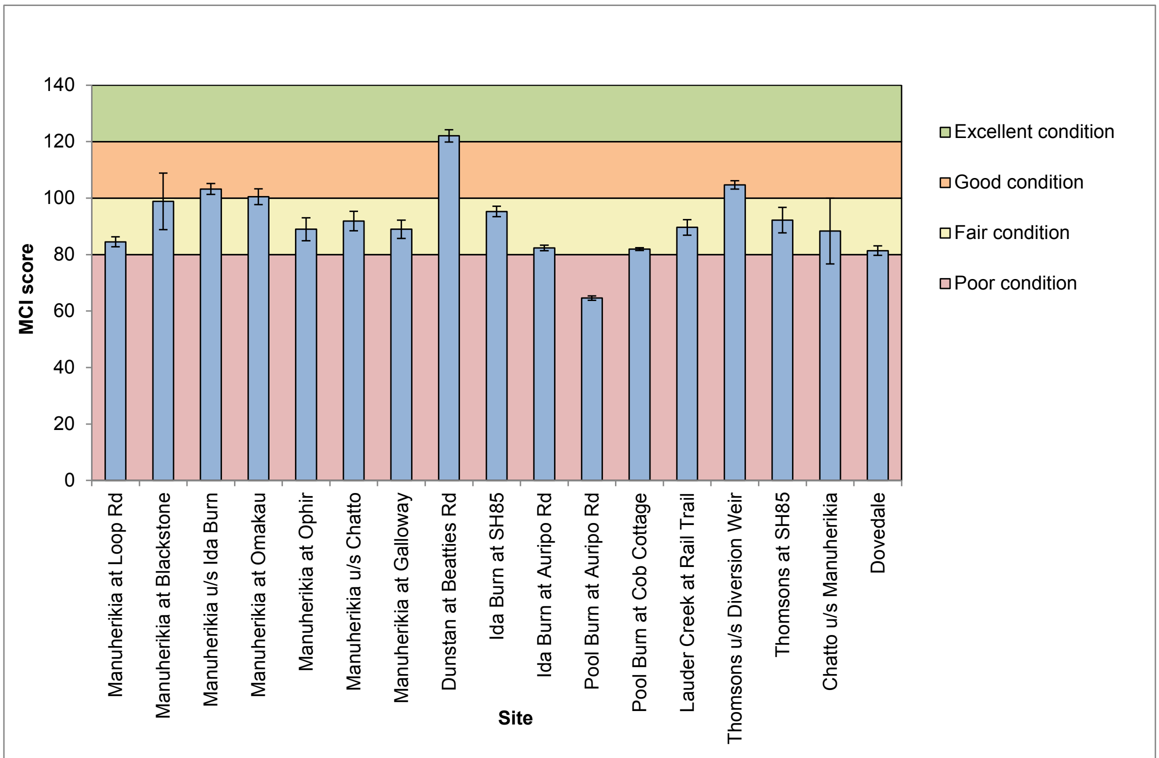
Mean macroinvertebrate Community Index (MCI) scores recorded in 2010 were highest in Dunstan Creek at Beatties Road, which was the only site to achieve a MCI score >120 and was indicative of “excellent” instream habitat or water quality conditions (Figure B-14). The macroinvertebrate community in Dunstan 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).



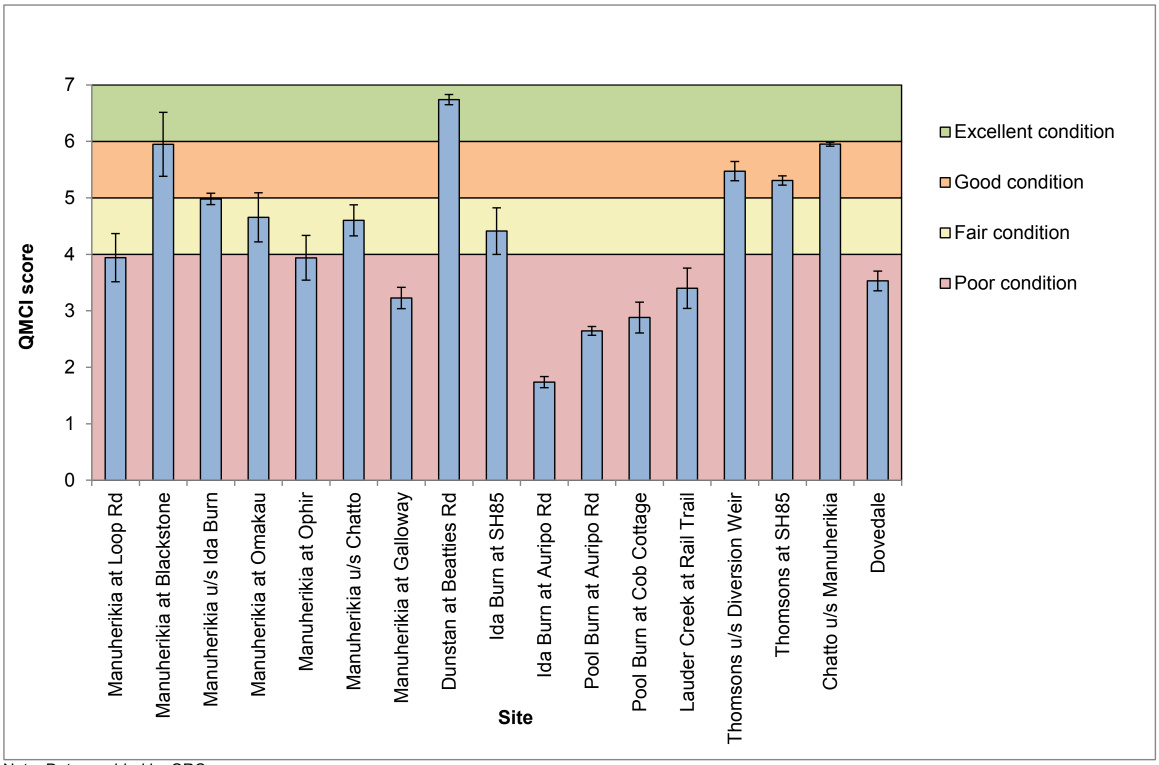
Note: Data provided by ORC.

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



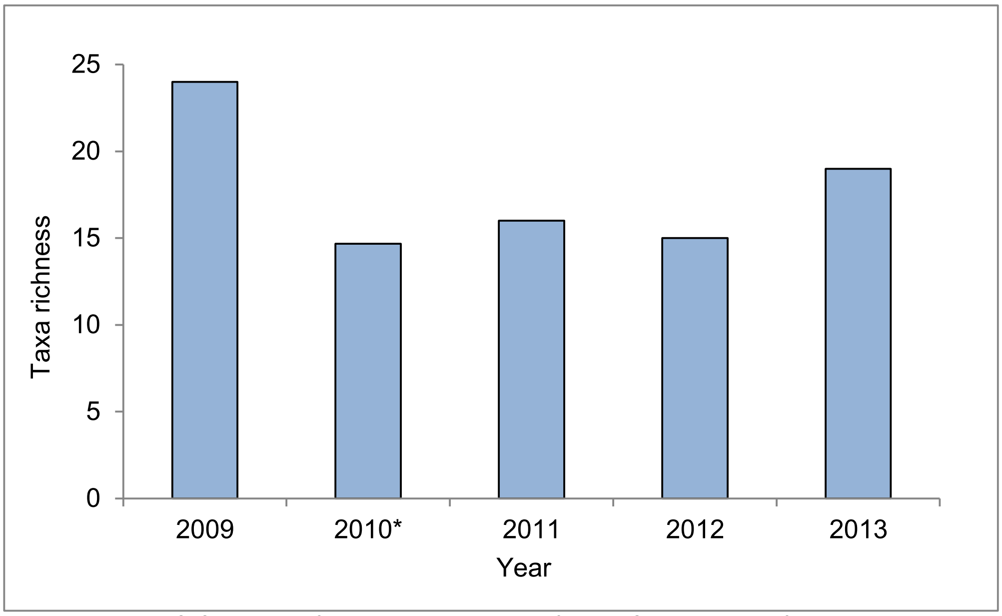
Note: Data provided by ORC.

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



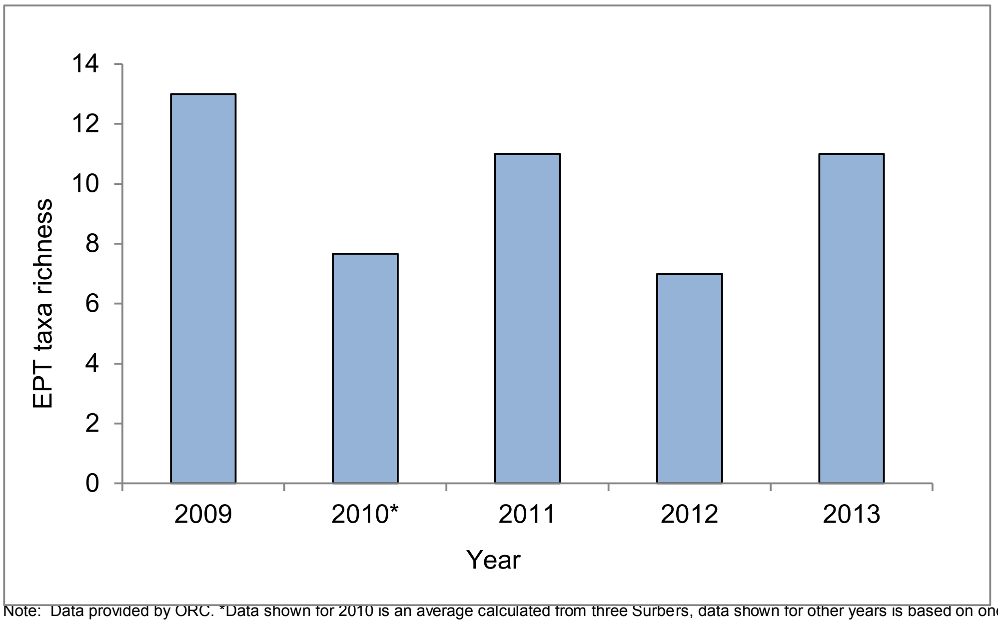
Note: Data provided by ORC.

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.

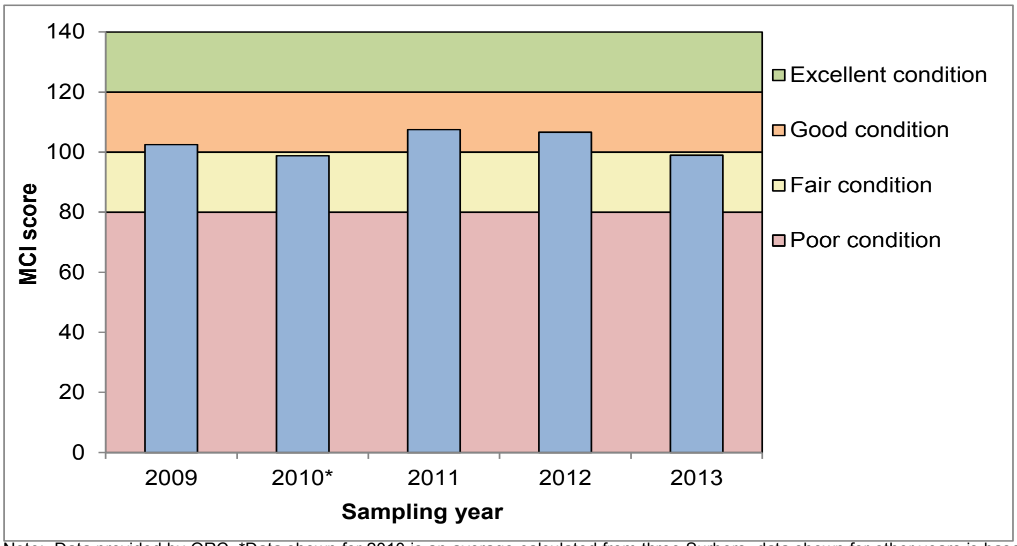


Note: Data provided by ORC. *Data shown for 2010 is an average calculated from three Surbers, data shown for other years is based on one kick-net sample. EPT richness excludes Hydroptilid caddisflies.

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

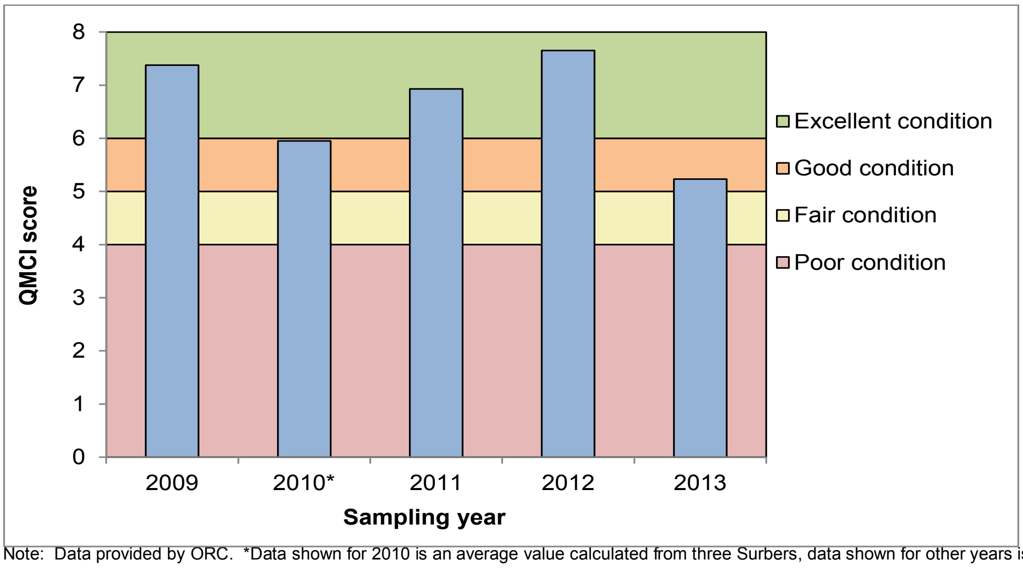
SQMCI scores recorded in the Manuherikia River at Blackstone Hill have ranged from 5.2 to 7.7, with scores being indicative of water and/or habitat quality in the “good” to “excellent” category (Figure B-19). SQMCI recorded in 2013 indicated a decline in “health” compared to previous years. However, 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 (≈ m^2)	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

Wildlands

R3510a

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

Contract Report No. 3510

January 2015

Project Team:
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CONTENTS

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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.

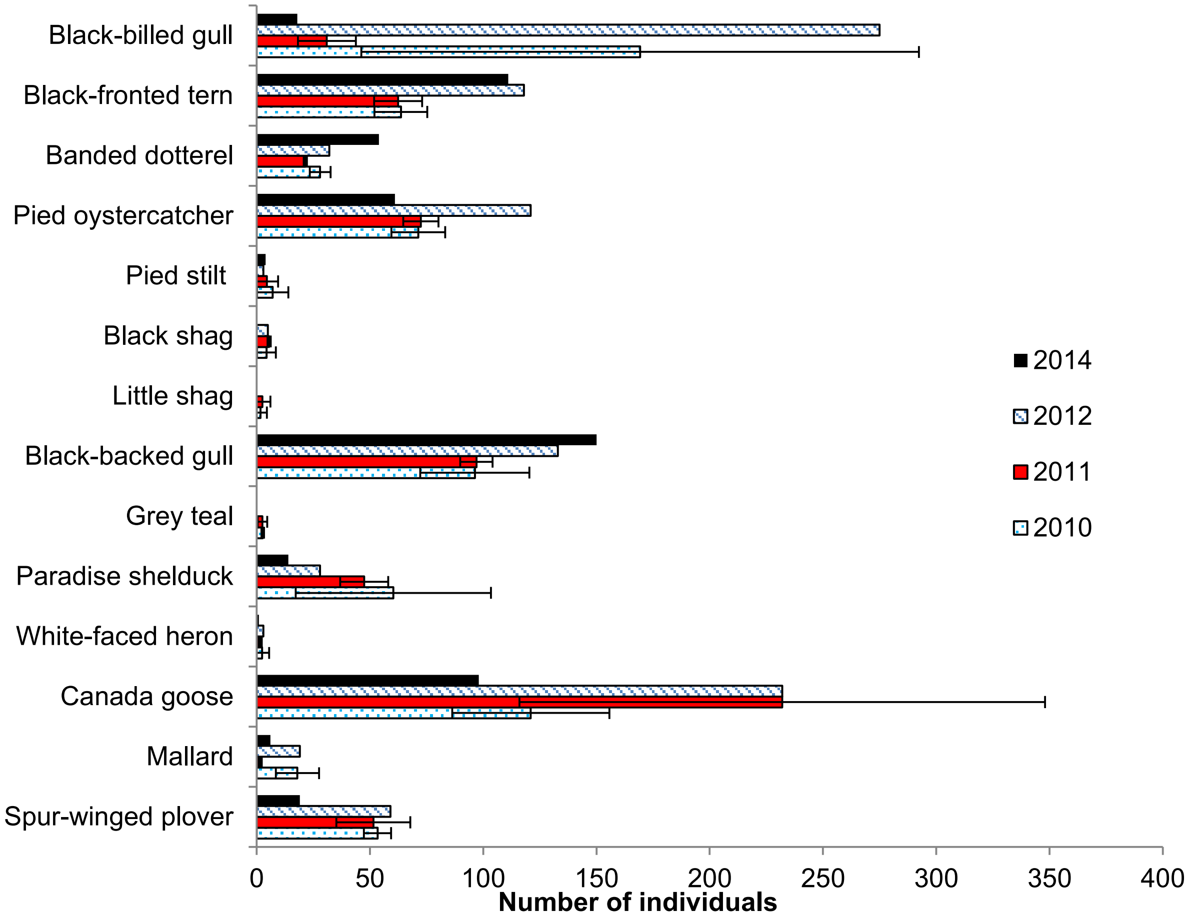
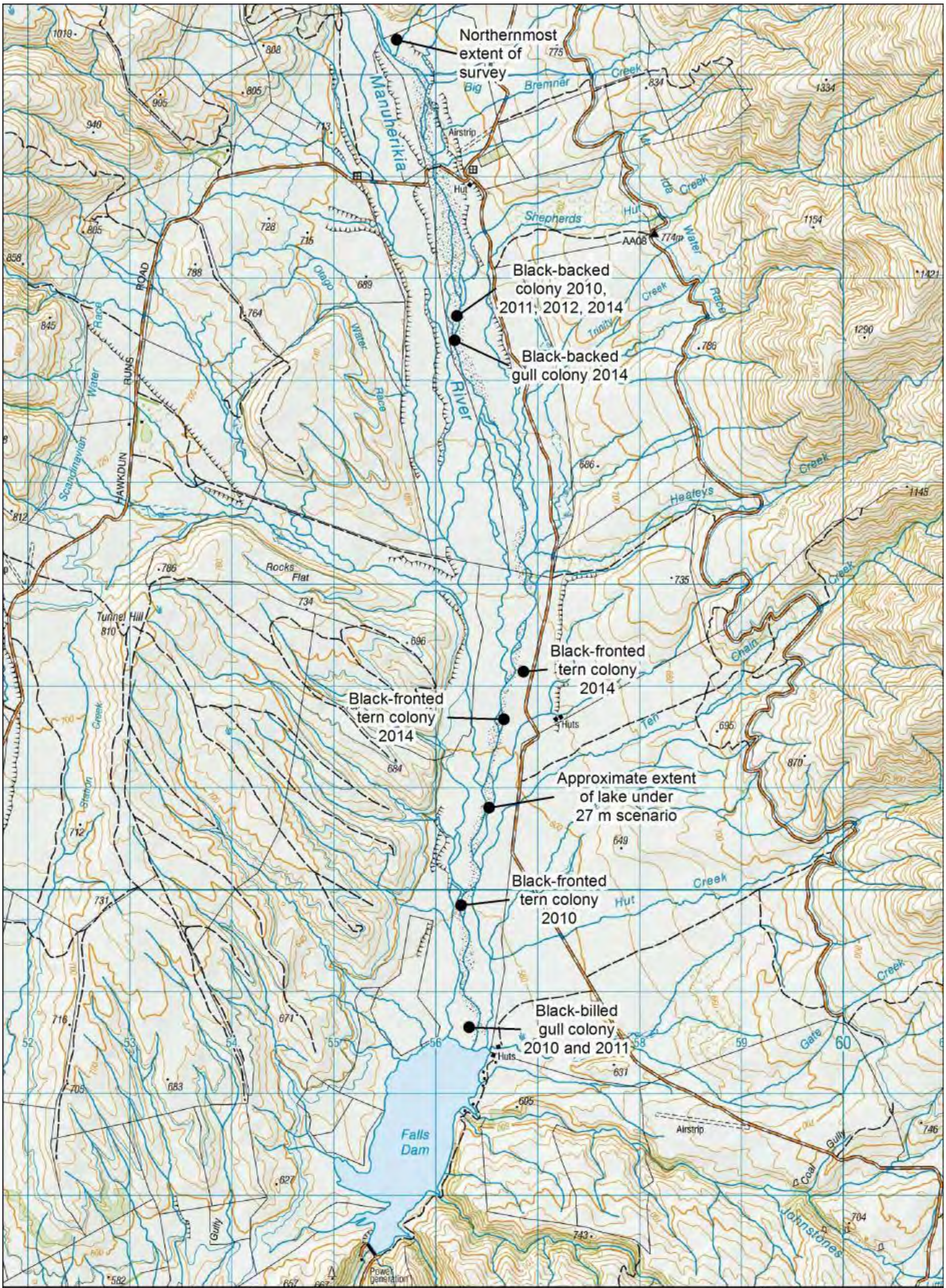


Figure 2: Mean number of birds observed on the braided section of the Manuherikia River, 2010-2014. Error bars indicate one standard deviation (only single counts were completed in 2012 and 2014).



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Data Acknowledgment
Map contains data sourced from LINZ
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Colony locations 2010-2012, 2014, Manuherikia River, Central Otago

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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

[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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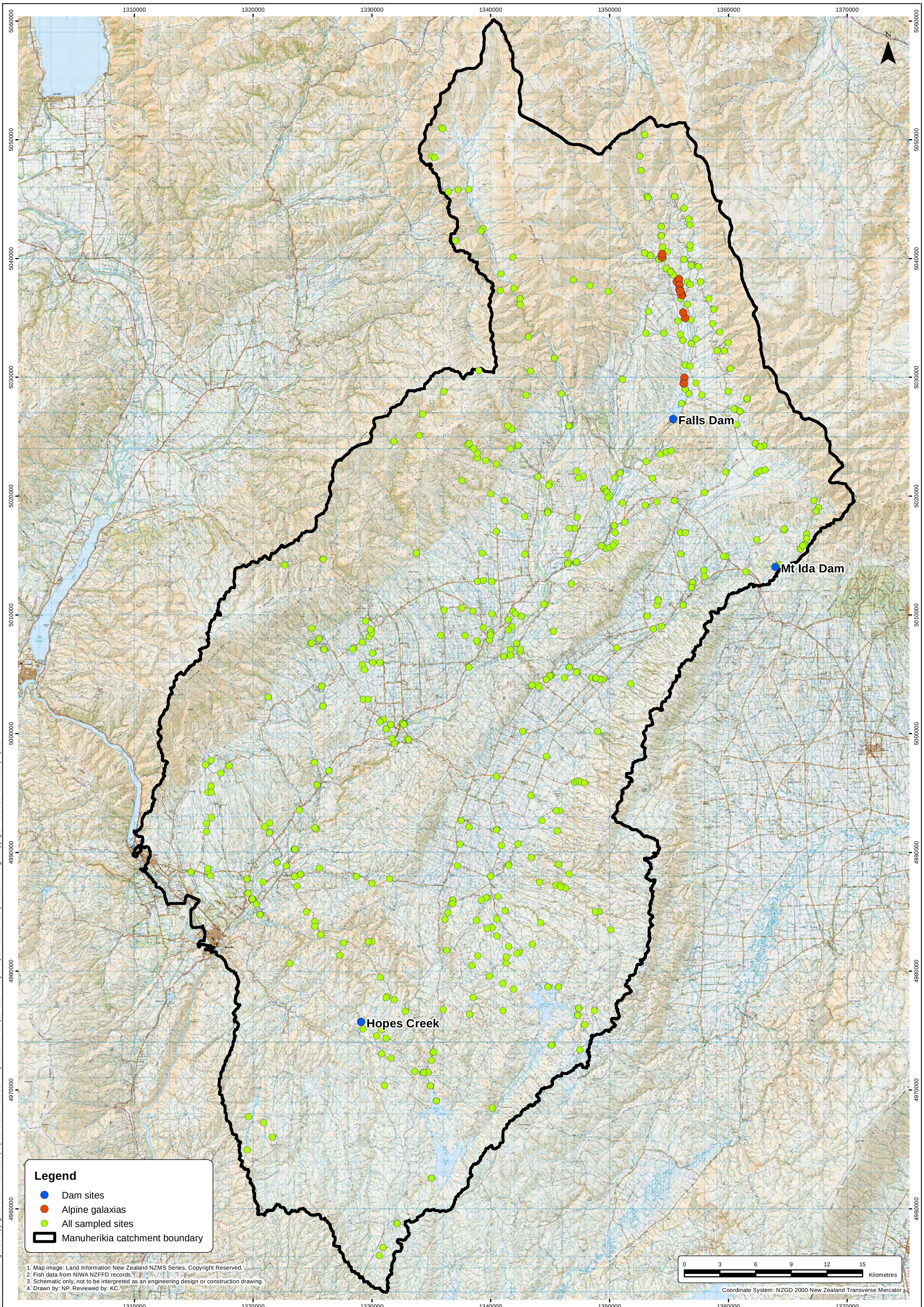
APPENDIX D

Native Fish Distribution (Freshwater Fish Database)



Golder Associates

TITLE MANUHERIKIA ALPINE GALAXIAS SITES REPORTED IN THE NZFFD

JUNE 2015

PROJECT 1378110270

D1

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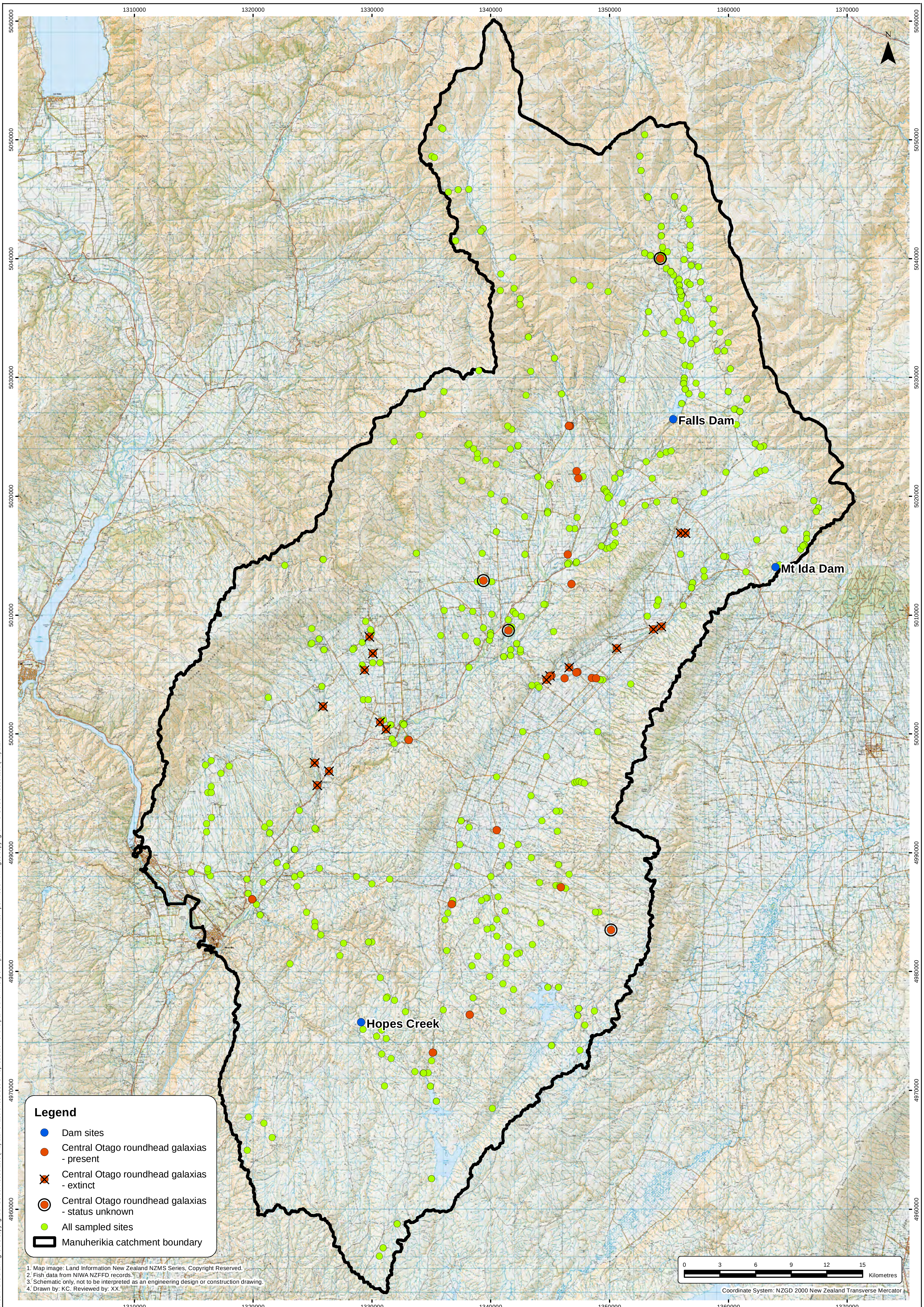

Golder Associates

TITLE CENTRAL OTAGO ROUNDHEAD GALAXIAS SITES REPORTED IN THE NZFFD

JUNE 2015

PROJECT 1378110270

D2

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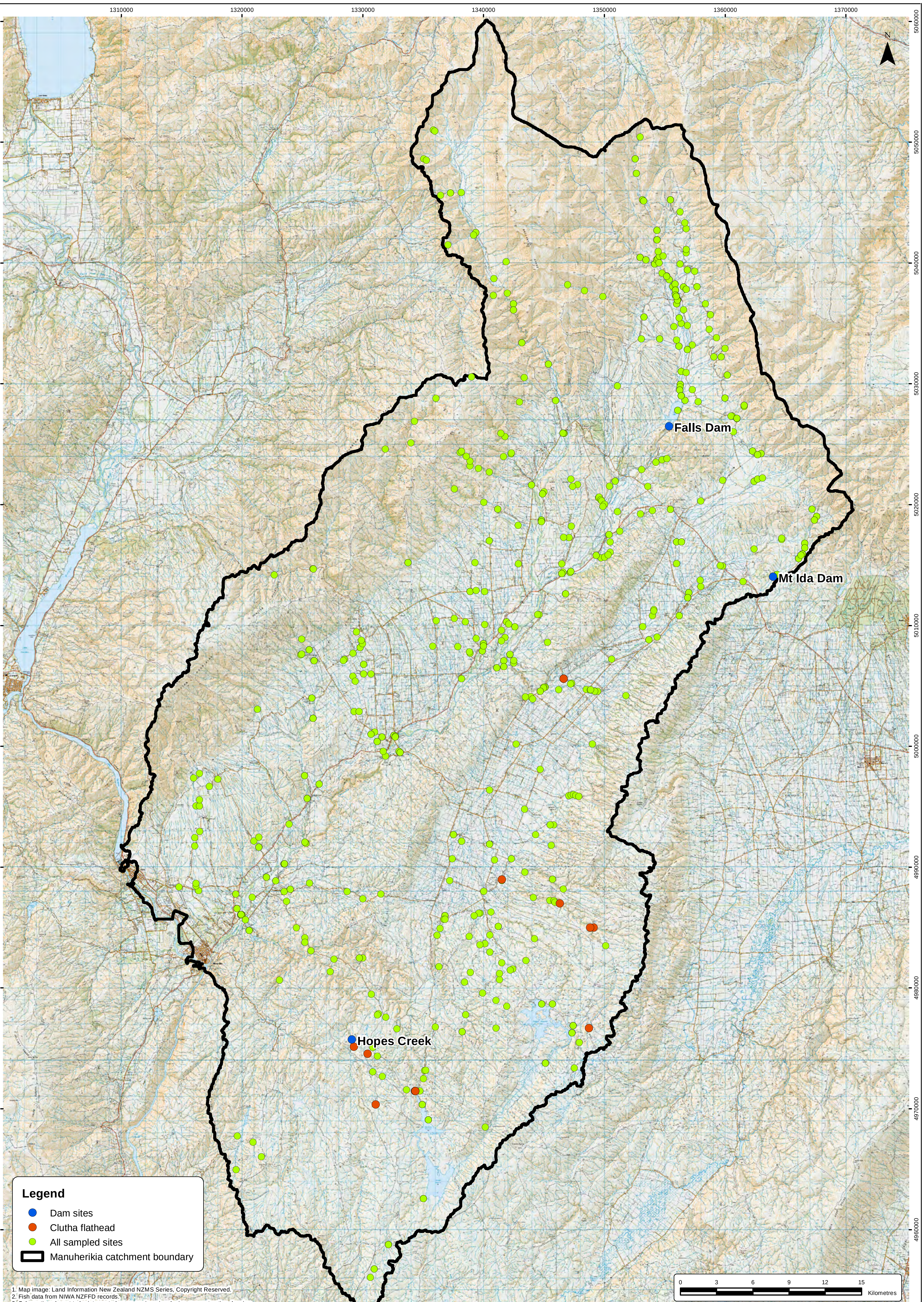

1. Map image: Land Information New Zealand NZMS Series, Copyright Reserved.
2. Fish data from NIWA NZFFD records.
3. Schematic only, not to be interpreted as an engineering design or construction drawing.
4. Drawn by: NP. Reviewed by: KC.

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TITLE CLUTHA FLATHEAD SITES REPORTED IN THE NZFFD

JUNE 2015

PROJECT 1378110270

D3

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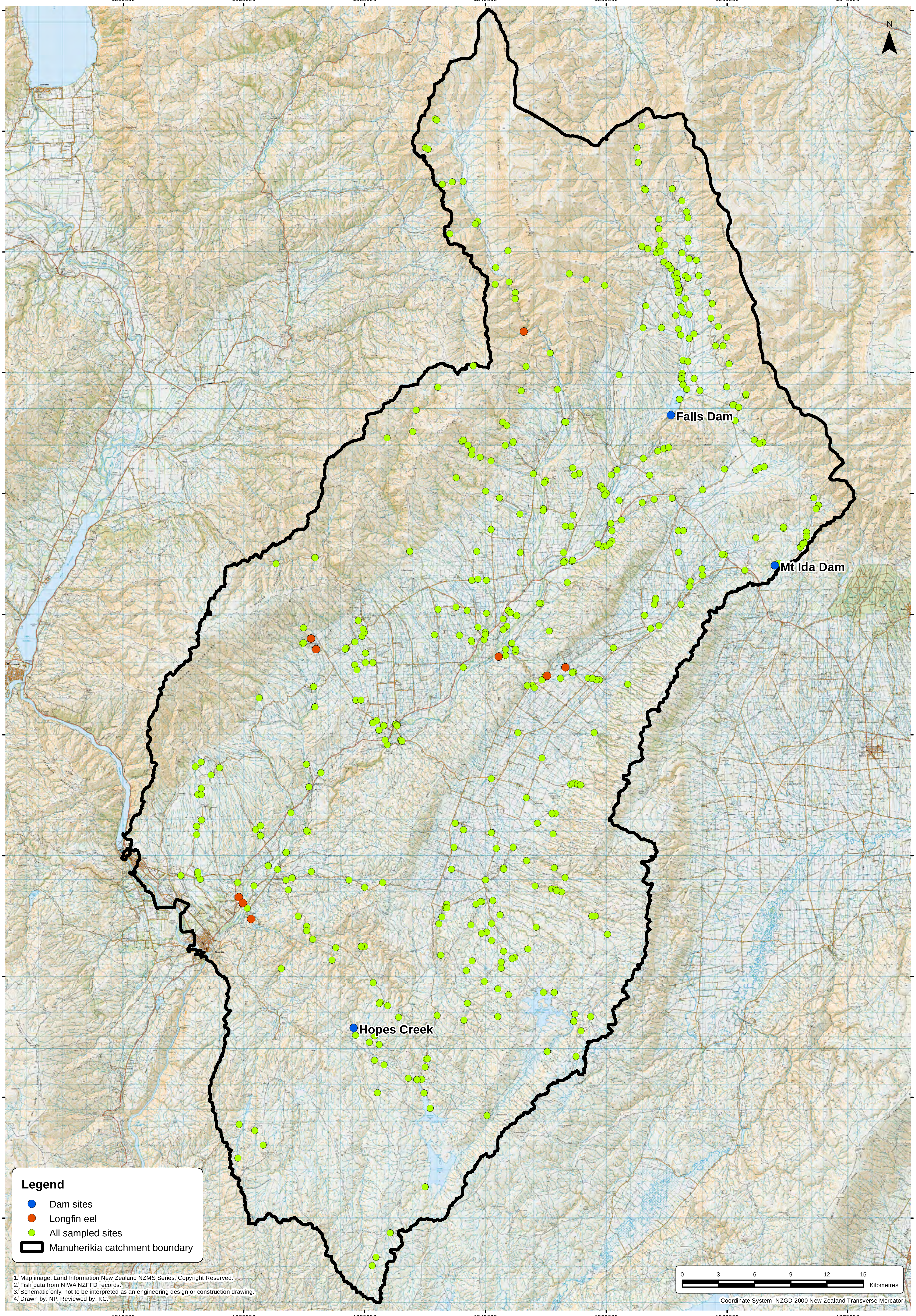

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JUNE 2015

PROJECT 1378110270

D4

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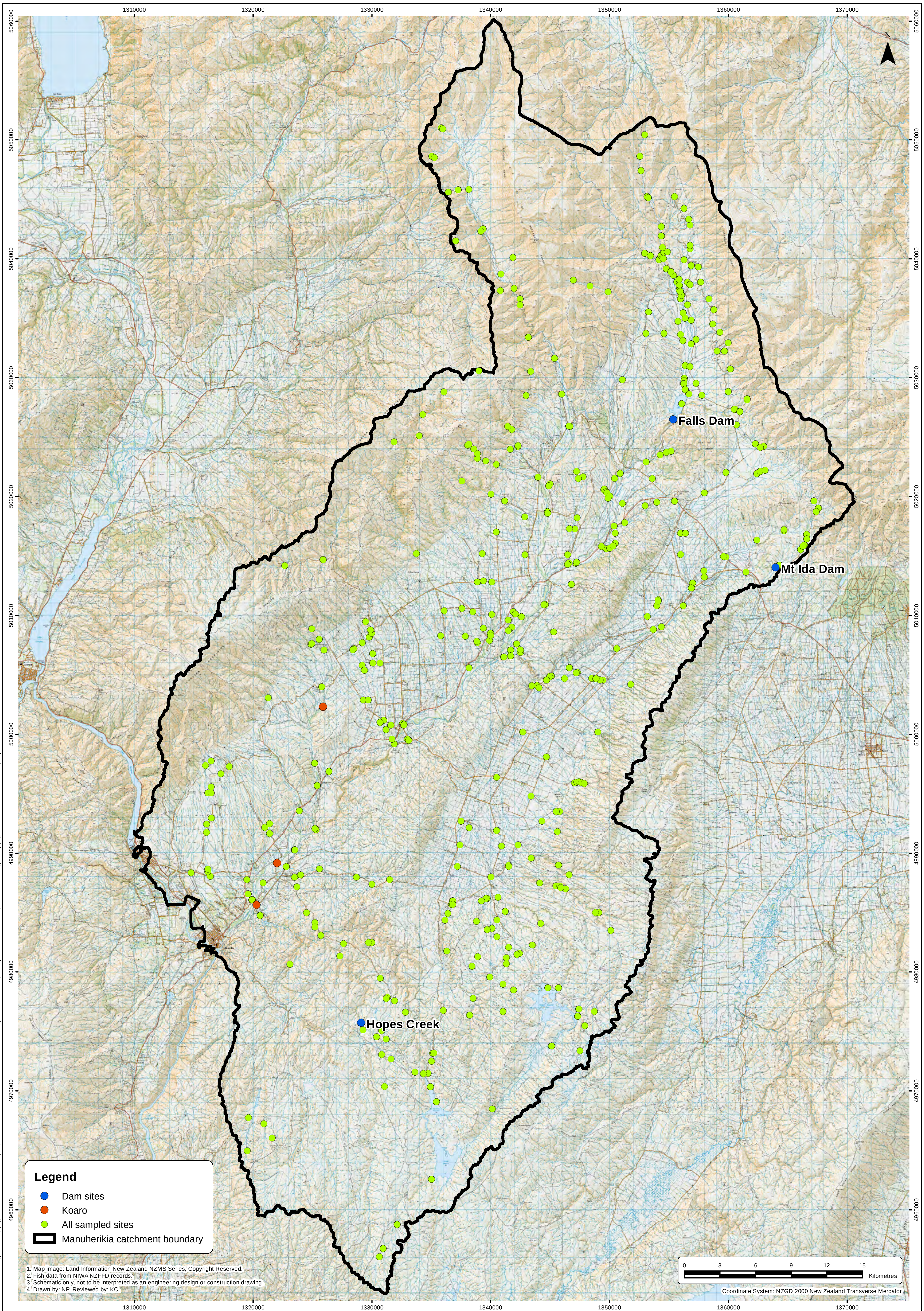

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TITLE KOARO SITES REPORTED IN THE NZFFD

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PROJECT 1378110270

D5

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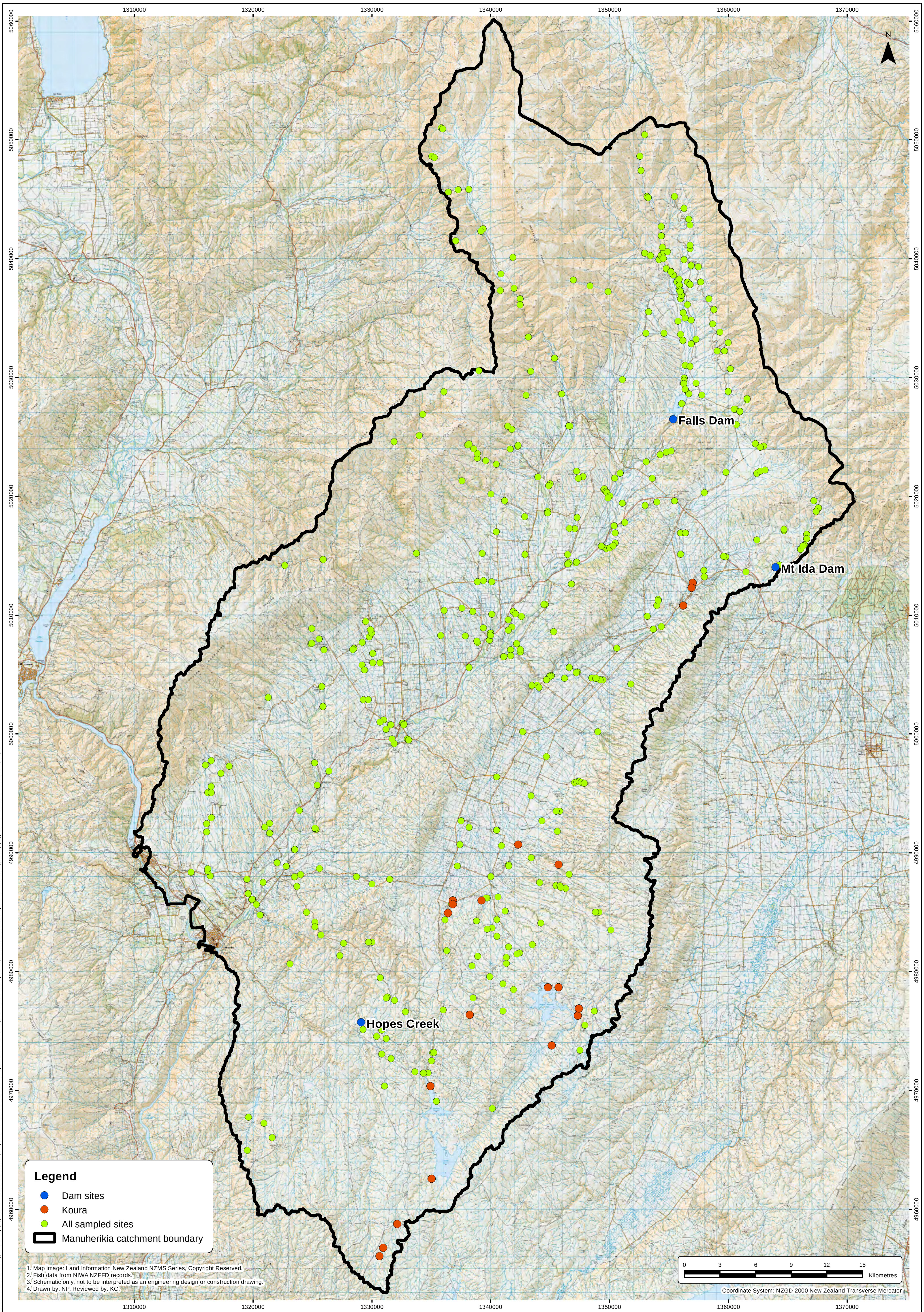

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TITLE KOURA DISTRIBUTION IN THE MANUHERIKIA RIVER CATCHMENT (DATA SOURCED FROM THE NZFFD)

JUNE 2015

PROJECT 1378110270

D6

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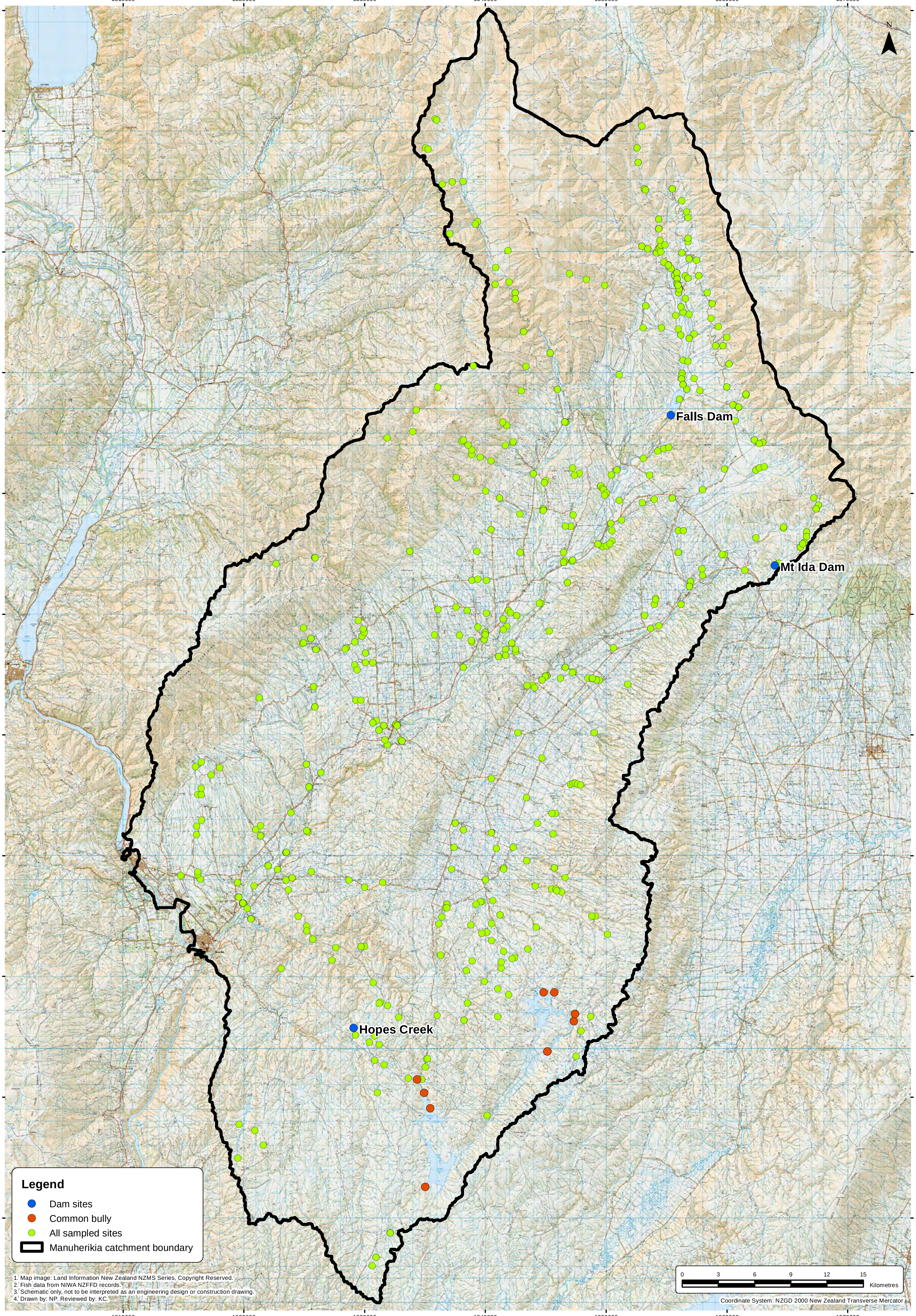

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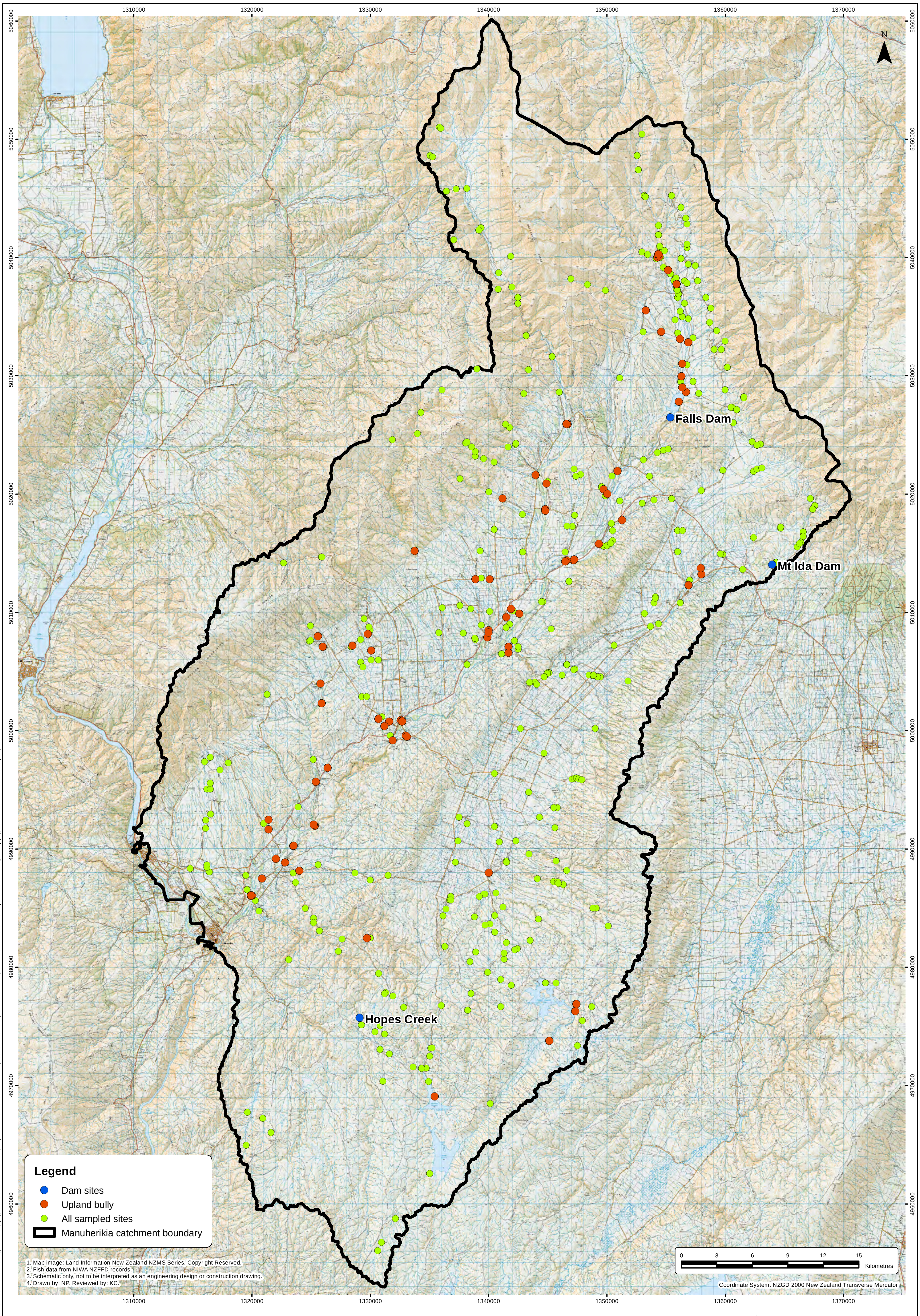

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JUNE 2015

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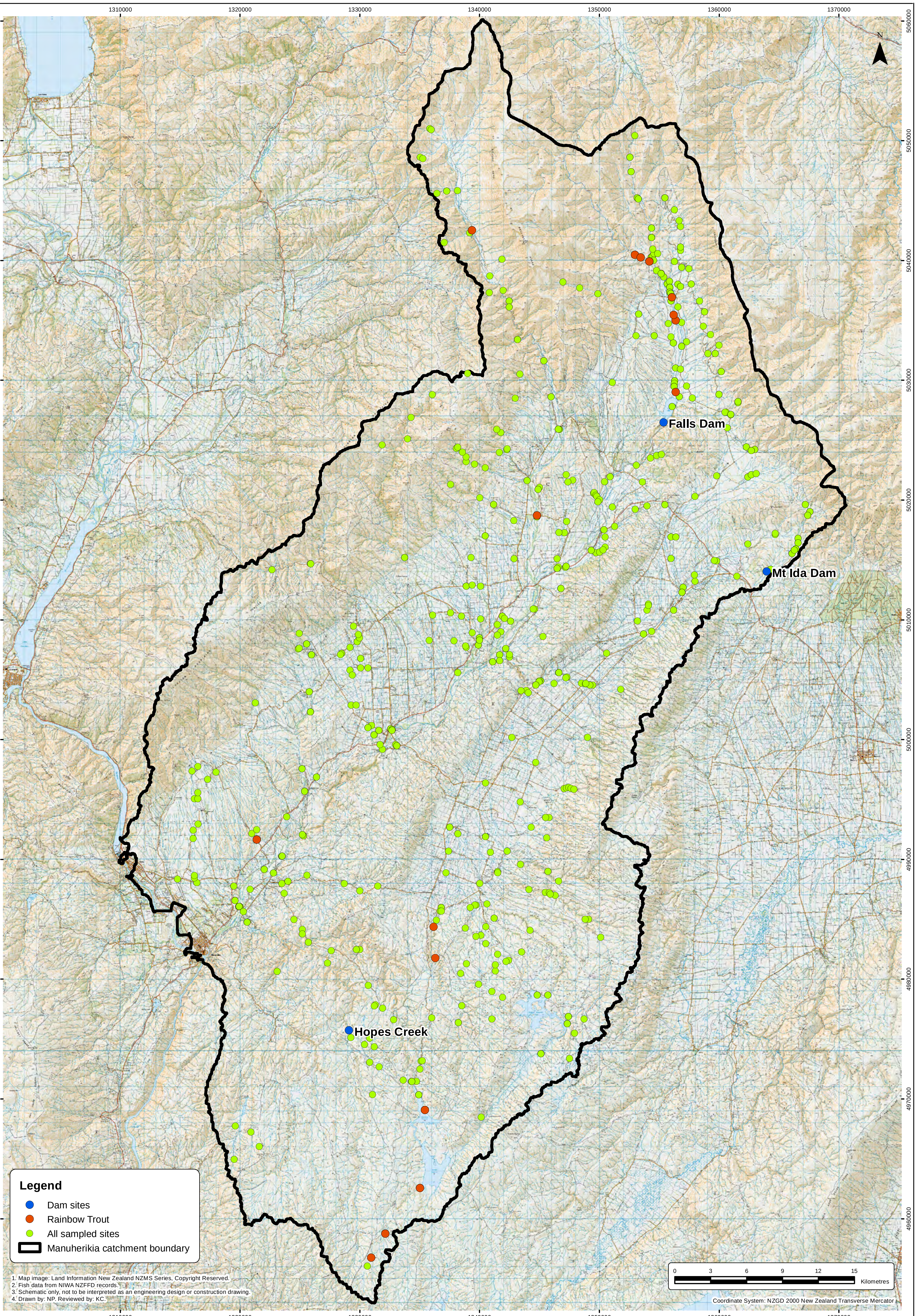

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TITLE RAINBOW TROUT SITES REPORTED IN THE NZFFD

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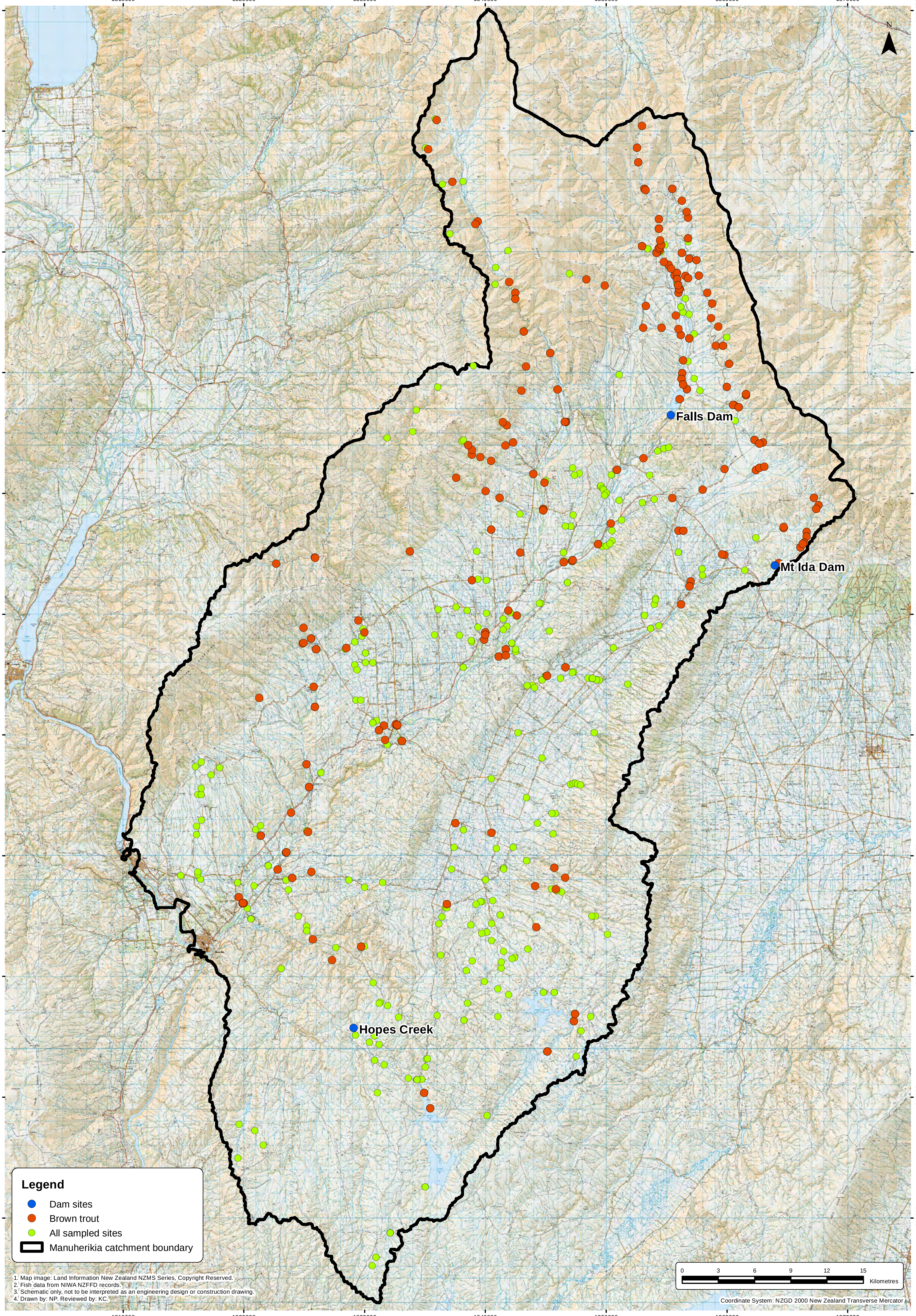

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TITLE BROWN TROUT SITES REPORTED IN THE NZFFD

JUNE 2015

PROJECT 1378110270

D10

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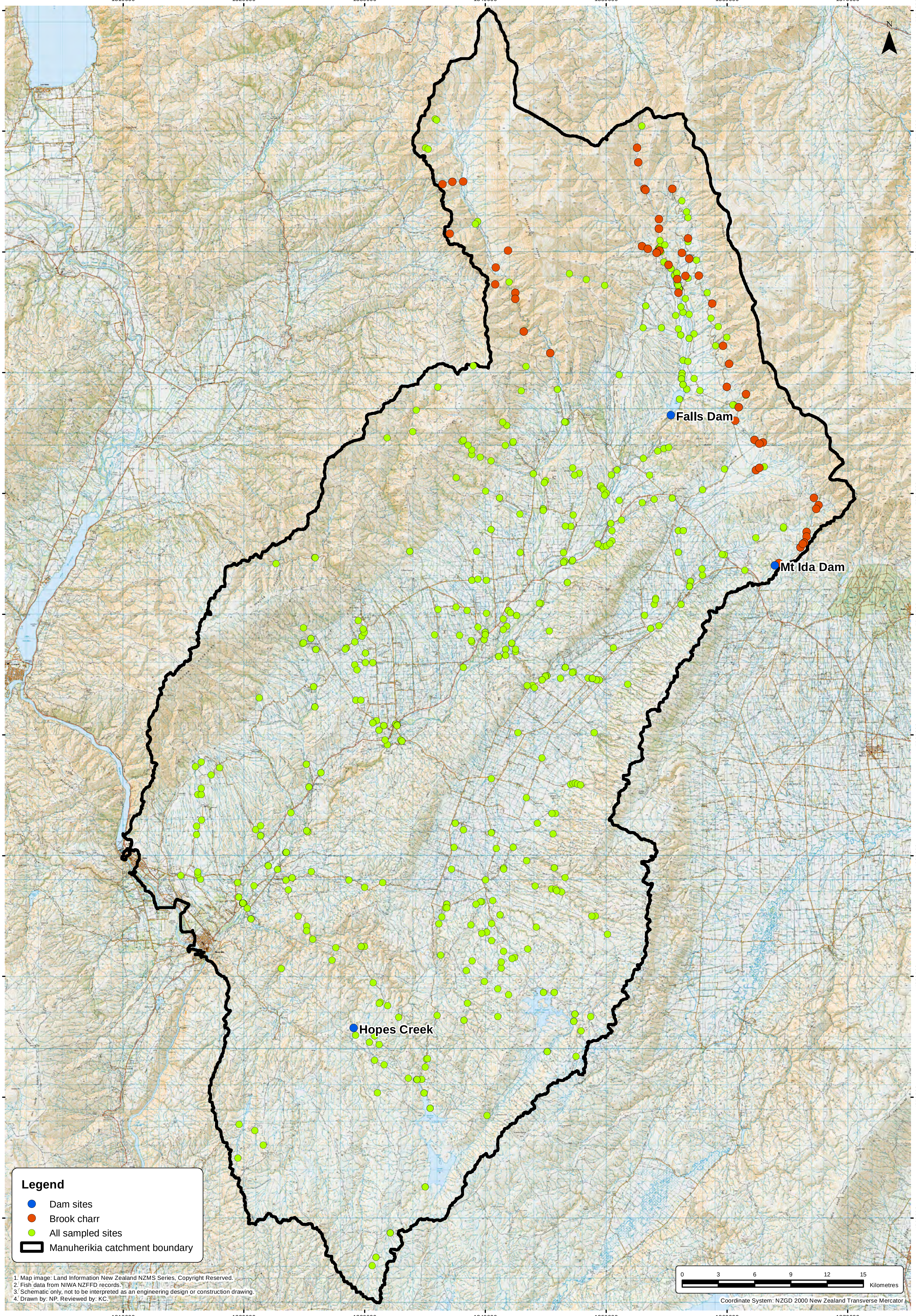

Golder Associates

TITLE BROOK CHAR SITES REPORTED IN THE NZFFD

JUNE 2015

PROJECT 1378110270

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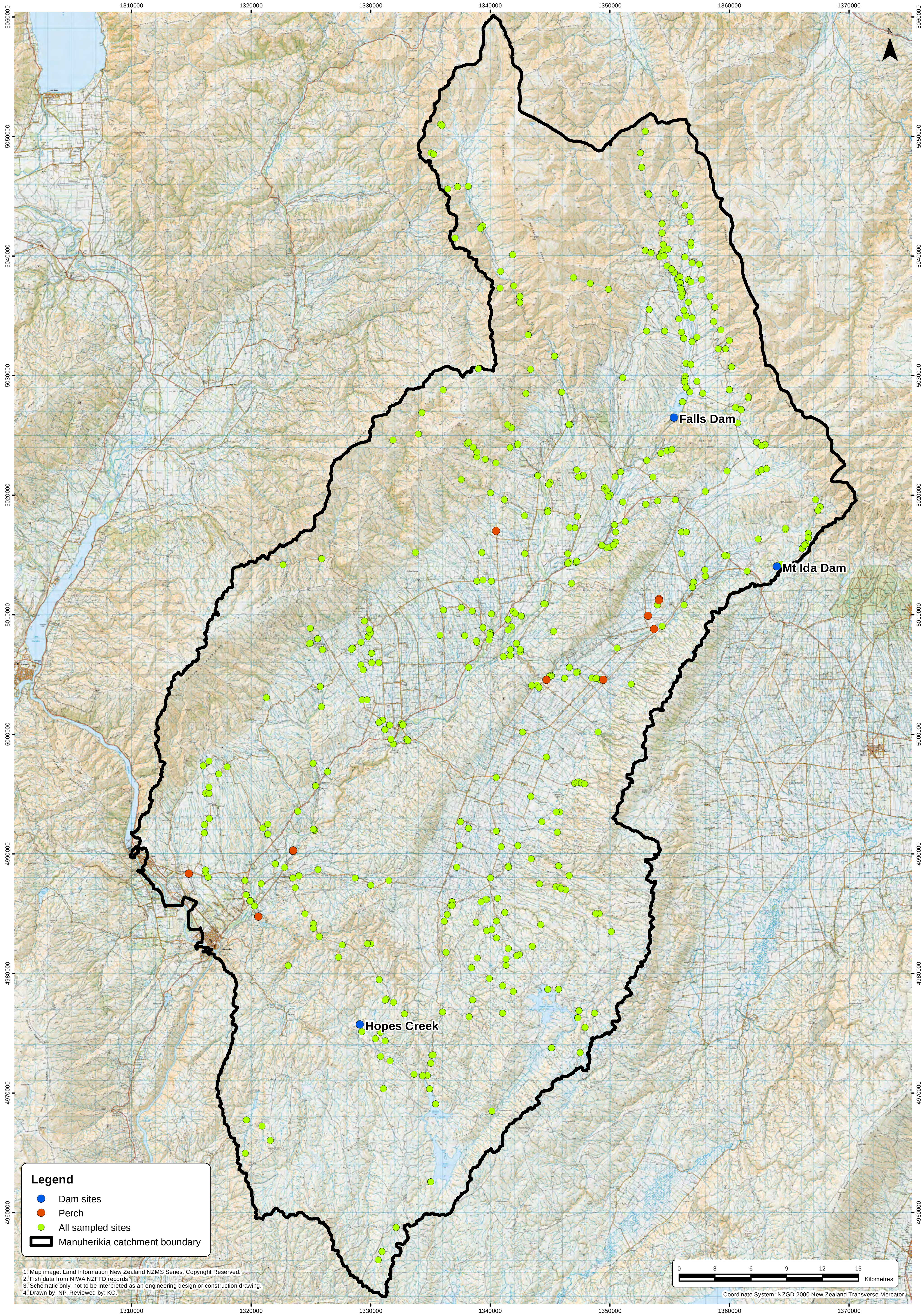

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JUNE 2015

PROJECT 1378110270

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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

Prepared by:
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Prepared For:
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New Zealand

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

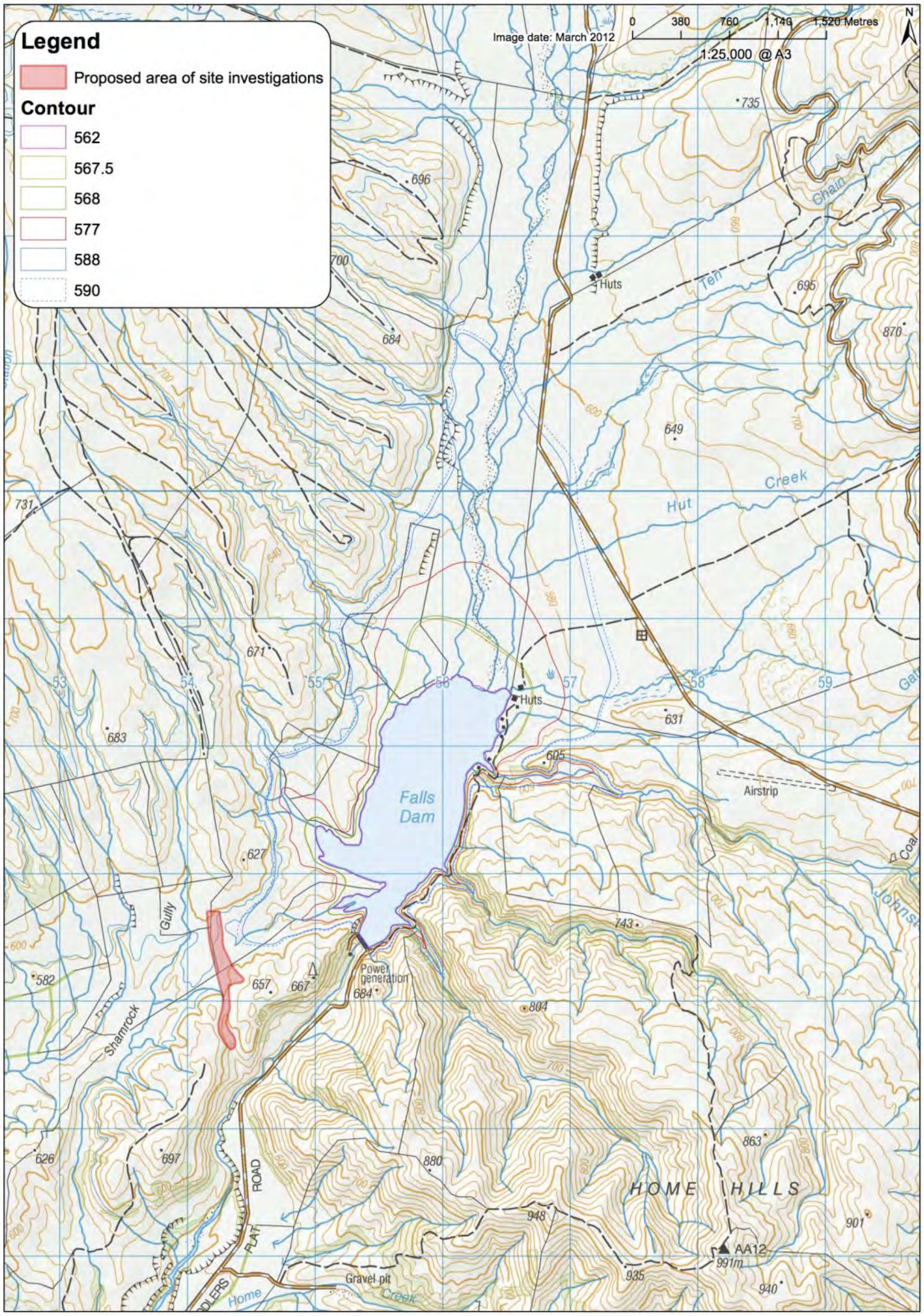
4.1 Falls Dam Site

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).

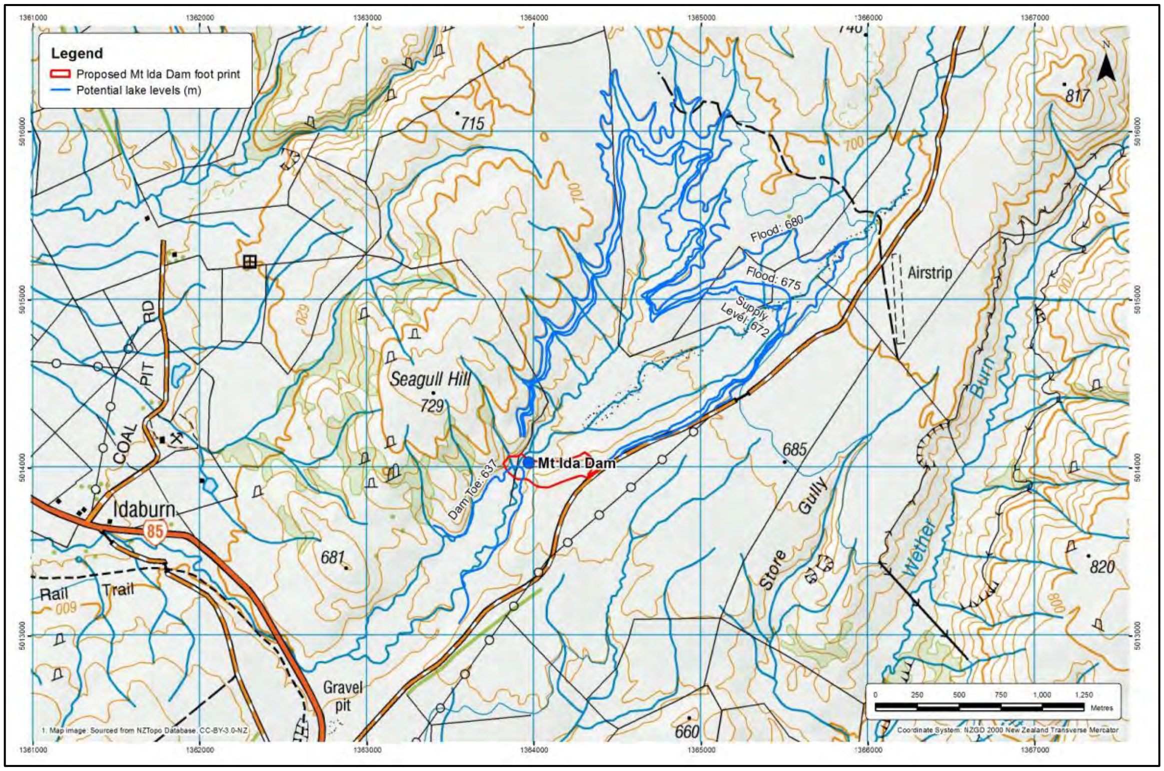


Figure 2: Location map of Ida Burn proposed dam footprint

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*).

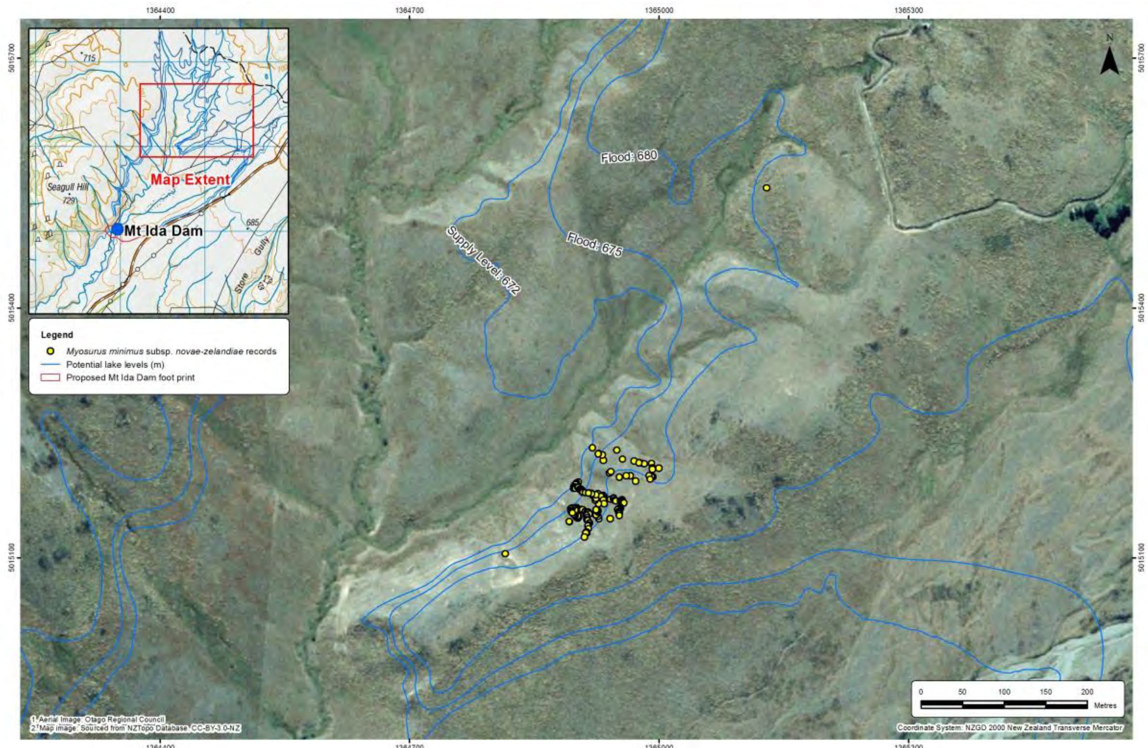


Figure 3: Location Map of New Zealand mousetail population within the highest proposed dam footprint (680m asl.)

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.

7. REFERENCES

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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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