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Tekapo Power Scheme Re-consenting

Assessment of Ecological Effects - Avifauna

Prepared for Genesis Energy Ltd
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Cover photograph: View of Takapō River (left), Pattersons Pond (centre) and Tekapo canal (right)

Executive Summary

- The construction of the eight hydroelectric stations that form the Combined Waitaki Power Scheme inundated about 7,400 ha of open braided river habitat and 3,900 ha of swamplands, and added 22,250 ha of open water (lake habitat) and 290 km of lake shoreline.
- Genesis' existing resource consents (which the current project seeks to replace) for the Tekapo Power Scheme (TekPS) were granted under the Water and Soil Conservation Act 1967 and are therefore "deemed resources consent" under the Resource Management Act 1991; these consents expire on 30 April 2025. As such Genesis must apply for resources consents in order to continue operating beyond that date.
- Due to the aquatic nature of the project, the focus of this Avifauna Assessment relates to waterbird species as they are the group most likely to be impacted by the direct and indirect effects of the ongoing TekPS.
- To conduct an assessment of the effects of the TekPS on avifauna, information was gathered on the ecological values (habitat and species) present at the TekPS site and within the wider area through a combined desktop and field approach.
- This assessment relied heavily on the data obtained by the Department of Conservation for Project River Recovery (PRR) riverbird counts undertaken between 1991 and 2019 in a number of the Waitaki catchments.
- The inter-relationship of a number of ecosystem factors potentially affecting freshwater birds as a result of the TekPS are complex and extremely difficult to separate. Furthermore, there are other variables, not associated with the TekPS, both within and beyond the Tekapo catchment that have the potential to impact on the freshwater birds that are present.
- The current freshwater species richness in the Lake Tekapo and surrounding habitats was found to be relatively similar to that recorded 15-20 years after the commissioning of Tekapo A, with a total of 21 species recorded.
- In terms of the specialist riverbird species, the data indicates that the abundance of several *Threatened* or *At Risk* species (banded dotterel, black-fronted tern, NZ pied oystercatcher and wrybill) has significantly decreased in the Tekapo River since 1991 (that being the time from which data has been collected for PRR).
- While no data is available regarding riverbird populations prior to the construction of the TekPS, it is likely that the loss of braided river habitat

in the Tekapo associated with the commissioning of Tekapo A (1950) and Tekapo B (1977) power stations would have resulted in a decline in the specialist riverbird species. However, it is not possible to definitively attribute the cause(s) of the apparent ongoing decline of these species on the Takapō River post-1991.

- Further analysis of the specialist riverbirds showed a general increase in abundance above the combined Waitaki power scheme (CWPS), most likely due to the PRR measures, and decrease below. Notably, significant increases in abundance of NZ pied oystercatcher and banded dotterel recorded in catchments above the CWPS where PRR management is occurring, are contrary to the national population trends recently reported by Riegen & Sagar (2020) for these two species.
- Conversely, a decreasing trend in abundance of wrybill was reported in five catchments, including three above the CWPS. These decreasing trends in abundance are contrary to the national population trend recently reported for this species (Riegen & Sagar, 2020).
- However, the detection of instances of significant decreases in species abundance above the CWPS indicate that additional pressures beyond the power scheme are threatening several populations. Based on our results, it appears that the Ahuriri catchment (in which significant decreases in abundances were recorded for banded dotterel, NZ pied oystercatcher and wrybill) would benefit from conservation measures.

Contents

Appendices

1.0 Introduction

The Combined Waitaki Power Scheme (CWPS), a large scale hydro-generation scheme which includes eight power stations (two owned by Genesis Energy Ltd (Genesis) and six by Meridian Energy Ltd (Meridian)), is located in the Waitaki Catchment in the Mackenzie District of the South Island (Map 1). Most of the generation water is derived from the alpine headwaters feeding three managed natural lakes (Lakes Takapō, Pūkaki and Ōhau), joined via a tunnel and canals. The Meridian part of the CWPS is known as the Waitaki Power Scheme (WPS) and the Genesis-owned part is known as the Tekapo Power Scheme (TekPS).

Genesis' existing resource consents (which the current project seeks to replace) for the TekPS were granted under the Water and Soil Conservation Act 1967 and are therefore "deemed resource consents" under the Resource Management Act 1991; these consents expire on 30 April 2025. As such, Genesis must apply for resources consents in order to continue operating beyond that date.

Due to the aquatic nature of the project, the focus of this Avifauna Assessment relates to waterbird species as they are the group most likely to be impacted by the direct and indirect effects of the ongoing TekPS (Map 2). This report begins with an outline of the methods used to collect data for this assessment (Section 2.0). An overview of the Tekapo waterbird assemblage is then provided (Section 3.0), along with general information regarding different habitat utilisation by the species. A description of the TekPS and operational parameters is then provided (Section 4.0). A range of potential impacts on birds within (Section 5.0) and beyond (Section 6.0) are then identified. An assessment of Significant Sites in the context of the Mackenzie District Plan and Canterbury Regional Policy Statement are provided (Section 7.0). An analysis of Tekapo waterbird population trends is then presented (Section 8.0). A high-level summary of Project River Recovery (PRR) (the "offset") is provided (Section 9.0), followed by an analysis of the success of PRR in relation to riverbird population trends to determine the sufficiency of the current mitigation / offset measures (Section 10.0). This report ends (Section 11.0) with the overall conclusions reached following the aforementioned analyses.

2.0 Methods

To conduct an assessment of the effects of the TekPS on avifauna, information was gathered on the ecological values (habitat and species) present at the TekPS site and within the wider area through a combined desktop and field approach as described below.

2.1 Desktop Investigation

A desktop investigation was undertaken to obtain information regarding historical and current avifauna assemblages (including seasonal distribution, abundance and diversity) associated with Lake Takapō, Tekapo Canal, Takapō River and their margins. The following sources were searched:

- Published literature;
- Unpublished reports;
- Relevant statutory documents;
- Data from the Ornithological Society of New Zealand's (OSNZ) 1985 atlas (Bull et al., 1985) were collated from 13 (52, 40; 51, 40; 50, 40; 49, 40; 49, 39; 48, 39; 48, 38; 48, 37; 47, 39; 47, 38; 46, 38; 45, 38; 45, 37) 10 000-yard squares of the national map grid encompassing Lake Takapō, Tekapo Canal, Takapō River and margin;
- Data from the Ornithological Society of New Zealand's (OSNZ) 2004 atlas (C. J. R. Robertson et al., 2007) were collated from the 15 10 km x 10 km grid squares (refer to Map 3) encompassing Lake Takapō, Tekapo Canal, Takapō River and margin;
- Information from the eBird1 database pertaining to Lake Takapō, Tekapo Canal, Takapō River and their margins;
- Information regarding primary and secondary habitat associations[2] was obtained for each species from Heather & Robertson (2005), along with each species' New Zealand threat status according to Robertson *et al*. (2021).

Further literature (published and unpublished) and website searches were undertaken to obtain additional information regarding bird species known to occur within the surrounding habitats, as well as information relating to their breeding and feeding ecology.

2.1.1 Upper Waitaki Basin river bird surveys

Historically, river bird surveys have been undertaken in 11 rivers in the upper Waitaki Basin, including the Takapō River, in an effort to record the effect of the hydro-electric development and associated mitigation / offsetting projects (e.g. PRR) on the bird life (B. D. Bell, 1969; Maloney et al., 1997).

As such, data from walk-through surveys along the Macaulay, Cass, Godley, Tasman, Takapō, Pūkaki, Ōhau and Ahuriri rivers were obtained from the Department of Conservation's Braided River Survey Database (Andy Grant and Jemma Welch, *pers. comm.*). The data set included:

- Surveys conducted in 1962, 1965 and 1968 by the Wildlife Service (B. D. Bell, 1969); and
- Surveys conducted since 1991 by the Department of Conservation (DOC) as part of the long-term monitoring for PRR whereby each river was walked over the course of a single day during the breeding season (methods described in Maloney *et al.* (1997)).

The following assumptions and data grooming were applied to the raw data to ensure an appropriate data set was analysed for this assessment:

- **Multiple counts:**
  - For each year surveyed, one count per river was used.
  - Where more than one survey was conducted in a river per year, rather than average the years records, we used the data collected from the same month as other years (generally October, November or December).

[1] https://ebird.org/home

[2] For the purpose of this report, primary habitat refers to the habitat in which the species spends most of its time. Secondary habitats are other habitat types which the species may also utilise.

- **Missing count data:**
  - We assumed that if a species was observed it would have been recorded. Therefore, zero counts were added to the data set in instances where there were missing river x species x year combinations.
- **Survey distances:**
  - Total distances for each river x year survey were identified by summing surveyed reach lengths.
  - Survey distances missing from the DOC data were estimated by NIWA using GIS.
  - Total survey distances represent the linear km surveyed and do not reflect survey area.

Population trends were assessed using the survey data over two time periods: 1962–2019, and 1991–2019. This approach has been taken as the data collected during the earlier surveys (pre-1990) is not directly comparable to that collected since 1991 due to differences in data collection techniques; however, there is still some value in exploring this earlier data as it was collected closer to the operational commencement of the TekPS.

The following statistical tests were performed on the PRR data for six riverbed specialists (banded dotterel, black-billed gull, black-fronted tern, kakī / black stilt, NZ pied oystercatcher and wrybill) collected between 1991 and 2019:

- Chi-square analysis was used to detect any difference in the first and last counts (abundance) of each key species in each of the catchments.
- Linear regression analysis was used to detect trends in mean densities of species in each catchment.
- Single factor ANOVA was used to explore differences in mean densities of birds between all rivers, between rivers upstream (Ahuriri, Cass, Tasman, Godley, Macaulay) of the CWPS and between rivers downstream (Takapō, Pūkaki, Ōhau) of the CWPS.

2.1.2 Takapō River vegetation cover

The following analysis was undertaken and resulting outputs provided by ecological Solutions Environmental Consultants in order to determine if the vegetation cover along the Takapō River margins was stable or encroachment was continuing (potentially due to low flows).

In the absence of a long term series of field data mapping the vegetation cover along the Takapō River margin since the commissioning of TekPS, data was analysed in QGIS using aerial imagery from Land Information New Zealand databases (Canterbury 0.4m Rural Aerial Photos (2013-2014) and GoogleEarth to map the approximate extent of the bed of the Tekapo River. An additional 30 m buffer was added to the mapped extent of the riverbed to generate an overall ‘study area’.

Landcover data from the Landcover database (LCDB v1 - v5) was overlayed on the study area to identify the type and extent of landcover classes within the study area at each of the five periods within the LCDB (1996, 2001, 2008, 2012 and 2018). Total extent of each of the landcover classes identified was calculated in QGIS and compared across the five different time periods.

2.2 2019 Field Investigations

A reconnaissance site visit was undertaken by the report author (LB) on 15-16 January 2019 to obtain an overview of the project area. The site visit included driving the length of both the Tekapo Canal and Takapō River (including Paterson's Ponds), recording the habitat types present and any avifauna species that were seen or heard.

On 2 September 2019 the report author undertook a helicopter flight along the entire length of the Tekapo River and around the perimeter of Lake Takapō. The objective of this site visit was to identify areas where riverine birds had previously been recorded.

2.2.1 Surrounding Environment

Between 14-18 October 2019, point count surveys were conducted at 10 locations (see Map 4 for survey sites and Appendix 1 for photos) around Lake Takapō and the surrounding area. Details of the survey sites and effort are provided in Appendix 2. With the exception of the Mailbox enclosure survey site, three point-count surveys were undertaken at each site. Only one survey was conducted at Mailbox Enclosure to reduce disturbance to nesting kakī.

Each count lasted 20 minutes and was preceded by a 5-minute stand down period to allow activity to settle following the observer arrival. During the stand-down period the observer recorded time, visibility, temperature, wind direction, and speed, precipitation, cloud cover, and visibility. For each point count, all avifauna species seen and heard during the 20-minute count period were recorded. Data collected included species and number of birds, time observed, direction of the birds from the observer, direction of bird movement, behaviour, the habitat they were observed in and any other notes of interest.

3.0 Tekapo Waterbird Assemblage

Takapō River, Lake Takapō and surrounding areas provided habitat for a diverse range of bird species, with a total of 63 avifauna species recorded by the OSNZ atlas programmes (1985 and 2004), other literature sources, and the field investigations in the Tekapo area (refer to Appendix 3 for the species list). Due to the nature of the TekPS, the focus in this assessment relates to waterbird species as they are the group most likely to be impacted by the direct and indirect effects of the scheme. Thus, of the 63 species recorded, 38 of those are affiliated with freshwater environments (Table 1).

Table 1: Freshwater birds recorded associated with Lake Takapō, Takapō River and surround environs.

SPECIES	THREAT CLASSIFICATION[3]	PRIMARY FRESHWATER HABITAT[4]
Australasian bittern	Threatened - Nationally Critical[CR DPT RF Sp TO]	L, R, E
Kakī	Threatened - Nationally Critical[CD CR RR]	L, R
Grey duck	Threatened - Nationally Critical[CR DPR DPS DPT SO]	L, R, E
White heron	Threatened - Nationally Critical[CR OL SO St]	L, R, E
Black-fronted tern	Threatened - Nationally Endangered[CI CD, PD, RF, Sp]	R, E
Caspian tern	Threatened - Nationally Vulnerable[CI SO Sp]	R, E
Southern crested grebe	Threatened - Nationally Vulnerable[DPS Inc SO]	L
NZ dabchick	Threatened - Nationally Increasing[Inc]	L
Wrybill	Threatened - Nationally Increasing[RR CD CR]	R, E
Banded dotterel	At Risk - Declining[CD CI CR DPS PD]	R, E
Black-billed gull	At Risk - Declining[CI CR RF]	R, E
Marsh crake	At Risk - Declining[CI CR DPS DPT PF RR]	L, E
NZ pied oystercatcher	At Risk – Declining[CI]	R, E
NZ pipit	At Risk - Declining	R, E
Red-billed gull	At Risk - Declining[CI]	E
Pied shag	At Risk – Recovering[CD]	E
Black shag	At Risk - Relict[CR DPS DPT SO Sp]	L, R, E
Little shag	At Risk - Relict[CR DPT]	L, R, E
Australian coot	At Risk - Naturally Uncommon[Inc SO]	L
Royal spoonbill	At Risk - Naturally Uncommon[Inc RR SO Sp]	E
Black-backed gull	Not Threatened[SO]	L, R, E
Black swan	Not Threatened[SO]	L, E
Grey teal	Not Threatened[Inc SO]	L, R, E
Kingfisher	Not Threatened	L, R, E
NZ scaup	Not Threatened[Inc]	L
NZ shoveler	Not Threatened	L, R, E
Paradise shelduck	Not Threatened	L, R, E
Pied stilt	Not Threatened[SO]	L, R, E
Pukeko	Not Threatened[Inc SO]	L, R, E
Spur-winged plover	Not Threatened[SO]	R, E
Welcome swallow	Not Threatened[SO St]	L, R, E
White-faced heron	Not Threatened[SO]	L, R, E
Canada goose	Introduced & Naturalised[SO]	L, R, E
Feral goose	Introduced & Naturalised[SO]	L, R, E

[3] Robertson et al. (2021) with qualifiers (Rolfe et al., 2021): CD=Conservation Dependent (CDB indicates the need for only good biosecurity); CI=Climate Impact; CR=Conservation Research Needed; De=Designated; DPR=Data Poor Recognition; DPS=Data Poor Size; DPT=Data Poor Trend; EF=Extreme Fluctuations; IE=Island Endemic; Inc=Increasing; OL=One Location; PD=Partial Decline; PF=Population Fragmentation; RF=Recruitment Failure; RR=Range Restricted; SO=Secure Overseas; Sp=Sparse; TO=Threatened Overseas.

[4] O'Donnell (2000): L=lakes and ponds; R=rivers; E=estuaries, river mouths and bar-type lagoons.

SPECIES	THREAT CLASSIFICATION[3]	PRIMARY FRESHWATER HABITAT[4]
Mallard	Introduced & Naturalised[SO]	L, R, E
Mute swan	Introduced & Naturalised[SO]	L, R, E
Chestnut-breasted shelduck	Vagrant[SO]	L, R, E
White-winged black tern	Migrant[SO]	R, E

There is considerable variability in habitat requirements of different waterbird species, particularly as these relate to feeding and breeding. O'Donnell (2000) identified waterbird guilds by characterising the main microhabitats and depth of water that species used for feeding and then grouped those species with similar characteristics (refer to Table 2). We assigned each of the waterbird species reported in the Tekapo area to a guild (Table 2).

*Table 2: O'Donnell's (2000) description of waterbird guilds and Tekapo species (†† Threatened; † At Risk; *non-native)*

GUILD	FORAGING HABITAT	BREEDING & ROOSTING HABITAT	TEKAPO SPECIES
Aerial hunting gulls and terns	Generally aerial hunters, flying over open water or river channels and diving for invertebrates and small fish.	Nest on open shingle bars and islands.	Black-billed gull† Black-fronted tern†† Caspian tern†† Red-billed gull† Black-backed gull White-winged black tern
Open water divers	Forage in open, deep waters on both lakes and rivers. Most hunt by diving for fish, though some consume invertebrates and water weed from lake bottoms.	Grebes and diving fowl nest in vegetation overhanging the water's edge at water level. Shags usually nest high in overhanging trees and rock outcrops.	Southern crested grebe†† Pied shag† NZ dabchick†† Black shag† Little shag† NZ scaup Australian coot†
Deep water waders	Waders with medium-long legs that allow them to forage in water depths >200mm as well as shallow waters.	Breed on the ground in open areas, especially shingle or sand, free of emergent vegetation. Usually roost in flocks in similar habitat.	Kakī†† White heron†† NZ pied oystercatcher† Royal spoonbill† Spur-winged plover Pied stilt White-faced heron
Shallow water waders	Waders with short legs that restrict them to feeding in water <80 mm, mostly in water <40 mm.	Breed on the ground in open areas, especially shingle or sand, free of emergent vegetation. Usually roost in flocks in similar habitat.	Banded dotterel† Wrybill††
Dabbling waterfowl	Predominantly feed by dabbling while floating on open water or graze on wetland turf, saltmarsh and pasture.	Most species nest within dense cover in swamps or riparian vegetation and roost by floating on open water.	Grey duck†† Black swan Grey teal NZ shoveler Paradise shelduck Canada goose* Feral goose* Mallard* Mute swan* Chestnut-breasted shelduck*

GUILD	FORAGING HABITAT	BREEDING & ROOSTING HABITAT	TEKAPO SPECIES
Swamp specialist	Diet consists of seeds and invertebrates gleaned from swamp vegetation or surface water with good vegetative cover. Bittern also consume fish and amphibians.	Generally, nest within *Carex secta* or *Typha orientalis* and other rushes.	Australasian bittern†† Marsh crake† Pukeko
Riparian wetland	Do not exclusively depend on either terrestrial or aquatic habitats. Associate with wetlands but not more dependent on these for foraging and breeding than other habitat types.		NZ pipit† Kingfisher Welcome swallow

3.1 Braided river specialists

Of the waterbirds recorded associated with Lake Takapō, Takapō River and surrounds, four endemic species have evolved on braided rivers (wrybill, kakī, black-billed gull and black-fronted tern) while a further two endemic species (banded dotterel and NZ pied oystercatcher) use braided rivers as their major breeding habitats (O'Donnell & Moore, 1983). Specific adaptations for living on rivers include migratory patterns, specialised morphological features, specialised foraging behaviours and narrowly defined range of preferred habitats, and the ability to breed in the unstable river environment (O'Donnell, 2000).

4.0 Tekapo Power Scheme

The TekPS controls Lake Takapō water levels for storage purposes and diverts water from Lake Takapō to Lake Pūkaki along the 26 km Tekapo Canal. Electricity is generated at two hydroelectric power stations – Tekapo A situated at the start of the Canal and Tekapo B situated above Lake Pūkaki at the downstream end of the Canal (Map 2). Construction of Tekapo A began in 1938 and was commissioned in 1950, the canal was constructed in 1970 with Tekapo B being commissioned in 1977.

4.1.1 Lake Takapō

Lake Takapō is fed at its northern end by the Godley River (see Map 1). This 30 km long glacial lake is both large (9,402 ha) and deep (120 m). Most of LakeTakapō's shore is steep and bouldery, but at the Cass River and Godley River deltas it is gently sloping with deposits of shingle, sand and silt (Pierce, 1983).

The lake, the sole source of water for the TekPS, is dammed by the Lake Tekapo Control Structure ("Gate 16") at the head of the Takapō River. Lake Takapō has a normal operating range from 702.1 metres above sea level ("masl") to 710.9 masl; however, the minimum and maximum operating levels vary throughout the year. The current minimum operating level of Lake Takapō is as follows:

- 1 April and 30 September – Minimum Level of 702.1 masl; and
- 1 October and 31 March – Minimum Level of 704.1 masl.

However, the level of Lake Takapō may be further reduced to 701.8 masl between 1 October and 31 March if the Electricity Commission determines that reserve generation capacity is required, or the National or South Island minzones have been breached.

The current maximum operating levels for Lake Takapō are as follows:

- September to February –709.7 masl;
- March –710.0 masl;
- April and August –710.3 masl;
- May – 710.6 masl; and
- June and July – Maximum Level of 710.9 masl.

Since 1952, when Gate 16 was commissioned, the lake level range has extended between 701.7 m and 712.6 m. However, since 1991, the lower part of the range has been entered less often, with the range being between 702.9 m and 712 m. The maximum recorded level was 712.55 m in December 1984, while the lowest recorded level was 701.75 m in August 1976. A graph of the Lake Takapō levels between 2000-2019 is provided in Appendix 4.

4.1.2 Takapō River

Takapō River is 55 km long and is augmented by spring fed flows and tributaries such as Fork Stream, and the Grays and Maryburn rivers. Takapō River converges with the Pūkaki River before discharging into the Haldon Arm of Lake Benmore.

Takapō River is dammed approximately 2 km downstream of Gate 16 by a concrete weir, creating Lake George Scott. Water spilled from Lake Takapō and impounded in Lake George Scott can be discharged into the Tekapo Canal via Gate 17. Water from LakeTakapō can also flow over Lake George Scott Weir and continue down Takapō River to Lake Benmore.

Flows in the upper Takapō River above Lake George Scott are a result of:

1) Operational top up flows every 2 days for 1 hour (10 cumecs);
2) Approximately 30 recreational releases annually (generally between November and April), with many of these occurring during the breeding season (about 16 cumecs); and
3) On occasion, Genesis is required to island[5] Tekapo A (both planned and unplanned) due to Transpower requirements, and Tekapo A maintenance / upgrade requirements. Flows can be up to 130 cumecs in this instance.

In addition, the following regime of gate testing is undertaken:

1) Monthly (Dam safety requirement) - up to or around 20 cumecs dependant on lake level for 10 minutes.
2) Annual Gate Testing (Dam safety requirement) - Open each gate individually up to or around 20 cumecs depending on lake level for 10mins for each gate equating to approximately 1 hour of tests (over 3 days).

[5] Islanding is when requested by the National Grid Operator ("Transpower"), Genesis is required to "island" Tekapo A Power Station, by restricting generation at, and diverting water around, Tekapo A Power Station during transmission network maintenance or faults, isolating Tekapo A Power Station from the grid but enabling the continued supply of electricity to the Tekapo township, Fairlie, Albury and Mt Cook areas.

3) 5-year Gate testing (Dam safety requirement) - Open each gate open individually up to or around 20 cumecs depending on lake level for 10mins for each gate equating to approximately 1 hour of tests over the week (1 gate per day for 10min a day).
4) Canal 5-year Protection testing (Dam safety requirement) - Up to 130 cumecs down to test trip functions of the gates from canal protection (1 day max).

Genesis operates Lake George Scott to a level of 684.05 masl which is also the level of the spillcrest of the weir. Genesis may discharge up to 600 m^3/s of water into Takapō River over the Lake George Scott Weir.

Flows below Lake George Scott into the lower Takapō River over the Lake George Scott weir result from inflow-driven lake level management so are largely out of Genesis' control.

4.1.3 Tekapo Canal

Outflows from Tekapo A Power Station can enter the 26 km long Tekapo Canal (refer to Map 2), which has a maximum capacity of 130 m^3/s, or be passed down the Tekapo River.

The canal has a homogenous trapezoid shape: the water surface width is approximately 35 m and the average depth approximately 5.8 m. The side slopes are 1V:2H in the upper section of the canal (upstream of 15.8 km) and 1V:2.5H in the lower section (downstream of 15.8 km). The canal bed is composed of gravels and cobbles.

5.0 Potential Impacts on Birds Within the Tekapo Catchment

5.1 TekPS

The construction of the eight hydroelectric stations (which includes TekPS) from the 1920's onwards inundated about 7,400 ha of open braided river habitat and 3,900 ha of swamplands, and added 22,250 ha of open water (lake habitat) and 290 km of lake shoreline (Wilson, 2000).

As outlined in the following sections, the potential effects of the TekPS on freshwater birds relate to the indirect and direct impacts on feeding and breeding habitat in the Takapō River and on the Takapō Lake edge.

5.1.1 Lake Takapō & Surrounds

The TekPS has dammed Lake Takapō. Wetland birds that utilise lake and pond habitats are susceptible to changes in water level (both increases and decreases), especially during the breeding season (Pierce, 1983; Sanders, 1999). For instance, lowering of water levels can leave nests exposed to introduced mammalian predators, whereas rising water levels may flood nests. River deltas, which provide important foraging habitat as the waters are generally slower moving at that point, can also be impacted by both lowering (drying) and rising (flooding) water levels (Pierce, 1983).

5.1.2 Takapō River

5.1.2.1 Changes in river levels

Changes in water levels within Takapō River have the potential to directly affect nesting birds, should such flows occur during the breeding season. The current regime of water flows and releases into Takapō River is outlined in Section 4.1.2 above.

The upper Takapō River (i.e. above Lake George Scott) currently experiences regular changes in flow associated with operational top up and recreational flows. In the case of operational top-up flows, these occur ever second day, are in the order of 10 cumecs, and result in the much of the river bed being underwater (as shown in Photo 1(a) and (b)). Such events occurring every second day (throughout the year) are not conducive to the establishment of nest sites for breeding river birds.

While birds may establish nest sites downstream of the Lake George Scott, flows into the lower Takapō River over the Lake George Scott weir result from inflow-driven lake level management so are largely out of Genesis' control.

Photo 1: Upper Takapō River looking northwards on 20/3/25 prior (a) and during (b) to Gate 16 top-up flow.

5.1.2.2 Aquatic changes resulting from flow regimes

The flow regime of a river has a strong direct influence on its physical structure and vegetation, which provide habitat for river birds, lizards, fish and aquatic and terrestrial invertebrates (Glova & Duncan, 1985; Jowett & Duncan, 1990; O'Donnell et al., 2016). Generally under natural flows riverbeds are highly unstable as they are in a continual state of erosion and aggradation (O'Donnell & Moore, 1983). Consequently, riverbed birds exhibit biological adaptation to frequent environmental instability of their habitat (O'Donnell & Moore, 1983).

The TekPS has removed flows from the Takapō River. Downstream flow patterns are now more constant through the year with fewer (and lesser) fluctuations. Mean flows are significantly lower than natural flows and the intensity, timing, duration and frequency of flood events which contribute to the braided riverbed state have been affected (Sinclair, 1995).

Reductions in total flow from a point discharge (such as a dam) into a braided river cause a range of physical aquatic habitat condition changes (Mosley, 1982). In the main, these changes are a reduction of water depth, lowering velocity and an overall reduction in water cover of cobble and gravels. Jowett & Duncan (1990) described rivers with less flow as longitudinally more uniform.

One of the more important results from decreasing depth, especially in lower gradient reaches, is the tendency for those reaches to have raised temperature through the day, especially over summer months. The reduction in flow also results in greater nutrient concentration, reduced oxygen levels with large daily fluctuations. There becomes greater hyporheic movement of aquatic species and overall, there is a reduction in habitat heterogeneity and increased flow stability.

The above physical changes lead typically to increased periphyton biomass and cover with a succession of algae, and macrophyte edge invasion, cover and biomass increase. It also leads to increased terrestrial plant invasion reducing the extent of bare cobble above water and native river plants (Caruso et al., 2013). These “plant” biomass and species changes, as well as changes from connected run habitat to back waters and greater isolation of low flow habitats, lead to a change in the macroinvertebrate assemblages. These initially respond to the periphyton biomass increase with a peak in grazing guild EPT until a shift to beetle and fly assemblages (especially Elmidae) occurs as periphyton species change and biomass builds. The slow low flow backwaters also become prominent midge breeding habitat. As the periphyton biomass builds (and includes cyanobacteria) the oxygen levels in the water swing substantially day to night, toxins occur and the aquatic living conditions for many hard-bottom river macroinvertebrates and fish become stressful. The change in depth, temperature and food resource changes fish size and species distribution in the river (Glova & Duncan, 1985); there is a reduction in macroinvertebrate species richness and fish abundance and a corresponding large-scale biomass increase for the very tolerant macroinvertebrate community and plant matter.

Thus for avifauna, reduced flows can alter the overall area of aquatic habitat and invertebrate abundance (Gray & Harding, 2007). Distribution, abundance and periodicity of invertebrate and fish species are likely to be major determinants of the patterns of bird distribution and usage of riverbeds (O’Donnell & Moore, 1983).

5.1.2.3 Exotic vegetation & encroachment

Species such as wrybill, black-billed gulls and black-fronted tern require substrates devoid of vegetation to breed on (Pierce, 1983; Sagar, 1992). However, the extent of bare substrate is related to the occurrence of flood events. Stable flow regimes stabilise the riverbed, thereby reducing the development of new channels and allowing establishment of vegetation on gravel bars and river terraces (Caruso, 2006). Thus, as a consequence of reduced river flows, introduced plant species, particularly lupin, gorse, broom and willow, have encroached upon much of the braided riverbed habitats and made extensive areas unsuitable to riverbird species (O’Donnell & Moore, 1983).

The results of a high level analysis of change in landcover along Takapō River margins (30 m either side of the river) between 1996-2018 are provided in Table 3 and Figure 1 (refer to Appendix 5 for graphical representation of the landcover over that time period). As shown, while there has been a decrease in exotic forest and deciduous hardwoods, and an increase in high producing exotic grasslands (most likely associated with dairy farming; refer to Section 5.4), the landcover over that period has remained relatively stable.

Table 3: Landcover composition change between 1996 – 2018 within the study area using LCDB data

Cover	1996 (m²)	1996(%)	2001 (m²)	2001(%)	2008 (m²)	2008(%)	2012 (m²)	2012(%)	2018 (m²)	2018(%)	1996 v 2018 (%Δ)
Manuka and/or Kanuka	44405	0.1	44405	0.1	44405	0.1	44405	0.1	44405	0.1	0.0
Transport Infrastructure	16879	0.0	16879	0.0	16879	0.0	16879	0.0	16879	0.0	0.0
Built-up Area (settlement)	100899	0.2	102246	0.2	102246	0.2	102246	0.2	102246	0.2	1.3
Deciduous Hardwoods	3220311	5.4	3192814	5.4	2739570	4.6	2739568	4.6	2739568	4.6	-14.9
Depleted Grassland	12127421	20.5	12126074	20.5	12161903	20.5	12098048	20.4	12161904	20.5	0.3
Exotic Forest	540123	0.9	540123	0.9	476267	0.8	438703	0.7	476268	0.8	-11.8
Forest - Harvested	0	0.0	0	0.0	0	0.0	101421	0.2	0	0.0	0.0
Gravel or Rock	8000732	13.5	8000732	13.5	8000732	13.5	8000734	13.5	8000734	13.5	0.0
Herbaceous Freshwater Vegetation	1061958	1.8	1094263	1.8	1094263	1.8	1094266	1.8	1094266	1.8	3.0
High Producing Exotic Grassland	26062	0.04	26062	0.04	54089	0.09	54089	0.09	54089	0.09	107.5
Lake or Pond	584097	1.0	584097	1.0	584097	1.0	584097	1.0	584097	1.0	0.0
Low Producing Grassland	29706217	50.1	29733714	50.2	30186958	50.9	30186956	50.9	30186956	50.9	1.6
Mixed Exotic Shrubland	376599	0.6	376599	0.6	376599	0.6	376600	0.6	376600	0.6	0.0
River	3433183	5.8	3433183	5.8	3433183	5.8	3433184	5.8	3433184	5.8	0.0

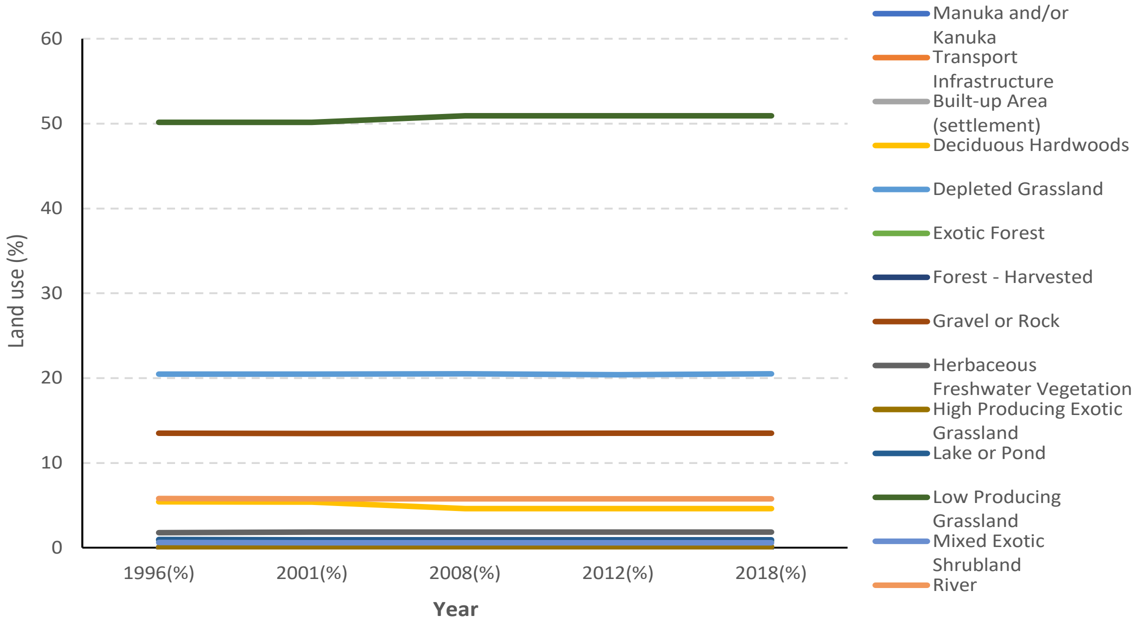


Figure 1: Land-use cover within study area between 1996-2018 (based on LCDB data)

5.1.2.4 Mammalian Predation

Reduced river flows (in terms of more shallow water and fewer water channel barriers) increase the incidence of mammalian predation allowing easier access of introduced mammals to gravel islands, where a number of riverbird species breed. Also, the increased vegetation cover on stabilised river section provides better cover for mammalian predators to stalk nesting and roosting birds.

5.1.3 Summary of Potential Effects of TekPS

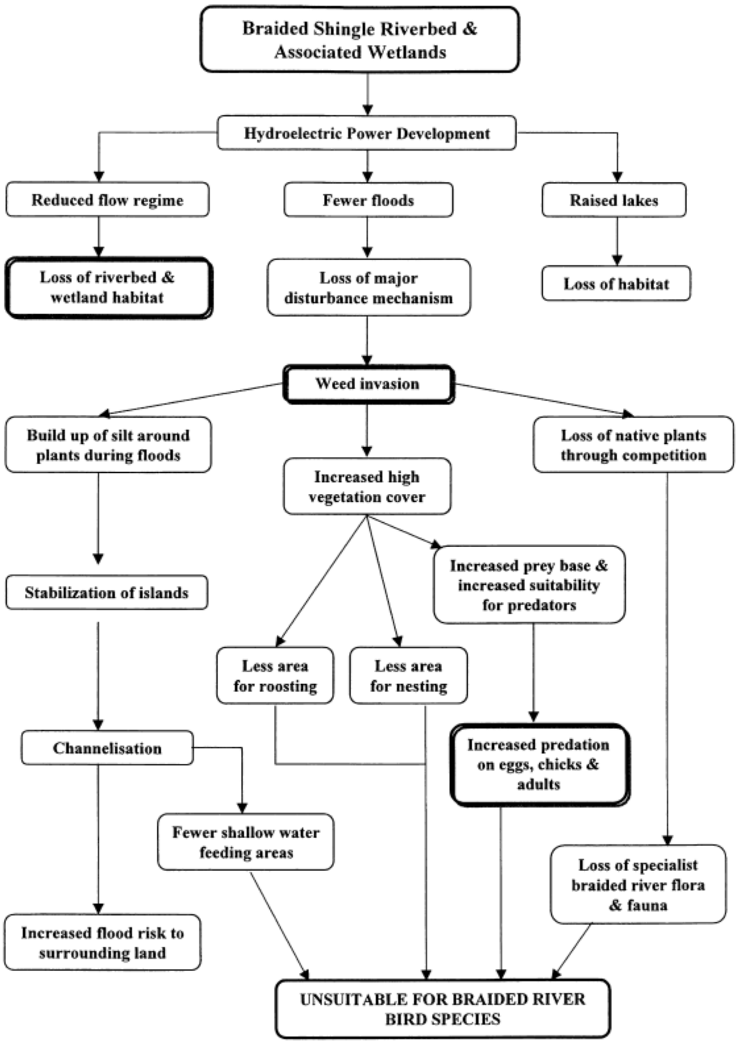
The complexity and inter-relationship of factors associated with reduced flow affecting freshwater birds as a result of the TekPS are summarised in Table 4 (taken from Table 3 in O'Donnell et al. (2016)) and Figure 2 (taken from Figure 2 in Caruso (2006)).

Table 4: Potential effects and consequences of reduced flow on braided river flora and fauna during the breeding season (taken from Table 3 in O'Donnell et al. (2016))

PARAMETER	POTENTIAL EFFECTS	POTENTIAL CONSQUENCES
Low flows	• Lower food availability • Increased weed encroachment • Less food-producing habitat • Increased access to islands by mammalian predators	• Greater competition for food • Less breeding and feeding habitat • Increased cover for mammalian predators and their prey • Lower productivity and survival
Fewer channels (braids)	• Reduced area of feeding habitat • Increased access to islands by mammalian predators	• Fewer habitat choices – greater competition for food • Less-optimal breeding habitat • Lower productivity and survival
Fewer islands	• Fewer islands safe from mammalian predators	• Lower productivity and survival

PARAMETER	POTENTIAL EFFECTS	POTENTIAL CONSQUENCES
Increased channel stability	• Reduced accessibility to preferred foods • Increased weed encroachment	• Less breeding and feeding habitat • Increased cover for mammalian predators

Figure 2: Schematic conceptual model developed by PRR of the impacts of HEP development of braided gravel river birds and wetlands in the Upper Waitaki Basin (taken from Figure 2 in Caruso (2006))



5.2 Flood Management

As part of their flood protection works, Environment Canterbury actively manage the Takapō River by the use of machinery to grade the riverbed and the planting of exotic species such as willow to stabilise the river. Such activities alter the habitat available for specialist braided river birds.

5.3 Didymo

Didymo (*Didymosphenia geminata*), an invasive aquatic algae, was first detected in New Zealand in 2004. Since that time, it has spread into many rivers in the South Island, including Takapō River.

Under favourable conditions, didymo forms conspicuous mats on the riverbed. These changes in algal community biomass and composition have flow-on impacts for the fauna; though studies have shown conflicting results regarding the impact of these blooms on invertebrate species richness and community density (McCallum, 2014). Nevertheless, the didymo mats covering the riverbed hinders the accessibility of the invertebrate food supply for foraging riverbirds at those locations.

5.4 Land use changes

Within the Tekapo catchment, there have been considerable changes to land use over the last few decades, with vast areas of tussockland being converted to productive farmland (see Figure 3). Such changes can impact specialist river birds.

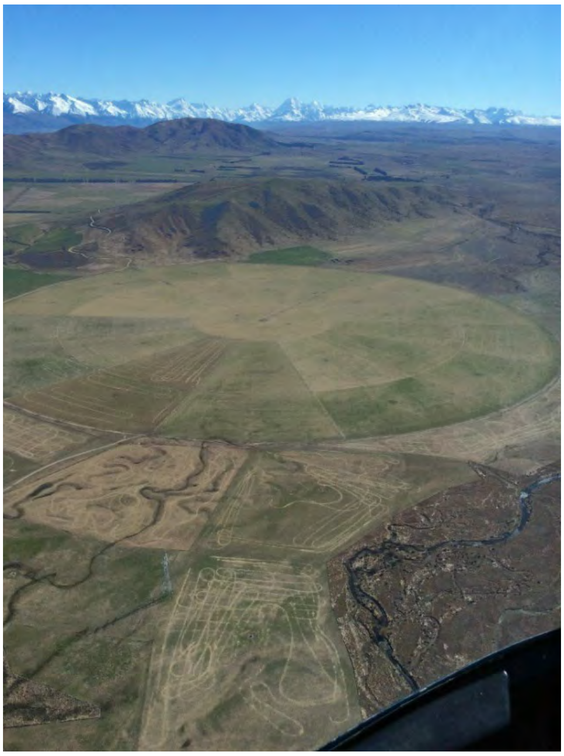


Figure 3: Example of land use change adjacent to a braided river reach.

Riegen & Sagar (2020) describe how NZ pied oystercatcher numbers increased in the 1940's when they became fully protected and much of the South Island tussockland was converted to pasture for sheep; thereby creating large areas of suitable breeding habitat for this species. However in more recent years Southland has been converted to dairy pasture where it is more difficult for NZ pied oystercatcher to breed, and is thus likely to have contributed to the recent declines in numbers (Riegen & Sagar, 2020).

6.0 Potential Impacts on Birds Beyond the Tekapo Catchment

In the most recent national census of wading birds in New Zealand, Riegen & Sagar (2020) reported that the numbers of most species have declined since the counts by the OSNZ began in 1983 (refer to Figure 4 and Figure 5). While the cause of such declines are not yet fully understood, it is likely that nest predation is a significant factor (Riegen & Sagar, 2020). However, some species are exposed to threats, including habitat modification and human disturbance, at locations away from their breeding sites.

Annual migrations away from the breeding grounds during the autumn / winter months is a feature for five of the six endemic braided river specialists recorded along the Tekapo River; with the exception of kakī, the other species disperse to coastal areas at the end of the breeding season, some a considerable distance away. For example, a significant proportion of banded dotterel migrate to southern Australia during the non-breeding season (Riegen & Sagar, 2020). These coastal winter sites are often popular with recreational users. Thus, unlike sedentary species which remain at the same location throughout the year, the migratory nature of these birds exposes them threats and pressures at multiple sites. Consequently, reduced numbers recorded at the summer breeding sites may actually be due to impacts on birds at their winter migratory sites.

Interestingly, while the majority (~87%) of wrybill winter in the greater Auckland region away from the South Island braided rivers, Riegen & Sagar (2020) reported a 33% increase in the winter counts between 1983-94 and 2005-19 (refer to Figure 6). Riegen & Sagar (2020) attributed the improved predator control and restoration of braided rivers in the South Island as important factors in this increase. However, it is also worth noting that wrybill have adapted to using industrial building rooftops in the Auckland area as high tide roosts; some 20% of the wrybill population roost on one factory roof in south Auckland. These rooftop roosts afford these birds a level of protection from disturbance and predation not necessarily provided by land-based roosts.

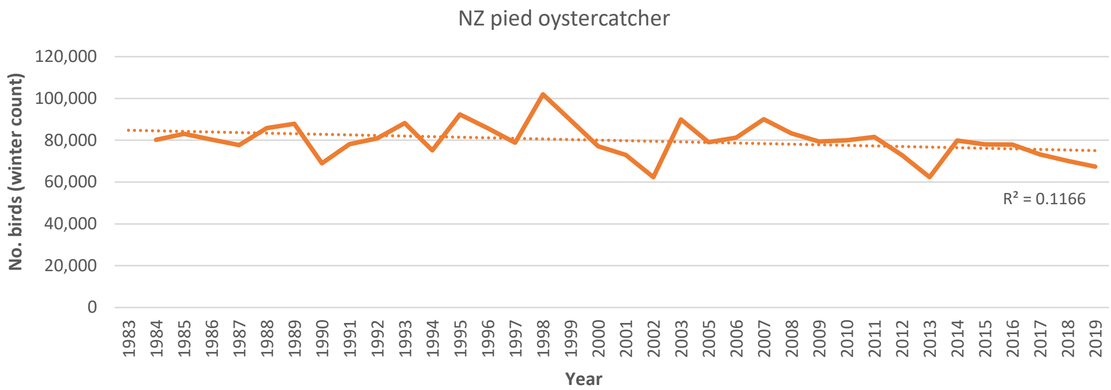


Figure 4: Number of NZ pied oystercatcher recorded at New Zealand coastal sites during the OSNZ winter (non-breeding) wader counts between 1983 and 2019 (Data sources: Sagar et al. (1999), Southey (2009) and Riegen & Sagar (2020)).

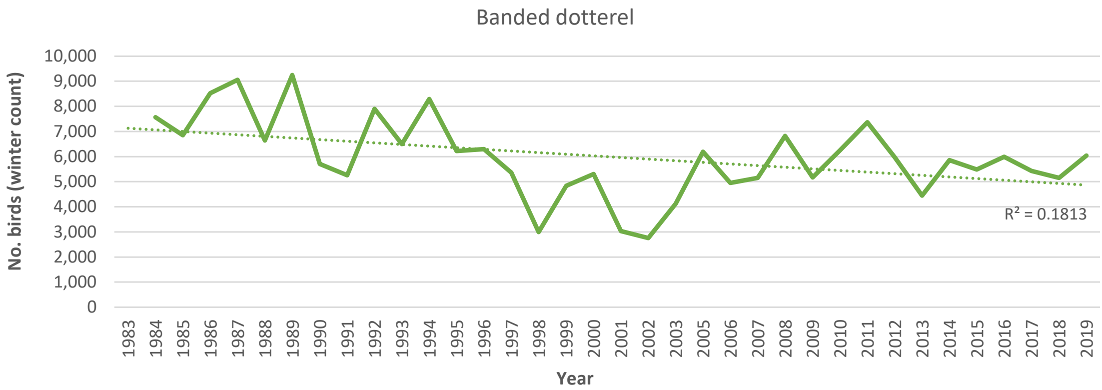


Figure 5: Number of banded dotterel recorded at New Zealand coastal sites during the OSNZ winter (non-breeding) wader counts between 1983 and 2019 (Data sources: Sagar et al. (1999), Southey (2009) and Riegen & Sagar (2020)).

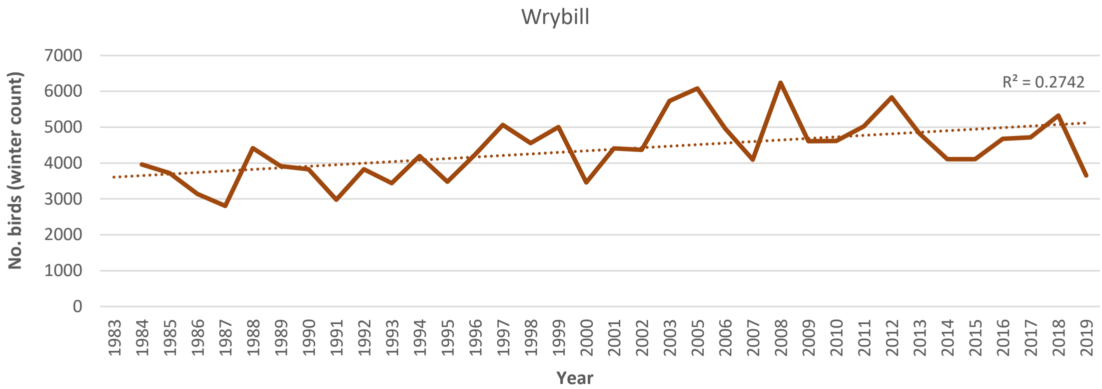


Figure 6: Number of wrybill recorded at New Zealand coastal sites during the OSNZ winter (non-breeding) wader counts between 1983 and 2019 (Data sources: Sagar et al. (1999), Southey (2009) and Riegen & Sagar (2020)).

6.1 Climate change

Changing temperatures and water availability as a result of climate change will have impacts on where species can survive (Royal Society of New Zealand, 2016). The range of ecosystems and species will change, as will the timing of annual and seasonal events, and ecosystem functions. Indirectly, climate change will increase the range and abundance of invasive pests and weed species which is currently a key driver of extinction (Climate Change Adaptation Technical Working Group, 2017; Lundquist et al., 2011; Macinnis-Ng et al., 2021; Tompkins et al., 2013).

In the Department of Conservation's most recent list of conservation status of New Zealand birds (H. A. Robertson et al., 2021), 69 taxa were assessed as are known or predicted to be adversely affected by long-term climate trends and / or extreme climatic events; these species are identified with a CI (Climate Impact) qualifier in their classification. Among such species are a number of the endemic riverbirds, including banded dotterel, black-fronted tern, black-billed gull and NZ pied oystercatcher.

7.0 Assessing Significant Sites

Appendix 1 of the Mackenzie District Plan (Mackenzie District Council, 2004) identifies Sites of Natural Significance which represent plant and animal communities and habitats which are representative, rare or unique within the District, or otherwise considered to be significant in terms of section 6(c) of the Resource Management Act. As noted in that District Plan, these significant sites of indigenous vegetation and fauna habitat have principally been identified from the following information sources:

5) **Recommended Areas for Protection (RAP)** identified in the Mackenzie Ecological Region Protected Natural Area Programme (PNAP) Survey Report, 1984 and the Heron Ecological District PNAP report, 1986. Some of the RAP's identified within the Mackenzie Ecological Region have been enlarged on the basis of recommendations from the Protected Areas Scientific Review Committee (PASAC), or as a result of consultation with the Forest Research Institute (FRI) (now Landcare NZ Ltd), or invertebrate surveys in the area. This was to provide better representation of communities and improved management boundaries.
6) **Special Sites of Wildlife Interest (SSWI)** identified in "Wildlife and sites of Special Wildlife Interest in the Upper Waitaki and Adjacent Areas" by Liz Jarman (1987), and the SSWI habitat database.
7) **Wetlands of ecological and representative importance (WERI).** The WERI database is an inventory of all types of wetlands in New Zealand. It focuses on those wetlands which are ecologically important or significant and which are representative of the natural diversity of the country. The database is administered by the Department of Conservation.
8) **Invertebrate habitat areas.** These sites have been identified by Mr B H Patrick, Conservancy Advisory Scientist, Otago Conservancy, Department of Conservation.
9) **Threatened plants sites** identified in the DSIR threatened plants database, or information held by the Department of Conservation.

The SNS, SSWI, WERI PNA and RAP sites identified in Appendix 1 of the Mackenzie District Plan (Mackenzie District Council, 2004) are shown on Maps 5 and 6. Those sites containing native avifauna values (i.e. Threatened or At Risk species) and which may be impacted by the TekPS are identified and described in Table 5 below.

Table 5: Mackenzie District Significant Natural Sites containing native avifauna values that may be impacted by the Tekapo Power Scheme.

SNS	SITE NAME	VALUES IDENTIFIED
45	Tekapo/Pūkaki Rivers	RAP P-15 (Tekapo/Pukaki and Ōhau Riverbeds); SSWI (Tekapo River); (Pūkaki River Ponds); WERI: Wide, braided alluvial riverbeds providing important habitat for waterfowl, waders, passerines and aquatic and terrestrial insect fauna. Breeding areas for black stilts, banded dotterels, black fronted terns, black backed gulls and wrybills. Native and introduced fish species occur in high numbers. A series of artificial ponds on margin of Pūkaki River also provide a habitat for waterfowl and waders.
56	Lake Tekapo	RAP T-26; T-27 (Small island adjacent to Motuariki Island); T-25 (Raupo Lagoon - Godley Peaks); SSWI; WERI: Large deep glacial lake with steep shoreline and mudflats. native

SNS	SITE NAME	VALUES IDENTIFIED
		fish occur in low numbers. Drawdown by Tekapo Power Station in winter exposes shoreline bays and deltas which are particularly important for waterfowl breeding (blackstilt, banded dotterel, grey teal and shoveler) and feeding. Rare scree skink observed here, and large numbers of aquatic and terrestrial insects. Raupo Lagoon contains an excellent example of raupo and associated vegetation. Good shelter and feeding site for waders and waterfowl. White-winged black tern sighted here. One of the islands contains a remnant scrub community that includes weeping mapou and the rare sympatric occurrence of two mistletoe species.
58 58a	Lake Alexandrina Lake McGregor	RAP T-18 (Lakes Alexandrina and McGregor), SSWI (Lake Alexandrina), (Lake McGregor); WERI: Includes covenant area with Ministry of Defence. Wildlife refuge. Montane lakes, mainly open water, partly bordered by rush and sedge swamp. Breeding area for one of New Zealand's largest populations of southern crested grebe and New Zealand Scaup. Little shags also nesting. Other waterfowl present, include marsh crake, black stilt and Australian coot. High numbers of native galaxids, bullies and eels occur in lakes. Colony of protected skink *L. lineocellatum*, and sympatric populations of skinks and geckos occur in the area.
61	Mailbox Exclosure	RAP T-20: Lagoon with exclosure built to protect breeding black stilts. Also inhabited by many other waterfowl and waders. Reassessed in 1996 and boundaries amended.

With regards to Policy 9.3.1 of the Canterbury Regional Policy Statement (RPS) (Environment Canterbury, 2021) states:

> *1. Significance, with respect to ecosystems and indigenous biodiversity, will be determined by assessing areas and habitats against the following matters:*
>
> *a. Representativeness*
> *b. Rarity or distinctive features*
> *c. Diversity and pattern*
> *d. Ecological context*
>
> *The assessment of each matter will be made using the criteria listed in Appendix 3*[6]*.*
>
> *2. Areas or habitats are considered to be significant if they meet one or more of the criteria in Appendix 3.*
> *3. Areas identified as significant will be protected to ensure no net loss of indigenous biodiversity or indigenous biodiversity values as a result of land use activities.*

The sites identified Table 5 are also considered significant under Policy 9.3.1 of the Canterbury RPS, particularly in relation to criterial pertaining to rarity / distinctiveness and ecological context.

[6] Canterbury RPS Appendix 3 significance criteria are provided in Appendix 5 of this current document.

8.0 Tekapo Avifauna Habitat & Population Trends

8.1 Lake Takapō & Surrounds

As noted previously, the construction of the CWPS resulted in the loss of open braided river habitat and swamplands, but increased the amount of open water (lake habitat) and lake shoreline habitat (Wilson, 2000).

There is very little information available regarding the avifauna values associated with Lake Tekapo and its surrounds prior to the construction (1938) and commissioning (1951) of Tekapo A. Approximately 15 years after the commissioning, Bell (1969) undertook replicated river bird surveys in 1962, 1965 and 1968 around Lake Takapō, including Godley rivermouth, Cass River delta, Lake Alexandrina, Lake MacGregor and its outlet delta on Lake Takapō. Through those surveys, Bell (1969) reported at total of 24 species (Table 6).

The 2019 point surveys recorded a total of 21 species and included most of those reported by Bell (1969) (Table 6). Bell (1969) only provided composite total numbers for species from all survey locations, rather than for individual survey points. As such, comparison of the two data sets cannot be made to investigate population trends over time in these habitats. Nevertheless, it can be noted that the current riverbird species richness in Lake Takapō and surrounding habitats is relatively similar to that recorded 15-20 years after the commissioning of Tekapo A.

Lake Takapō is classified as a Site of Natural Significance (Mackenzie District Council, 2004) and a Site of Special Wildlife Interest (SSWI) of Outstanding Value (Espie et al., 1984) (refer to Map 5). Lake Takapō drawdown by TekPS in the winter exposes shoreline bays and deltas which are particularly important for waterbird breeding (kakī, banded dotterel, grey teal and shoveler) and feeding (Espie et al., 1984; Mackenzie District Council, 2004).

The various wetlands, lagoons, tarns, ponds, streams and swamps that surround Lake Takapō also provided important waterbird breeding, feeding and roosting habitat. Lake Alexandrina and Lake McGregor have legal protection for conservation, both being classified as Wildlife Refuges under the Wildlife Act (1953) (Cromarty, 1996). Lake Alexandrina supports the largest New Zealand population of southern crested grebe, as well as marsh and spotless crake (McEwen, 1987). PRR's recent (January 2019) survey of crested grebe recorded 92 birds in Lake Alexandrina and 19 in Lake McGregor (Gale et al., 2020; Welch et al., 2019); these numbers are higher than previous surveys at the lakes (Jensen & Snoyink, 2005; Sagar, 1981), but this may be an artefact of the different survey methods (Welch et al., 2019). Lakes Alexandrina and McGregor are classified a SSWI of Outstanding Value (Espie et al., 1984).

Other SSWI's identified by Espie et al. (1984) as having waterbird values include Lake Murray (kakī feeding and breeding habitat), Mailbox Enclosure (kakī breeding), Glenmore Tarns (wader and waterfowl feeding and breeding), Mick's Lagoon (kakī breeding), Godley Peaks raupo lagoon (shelter and feeding for waders and waterfowl), Mount Hay Station tarns and Tekapo tarns.

Table 6: Waterbird species recorded during the 2019 point counts (refer to Map 4 for survey locations)

SPECIES	THREAT CLASSIFICATION (H. A. Robertson et al., 2021)	BELL (1969)	2019 POINT COUNTS									
			1 Rivermouth	2 Lake Takapō wetland	3 Takapō River control gate	4 Takapō River upstream of canal gate	5 Pattersons 1	6 Pattersons 2	7 Lake McGregor	8 Lake Takapō SW edge	9 Mailbox enclosure	10 Mailbox Inlet
Australasian bittern	Threatened - Nationally Critical	✓										
Kakī	Threatened - Nationally Critical	✓		✓						✓	✓	✓
Grey duck	Threatened - Nationally Critical	✓										
Black-fronted tern	Threatened - Nationally Endangered	✓		✓			✓					✓
Southern crested grebe	Threatened - Nationally Vulnerable	✓			✓				✓	✓		
Wrybill	Threatened - Nationally Increasing	✓										
NZ dabchick	Threatened - Nationally Increasing	✓										
Banded dotterel	At Risk - Declining	✓	✓	✓						✓	✓	✓
Black-billed gull	At Risk - Declining	✓		✓	✓							
NZ pied oystercatcher	At Risk - Declining	✓	✓							✓	✓	✓
Pied shag	At Risk - Recovering						✓		✓			
Black shag	At Risk - Relict	✓	✓							✓		
Little shag	At Risk - Relict	✓			✓	✓						
Australian coot	At Risk – Naturally Uncommon	✓							✓			
Black-backed gull	Not Threatened	✓	✓			✓				✓		✓
Black swan	Not Threatened	✓							✓		✓	
Grey teal	Not Threatened	✓		✓	✓	✓	✓	✓		✓		✓
NZ scaup	Not Threatened	✓			✓	✓	✓	✓	✓	✓		
NZ shoveler	Not Threatened	✓		✓							✓	
Paradise shelduck	Not Threatened	✓		✓		✓				✓	✓	✓
Pied stilt	Not Threatened	✓									✓	✓
Pukeko	Not Threatened	✓										
Spur-winged plover	Not Threatened		✓			✓				✓		✓
White-faced heron	Not Threatened	✓							✓			
Canada goose	Introduced & Naturalised	✓						✓	✓	✓		
Mallard	Introduced & Naturalised	✓		✓	✓	✓	✓	✓	✓			✓

There are historic records of Australasian bittern associated in the wider environs around Lake Takapō, Pūkaki, Ōhau and Ahuriri catchments (B. D. Bell, 1969, p. 196; Gale et al., 2020); however recent targeted surveys by PRR in those areas did not detect the presence of any bittern (Gale et al., 2020).

8.2 Tekapo Canal

The Tekapo Canal is not identified as an ecologically significant site (Map 6).

The slope, water depth and velocity are not conducive to the habitat requirements for a number of waterbirds, particularly waders. With the exception of shags and gulls roosting on aquaculture structures within the canal, there are limited habitat opportunities for most waterbirds in the area.

8.3 Takapō River

Takapō River bed is recognised as a SSWI of Outstanding value (Espie et al., 1984). The river provides 3,178 ha for braided river birds such as kakī, banded dotterel, wrybill, black-fronted tern, black-billed gull, red-billed gull, Caspian tern, NZ pied oystercatcher, kakī, pied stilt; most of these species breed on the riverbed. The river contains >5% of the total black-fronted tern population, and is recognised as being nationally important for that reason (Hughey & Baker, 2010; Keedwell, 2002).

In the following sections, we explore historic population trends of the waterbirds associated with the Tekapo River.

8.3.1 1962 – 2019 surveys

Waterbird species richness recorded in the Takapō River during surveys between 1962 and 2019 has ranged between 16 and 22 species. Over this time, the number (abundance) of waterbirds and species composition has varied, with the highest numer of birds recorded during the 1991 survey (Figure 7).

The proportion of birds recorded during each suvery which belong to the various guilds is shown in Figure 8; the majority of birds recorded belong to the aerial hunting gulls and terns guild. The data show two main trends: an apparent decline in shallow water waders, and an increase in dabbling waterfowl over the 57 year time period (Figure 8).

As mentioned previously, the following six *Threatened* or *At Risk* endemic species are braided river specialists: wrybill, kakī, black-billed gull, black-fronted tern, banded dotterel and NZ pied oystercatcher. The population trends recorded for each of these species between 1962-2019 are presented in Figure 9. This long-term data set indicates a declining trend for banded dotterel (R^2=0.29) and kakī (R^2=0.73), but an increasing trend for black-fronted tern (R^2=0.49).

8.3.2 1991 – 2019 surveys

Based on the data collected from the standardised riverbird surveys undertaken on the Takapō River between 1991–2019, colonial nesting species, such as gulls and terns, were among the most abundant species recorded (Figure 10). Within the Tekapo River, there has been a trend of decreasing numbers (Figure 10) of both aerial hunting gulls and terns (R^2=0.67) and shallow water waders (R^2=0.51) recorded, while there has been an increasing trend in dabbling waterfowl (R^2=0.39).

Figure 7: Number of river birds and species composition recorded during Takapō River surveys between 1962 and 2019.

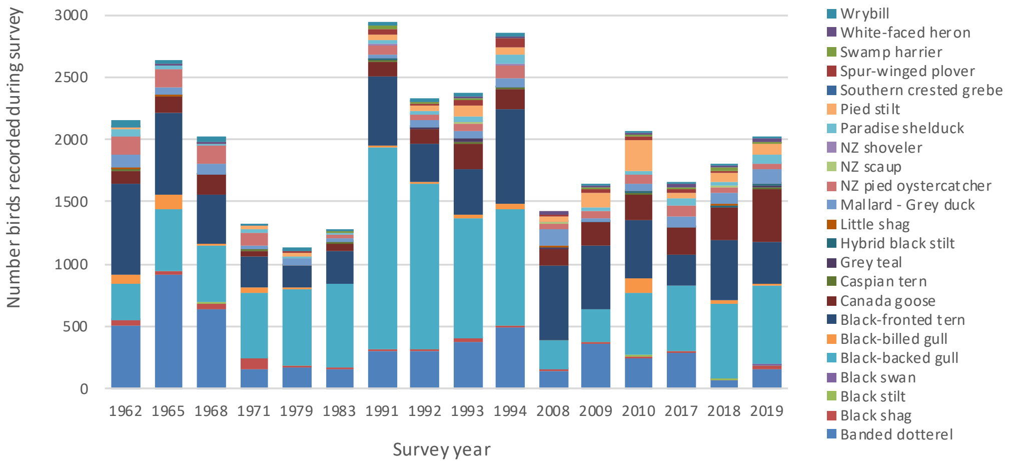


Figure 8: Proportion of river birds recorded during Takapō River surveys (1962-2019) belonging to different guilds.

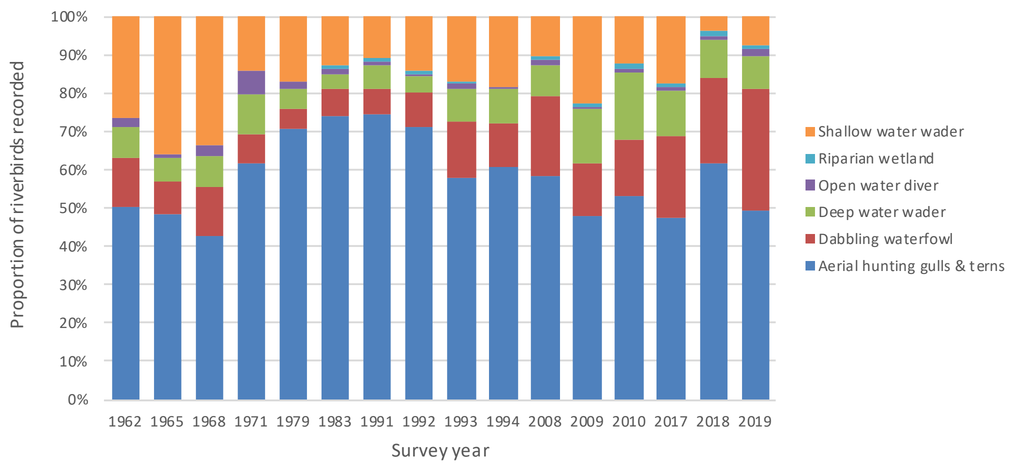


Figure 9: Population trends for specialised river birds recorded along the Takapō River from 1962-2019.

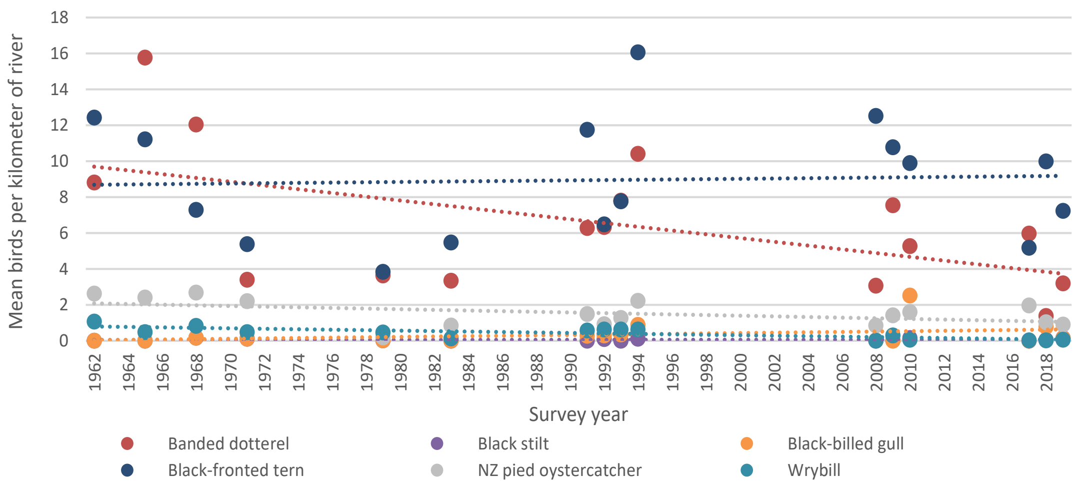
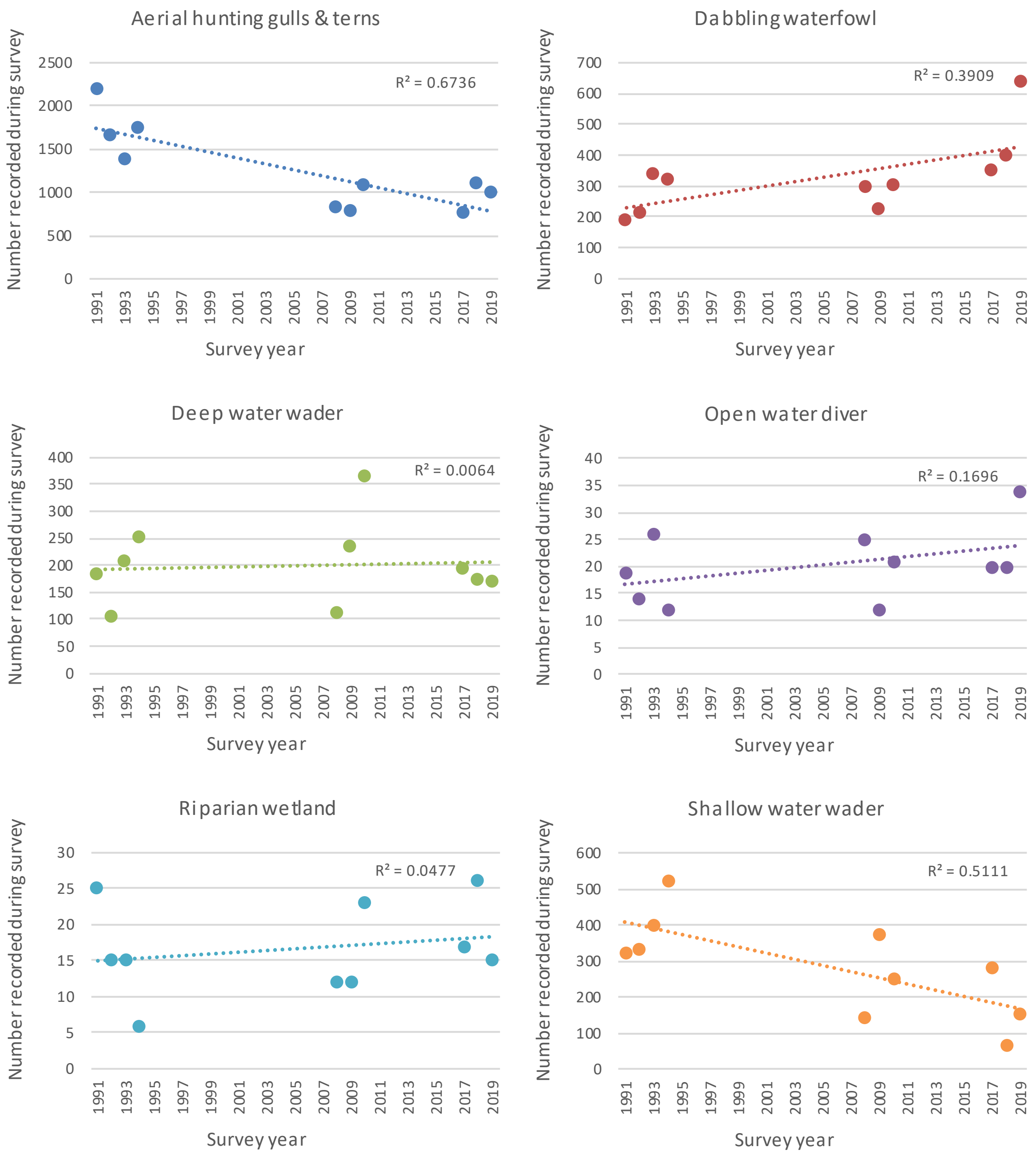


Figure 10: Trends in the number of birds recorded grouped by guild in the Takapō River standardised surveys 1991 - 2019



The breakdown of individual species abundances by guild are shown in Figure 11; there has been a mixture of species responses to the river habitat changes over the survey period. For aerial hunting gulls and terns, black-backed gull have shown the steepest decline (R^2=0.58) between 1991 and 2019. Most species of dabbling waterfowl have shown an increasing trend in numbers over the survey period, particularly the introduced Canada goose (R^2=0.48). Of the deep water wader species, white-faced heron have shown the strongest increasing trend (R^2=0.72), and spur-winged plover have shown the strongest declining trend (R^2=0.32). For open water divers, little shag exhibited an increasing trend (R^2=0.33). Banded dotterel and wrybill, both shallow water wading species, showed declining trends (R^2=0.45 and R^2=0.87 respectively).

The six specialised riverbird species of high conservation value and for which the TekPS is likely to have impacted negatively on their foraging and / or breeding habitat are listed in Table 7. A significant difference (decrease) was detected in the number of birds recorded between 1991 and 2019 for black-fronted tern, NZ pied oystercatcher, banded dotterel and wrybill recorded.

Table 7: Takapō River population trends of Threatened and At Risk species

GUILD	SPECIES	THREAT CLASSIFICATION	1991-2019		
			Trend	R^2	χ^2 p value
Aerial hunting gulls and terns	Black-billed gull	At Risk - Declining	→	0.0009	
	Black-fronted tern	Threatened – Nationally Endangered	↓	0.10	<0.05
Deep water waders	Kakī	Threatened – Nationally Critical	↑	0.03	-
	NZ pied oystercatcher	At Risk - Declining	↓	0.03	<0.05
Shallow water waders	Banded dotterel	At Risk - Declining	↓	0.45	<0.05
	Wrybill	Threatened – Nationally Increasing	↓	0.87	<0.05

8.4 Summary

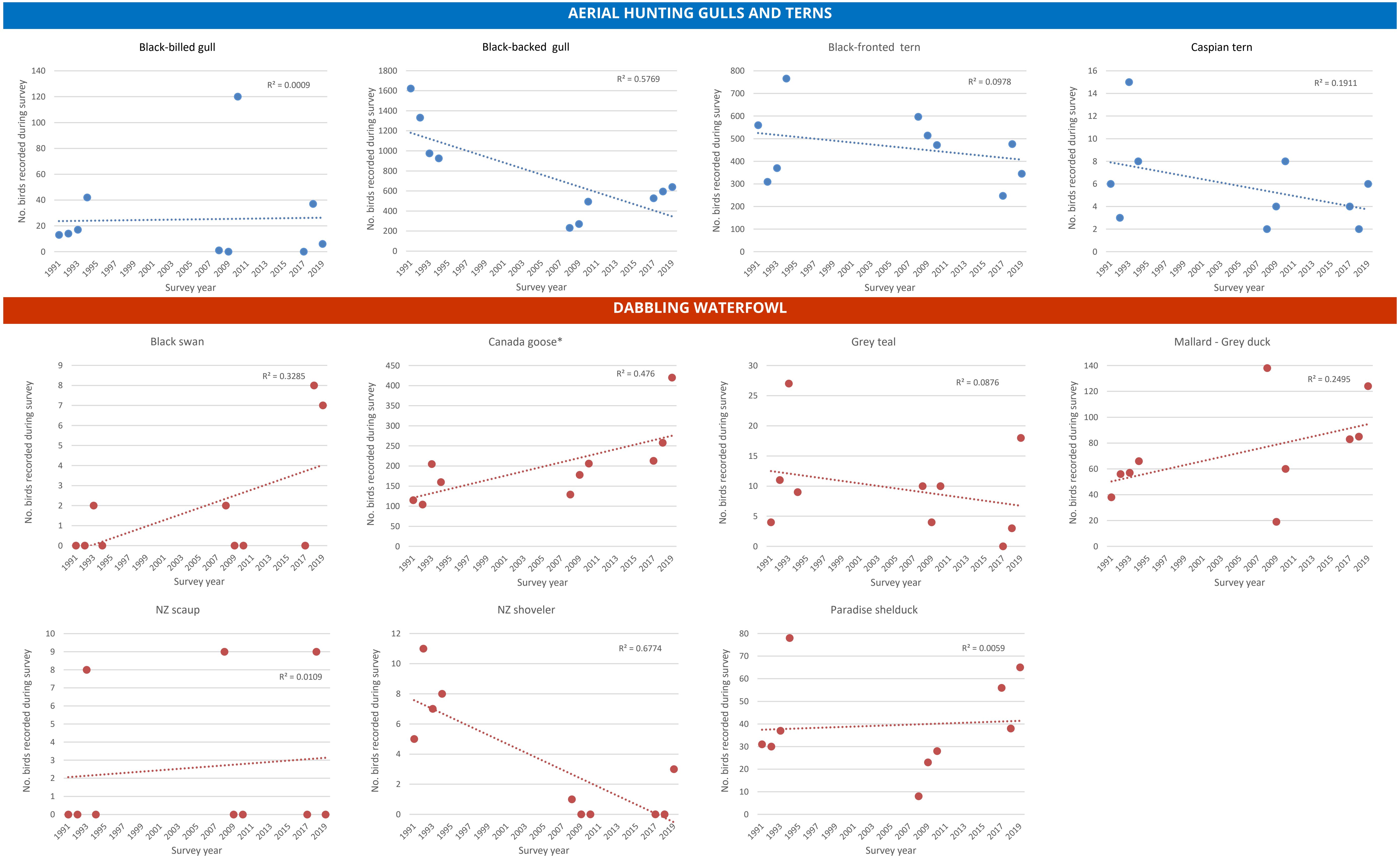
Overall, the construction of the CWPS resulted in the loss of braided river and swamp / wetland habitat but increased open water (lake) and lake shoreline habitat; this pattern of habitat change is evident in the Tekapo catchment.

There is no data available to determine the initial impact of the TekPS immediately after the commissioning of Tekapo A in 1950. Nor is it possible to attribute or quantify the potential ongoing impacts of the TekPS on the birds due to the inter-related nature of a number of ecosystem variables (refer to Section 5.1.3) and the number of additional factors both within and beyond the Tekapo catchment (refer to Sections 5.2, 5.3, 5.4 and 6.0). Thus, it is only possible to comment on the trends in numbers recorded, rather than attribute these changes to any one factor.

Based on the Takapō River surveys conducted since 1991, banded dotterel, black-fronted tern, NZ pied oystercatcher and wrybill (*Threatened* or *At Risk)* have shown declines in overall abundances (Table 7). These species are braided riverbed specialists, a habitat type which was significantly impacted by the construction of the TekPS.

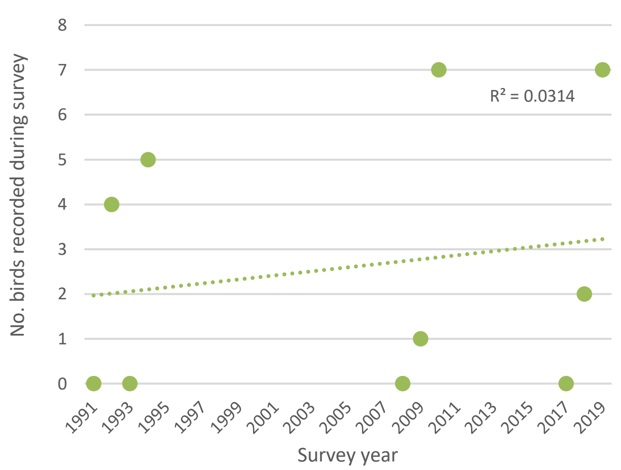
However, the abundance of several native (*Not Threatened*) and introduced species appear to have increased over the same period, including black swan, Canada geese, and white-faced heron; these species are open water and shoreline specialists, the habitat types that have increased in the catchment following the construction of the TekPS. Little shag (*At Risk*) numbers have also increased over that time period.

Figure 11: Riverbird abundance recoded during each Takapō River survey between 1991 and 2019.

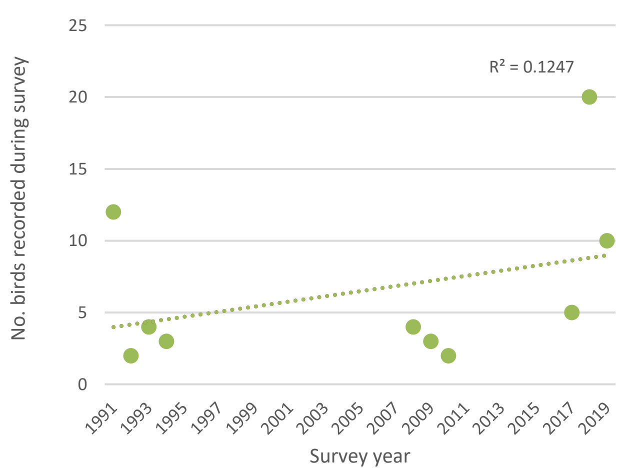


DEEP WATER WADERS

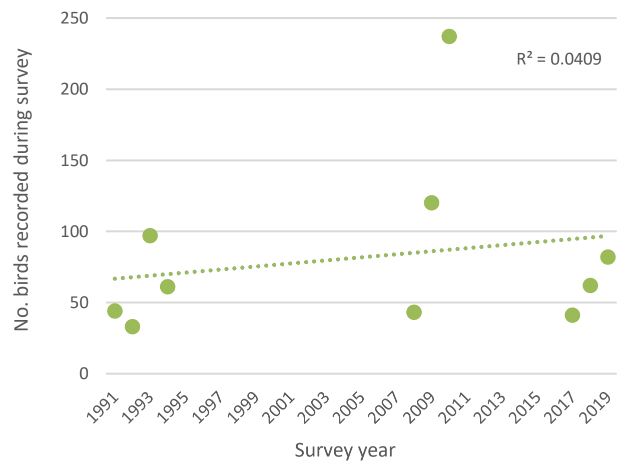
Kakī



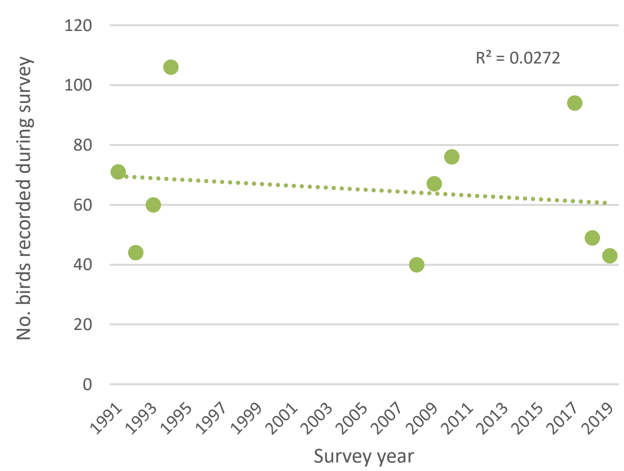
Hybrid black stilt



Pied stilt

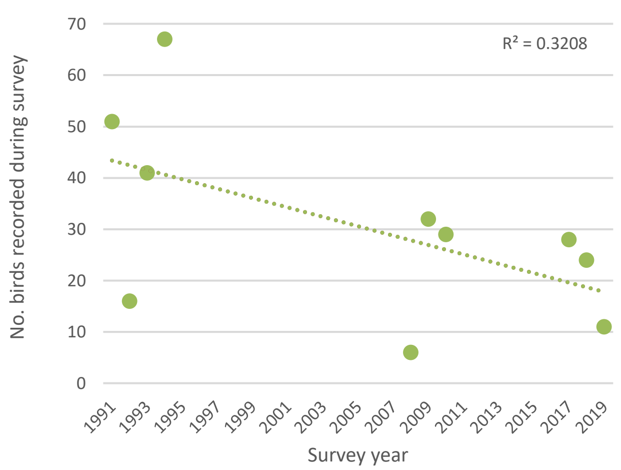


NZ pied oystercatcher

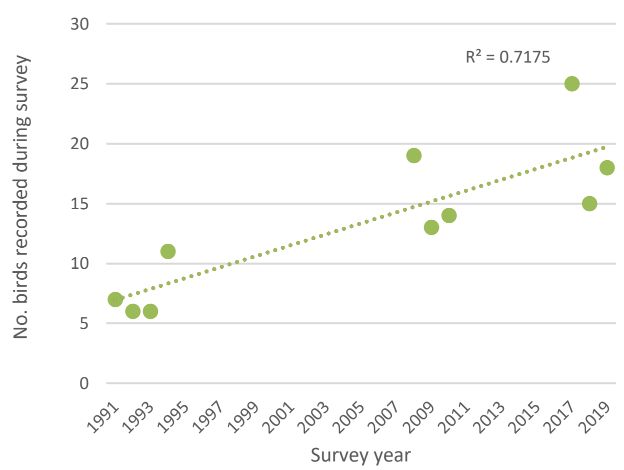


DEEP WATER WADERS

Spur-winged plover

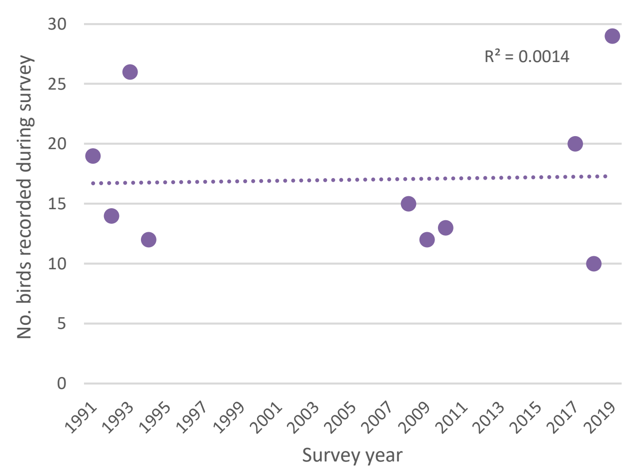


White-faced heron

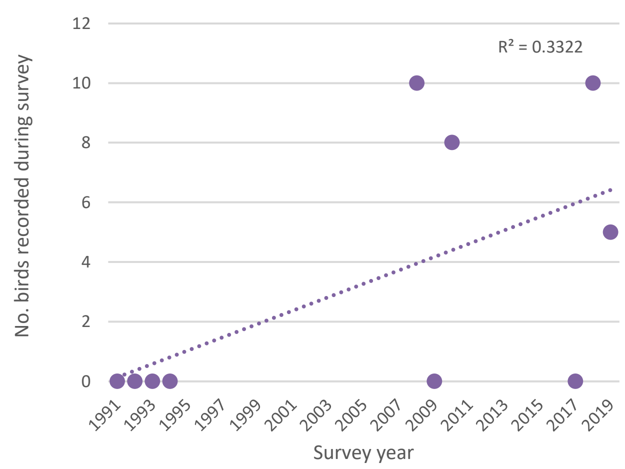


OPEN WATER DIVER

Black shag

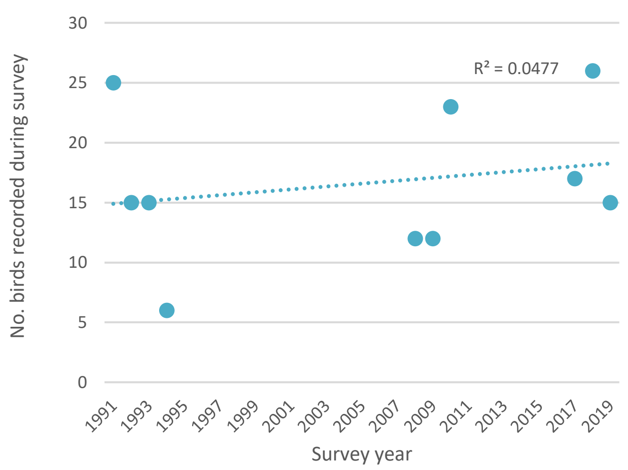


Little shag



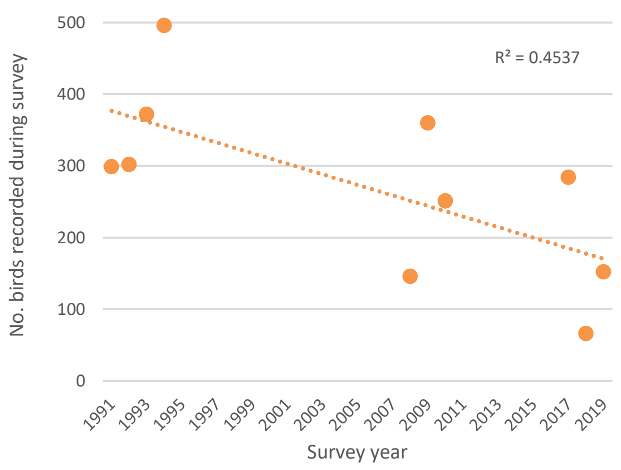
RIPARIAN WETLAND

Swamp harrier

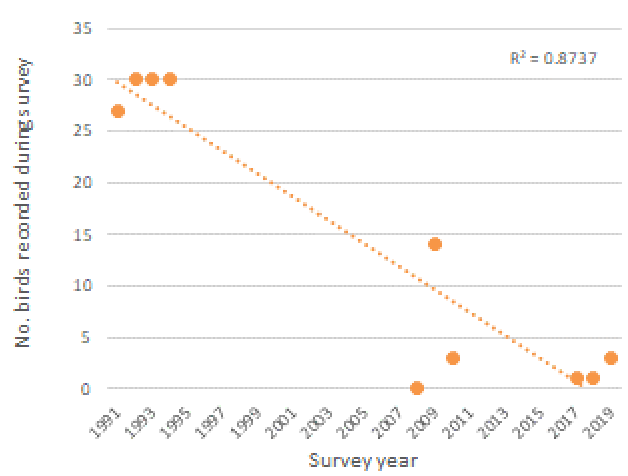


SHALLOW WATER WADER

Banded dotterel



Wrybill



9.0 Project River Recovery

Legal water-use rights were acquired by the former Electricity Corporation of New Zealand in the 1970's. Prior to their expiry in 1990, working parties assisted the Waitaki Catchment Commission to establish several compensatory agreements between the Corporation and interested stakeholders and user groups. One was the Compensatory Funding Agreement between the Corporation and DOC, which acknowledged that habitats and species characteristic of braided rivers had been impacted by the hydroelectric development (Innes & Saunders, 2012). PRR is the Department of Conservation programme established as part of that agreement in 1990 and is now funded by Meridian Energy and Genesis.

PRR operations began in 1991 and aims to mitigate some of the impacts of hydroelectric power generation by protecting or restoring braided river and wetland ecosystems in the upper Waitaki Basin. The approach was to develop new habitat or to redevelop degraded habitat, in an effort to increase the amount of good habitat in the basin, commensurate with or greater than what existed prior to hydro-electric development in the Upper Waitaki.

9.1 PRR 1991 – 1997

In the first seven years, both management and research were targeted mainly at improving habitat for wildlife, particularly kakī and other braided birds. By 1998, the 7th anniversary year, PRR had:

- Created 98 ha of new wetlands at seven sites;
- Cleared weeds from over 11,000 ha of riverbed;
- Undertaken baseline river bird surveys in the main rivers;
- Enlarged and fenced Mailbox Inlet (13 ha, 1997), Mick's Lagoon (10 ha, 1994) and Ruataniwha (11 ha, 1993); and
- For one season, established a new colony of 80 black-fronted terns in the Ruataniwha wetland complex.

9.2 PRR 1998 – 2005

The first strategic plan (1998-2005; Brown & Sanders (1999)) was developed and a new set of PRR objectives included emphasis on understanding the effect of introduced predators on native fauna, and developing more effective predator-management techniques. PRR prioritised weed control sites by considering management units within river systems for weed control based on diverse fauna and flora rather than just wading birds. Other focuses were to continue researching bird predation, predator behaviour and ecology, and cost-effective large-scale predator control strategies.

In 1999, PRR produced a 5-year weed control plan for the upper Waitaki basin that aimed to control pest plants to very low levels in the more natural braided riverbeds above the main lakes. In riverbeds below the lakes, the plan was to keep the pressure on pest plants in areas treated over the first seven years and extend weed-free areas where practicable. Weeds targeted were woody species that, if left unmanaged, would greatly alter bare-gravel landscapes and render them unsuitable habitats for braided river endemic birds and other fauna (Innes & Saunders, 2012).

Measures achieved during the term of the first strategic plan included maintaining over 35,000 ha of near-pristine braided river habitat by targeted removal of problem weeds before they become widespread (Woolmore & Sanders, 2005). By concentrating on protecting high quality habitats PRR has achieved greater conservation benefits than using the same resources to restore small sections of heavily modified or degraded riverbed (Woolmore & Sanders, 2005).

In regard to wetlands, additional wetlands were constructed at lower Ruataniwha and Waterwheel and predator fences were maintained at upper Ruataniwha, Mick's Lagoon and Mailbox wetlands (Woolmore & Sanders, 2005).

9.3 PRR 2006 – 2012

A second strategic plan (2006-2012) was developed by Woolmore & Sanders (2005). Over the next seven years of that plan, PRR aimed to consolidate its knowledge of braided river ecology, the plants, birds, fish and insect life, and develop a predator control programme for the Tasman Valley. During the period of the second strategic plan, PRR's achievements which related to avifauna included:

- Maintaining more than 23,000 ha of natural braided river habitat by targeted removal of problem weeds before they become widespread, concentrating on protecting high quality habitats.
- Undertaking weed management of selected sections of modified habitat to restore habitat quality over a further 7000 ha of braided riverbed.
- Establishing a large-scale predator control operation in the Tasman River to benefit multiple wader bird species. This was the first intensively managed, catchment-scale predator control operation attempted for multiple predator species in a braided river environment. Outcomes included:
    - Wrybill hatching success was consistently high, with almost no egg loss due to predation.
    - Banded dotterel hatching success was high with very few failures attributed to predation.
    - Breeding success of black-fronted tern was low compared to the other species, with predation, particularly by native avian predators, consistently being the largest cause of nest failures.
- Repeating riverbird surveys in the Tekapo River over three consecutive years.
- Ongoing management of over 80 ha of constructed wetlands.

9.4 PRR 21-year review (2012)

A review of the progress of PRR in its first 21 years (1991-2012) was undertaken by Innes & Saunders (2012). One of the objectives of that review was to determine the difference that PRR work had made to the maintenance and enhancement of indigenous species, ecosystems and habitats in the upper Waitaki basin braided river and wetland systems.

The following points were raised by Innes & Saunders (2012) in their review of the progress of PRR in its first 21 years (1991-2012):

- Pest-plant management was identified as the largest draw on annual expenditure, with between 42-67% of funds going into weed control.
- By intervening in 7,740 ha of riverbed at intervals ranging from once per year to once per four years, PRR maintained intermittent near-zero density of selected large weeds in 18,756 ha (93%) of the 20,086 ha of braided river in its 16 management units. This represented 63% of the braided river habitat in the upper Waitaki basin.
- Level of resources available to PRR meant that predator control could not be carried out on the same scale as weed control and the extent to which 15 years of experiment pest mammal management had assisted braided river birds (especially kakī, wrybill, banded dotterel and black-fronted term) was uncertain.
- More research on threatened species' breeding and recruitment to confirm ecological outcomes was recommended.

Innes & Saunders (2012) noted that weed control above the CWPS had preserved a substantial area of braided river habitat in excellent ecological condition, which in turn maintains habitat suitable for nesting by specialist braided river birds and other fauna. However, successful nesting also requires effective control of mammalian predators which unfortunately had not been done on the same scale as the weed control. Innes & Saunders (2012) were of the opinion that the difference made by 15 years of experimental pest management in the upper Waitaki Basin was probably the addition of 100s or perhaps 1000s of individuals of banded dotterel, wrybill, black-fronted tern and other species that may then live 10-20 years as breeding adults.

The initial high promise of the benefit to birds from fencing of Micks Lagoon, Mailbox and Ruataniwha wetlands was not sustained in the longer term. Monitoring during 1999-2002 showed no clear overall benefit to nesting birds in terms of hatching or fledging success, possibly due to the presence of Norway rats inside the fences and the inability to exclude avian predators.

Despite some uncertainties, Innes & Saunders (2012) concluded that PRR was seen by local stakeholders, and by braided river managers and researchers as "worthwhile and successful". Also that PRR was "very resource efficient at achieving its outcomes".

9.5 PRR 2012 – 2019

The third strategic plan (2012-2019; Rebergen & Woolmore (2015)) looked to widen the project's scope to a 'whole ecosystem' approach to include riverbanks and low terraces. Other aspects included repeating the comprehensive riverbird surveys (including Takapō River), obtaining a better understanding of black-fronted tern population dynamics, along with more research on the braided-river lizard and invertebrate communities and their habitat requirements. With regards to predators, the strategic plan included the continuation of testing the effectiveness, and implement of, large-scale experimental predator control for population recovery of braided river and wetland fauna. In terms of weed management, PRR's vision as expressed in the strategic plan include:

- Rivers above the glacial lakes will remain in 'essentially pristine condition' through weed control that keeps lupins, willows, gorse, broom and wilding trees at near-zero densities.
- River systems below the lakes will have their burden of weed species managed in an economically and ecologically-sustainable manner.

In the PRR 2019 – 20 annual report, Gale (2020) reported the following outcomes:

- Targeted ground-based control of weeds was carried out in the Godley, Macaulay, Cass, Tasman, Ōhau, Ahuriri, Twizel and Pūkaki rivers.
- Excellent condition of rivers above Lakes Takapō and Pūkaki, and the Ahuriri River above Longslip Creek were maintained. The Godley River is almost entirely free of Russell lupins (*Lupinus polyphyllus*) and introduced broom (*Cytisus scoparius*), while the Tasman River has had Russell lupin infestations reduced substantially.
- Control of southern black-backed gulls in the Tasman River continued. This species has shown to be a significant predator of both eggs and chicks of other braided river birds (M. Bell & Harborne, 2018).
- Te Manahuna Aoraki took over control of southern black-backed gull in the Godley and Cass Rivers, enabling PRR to extend control in three large colonies in the Tekapo and lower Pūkaki rivers.
- The Upper Ōhau trapping network programme of intensive predator trapping around the black-fronted tern colony continued.
- The fifteenth year of extensive mammalian predator control programme in the Tasman Valley was completed.
- Tasman River outcome monitoring of black-fronted tern and black-billed gull colonies showed relatively low hatching success of known nests; 27% for black-fronted tern nests 24% for black-billed gull nests. In previous years, tern nest hatching success has been 70%+; this years' low success was in part attributed to severe spring heavy rain events leading to flooding of nests.
- Wrybill monitoring was discontinued several seasons ago due to their consistently high hatching success over the course of the outcome monitoring study (average 79.5% for years 2004-2018) and the difficult and time-consuming nature of finding and following chicks through to fledging.
- Southern crested grebe surveys were undertaken on Lake Ruataniwha, Wairepo Arm, Kellands Ponds, Lake Alexandrina and Lake McGregor, revealing similar numbers as the previous year.
- Wetland management to sustain suitable habitat for both wading birds and threatened endemic flora included fence maintenance and water-level manipulation at Waterwheel and Ruataniwha wetlands.

10.0 PRR and Avifauna Population Trends

Given the focused effort of PRR on protecting and preserving the high ecological values in the catchments above the CWPS, it is expected that the riverbird assemblages in those catchments will be benefiting the greatest from those measures. Results of the chi-squared analysis of the differences in the number of each of the six braided riverbed specialists recorded within each catchment during the first PPR survey compared to those in the most recent surveys over a consistent distance is provided in Table 8; the purpose of this is to essentially look at the first and last comparable PRR survey results and to see if there is any significant difference between these numbers. This analysis shows, for instance, that in the Tasman catchment three (banded dotterel, black-billed gull and black-fronted tern) of the six riverbed specialists had significantly higher numbers recorded in the last PRR survey (2019) compared to the first survey (1992). The river lengths over which the Pūkaki data was collected varied over time and as such were not included in this analysis of abundance. We also note that for the Ōhau catchment the comparable river length data was for 1992 and 2010, which is a protracted period relative to other catchments.

In the following sections, we examine individual species patterns to obtain an understanding of how each of these has responded to the PRR management measures at the scale of the Upper Waitaki Basin.

Table 8: Significant differences (χ^2 p < 0.05) in species abundances recorded between the first and last PRR surveys over the same river distance within each catchment. (Red and green arrows indicate decreases and increases respectively. Shaded cells indicate insufficient data to undertake chi-square analysis).

SPECIES	DOWNSTREAM OF CWPS			UPSTREAM OF CWPS				
	Takapō	Ōhau	Pūkaki	Cass	Godley	Macaulay	Ahuriri	Tasman
Banded dotterel	↓	↓	-	↑	↑		↓	↑
Black-billed gull		↓	-	↑	↑		↑	↑
Black-fronted tern	↓	↓	-	↑				↑
Kakī			-					
NZ pied oystercatcher	↓	↓	-	↑	↑	↑	↓	
Wrybill	↓	↓	-	↓	↓		↓	

First PRR data point	1991	1992		1991	1992	1992	1991	1992
Last PRR data point	2019	2010		2015	2016	2016	2019	2019
Distance surveyed	23.1 km	20.6 km		23.1 km	20 km	12.9 km	79.7 km	7.2 km

10.1 Banded dotterel

Mean density of banded dotterel was found to differ significantly between all sites (p=2.81E^{-19}), including between the upstream sites (p=1.01E^{-12}), but not between the downstream sites (p=0.43) (Figure 12). Overall, the highest average density of banded dotterel was recorded in the Godley catchment (Figure 13).

In terms of trends in mean bird densities over time, a significant decreasing regression were detected for banded dotterel in the Ahuriri (upstream of CWPS) and Pūkaki (downstream of CWPS) catchments (Figure 12).

Compared to the first PRR counts, significantly (χ^2 p < 0.05) lower numbers of birds were recorded in last PRR counts in the Takapō, Ōhau and Ahuriri (Table 8). Whereas, over the same period significantly higher numbers were recorded in the Cass, Godley and Tasman catchments (Table 8).

Overall, banded dotterel numbers are increasing in catchments above the CWPS, with the exception of the Ahuriri, where a significant decreasing trend in the mean density of birds was detected.

In regard to the Takapō River, significantly (χ^2 p < 0.05) lower numbers of banded dotterel were recorded in last PRR counts in 2019 compared to 1991.

Figure 12: Banded dotterel: Mean birds recorded per kilometre of river during PRR riverbird surveys up- and down-stream of the CWPS.

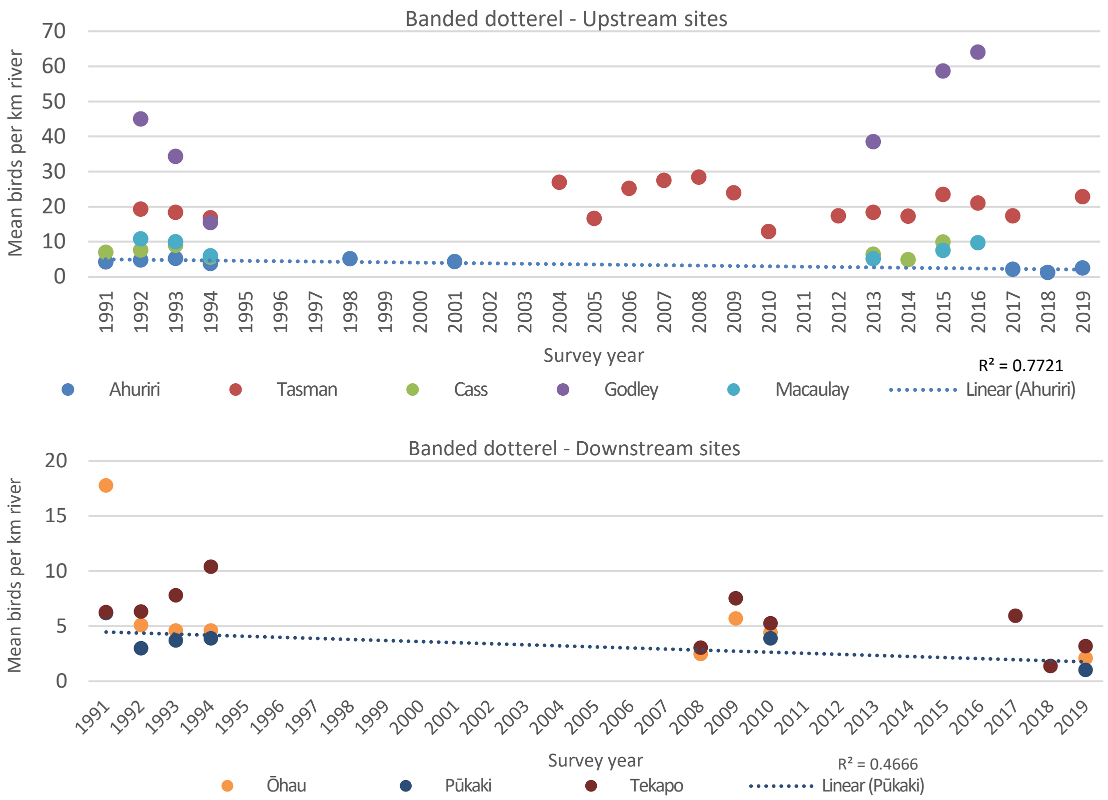
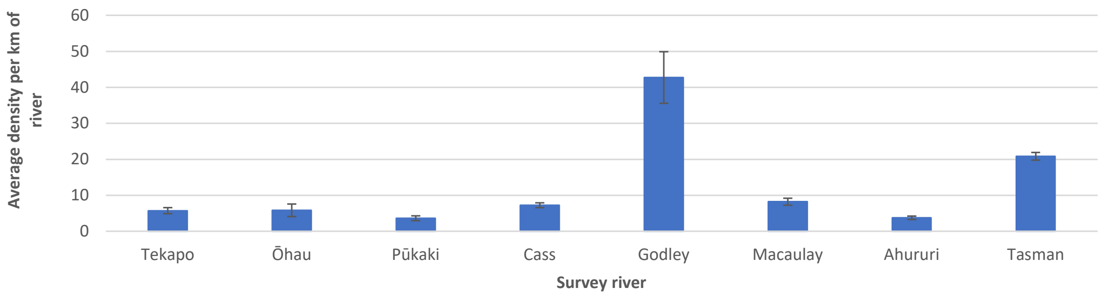


Figure 13: Average density (±SE) (1991-2019) of banded dotterel recorded per kilometre of surveyed river.



10.2 Black-billed gull

Mean density of black-billed gull was found to differ significantly between all sites (p=0.005), including between upstream sites (p=0.04), but not between the downstream sites (p=0.52) (Figure 14). The Ahuriri catchment recorded the highest mean density of black-billed gull (Figure 15).

In terms of trends in mean bird density over time, significant increasing regressions were detected for black-billed gull in Tasman and Ahuriri catchments, both upstream of the CWPS (Figure 14).

Overall, black-billed gull numbers were found to have significantly (χ^2 $p < 0.05$) increased in four the catchments above the CWPS (Cass, Godley, Ahuriri and Tasman), and significantly decreased in one catchment below (Ōhau) (Table 8).

In regard to the Takapō River, no significant trends in mean density or numbers of black-billed gull were detected from the data between 1991 and 2019.

Figure 14: Black-billed gull: Mean birds recorded per kilometre of river during PRR riverbird surveys up- and down-stream of the CWPS.

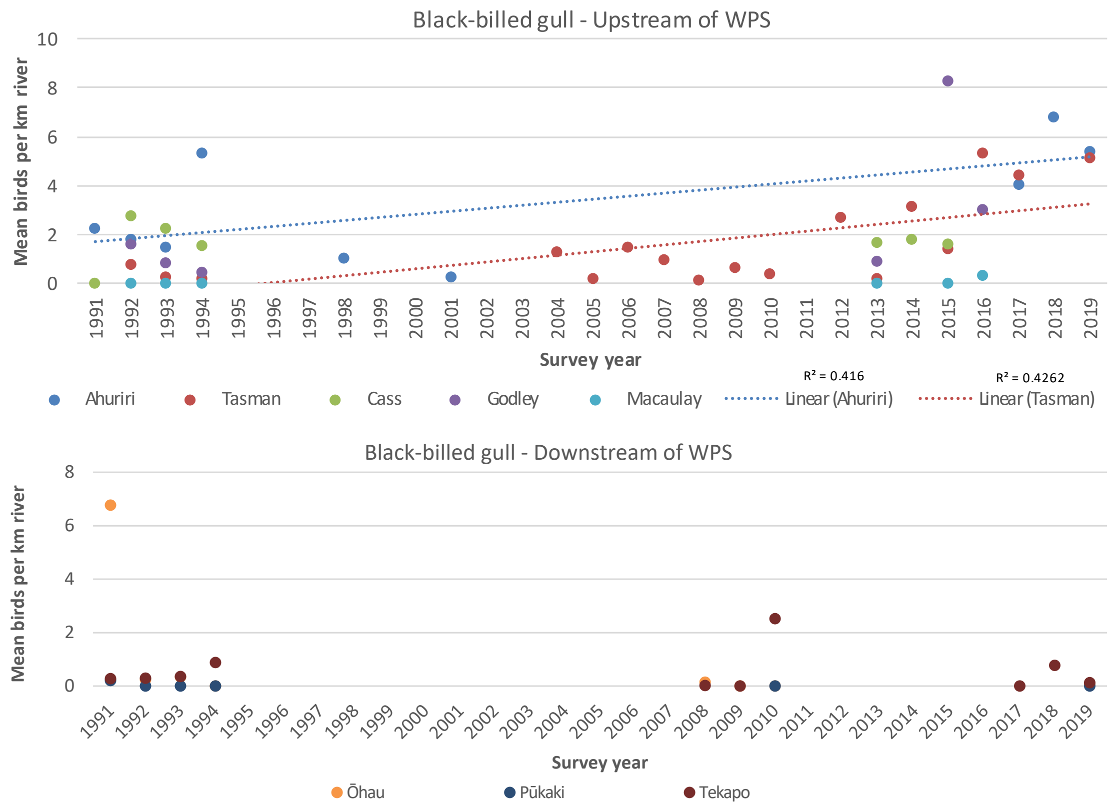
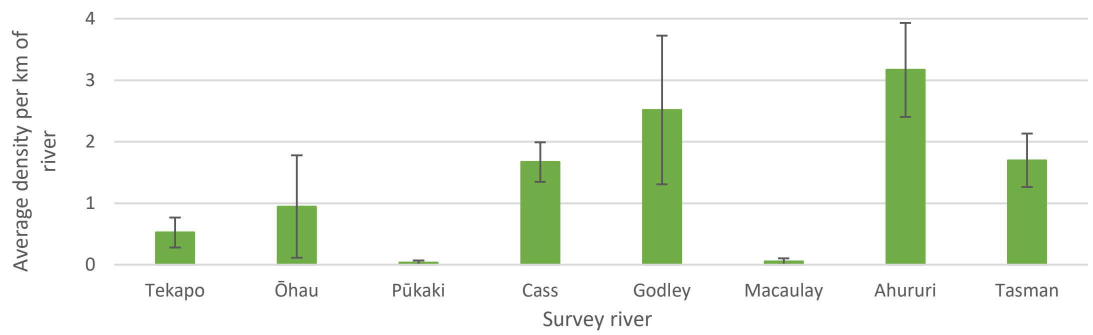


Figure 15: Average density (±SE) (1991-2019) of black-billed gull recorded per kilometre of surveyed river.



10.3 Black-fronted tern

Mean density of black-fronted term was found to differ significantly between all sites, (*p*=0.0009); furthermore, a significant difference was found between upstream (*p*=0.001) and downstream sites (*p*=0.04) (Figure 16). Overall, the highest mean density of black-fronted tern was recorded in the Ōhau catchment (Figure 17), downstream of the CWPS. We note that an extensive trapping programme occurs in the Ōhau, with black-fronted tern being the species aimed to benefit from that work.

No significant trends were detected in the mean densities of birds within each catchment over the survey period.

Compared to the first PRR count, significantly (χ^2 $p < 0.05$) lower numbers were recorded in last PRR counts in the Tekapo and Ōhau catchments (Table 8), whereas significantly higher numbers were recorded in the Cass and Tasman catchments (Table 8).

Thus, in the Tekapo, the number of black-fronted tern recorded in 2019 was significantly less than in 1991.

Figure 16: Black-fronted tern: Mean birds recorded per kilometre of river during PRR riverbird surveys up- and down-stream of the CWPS.

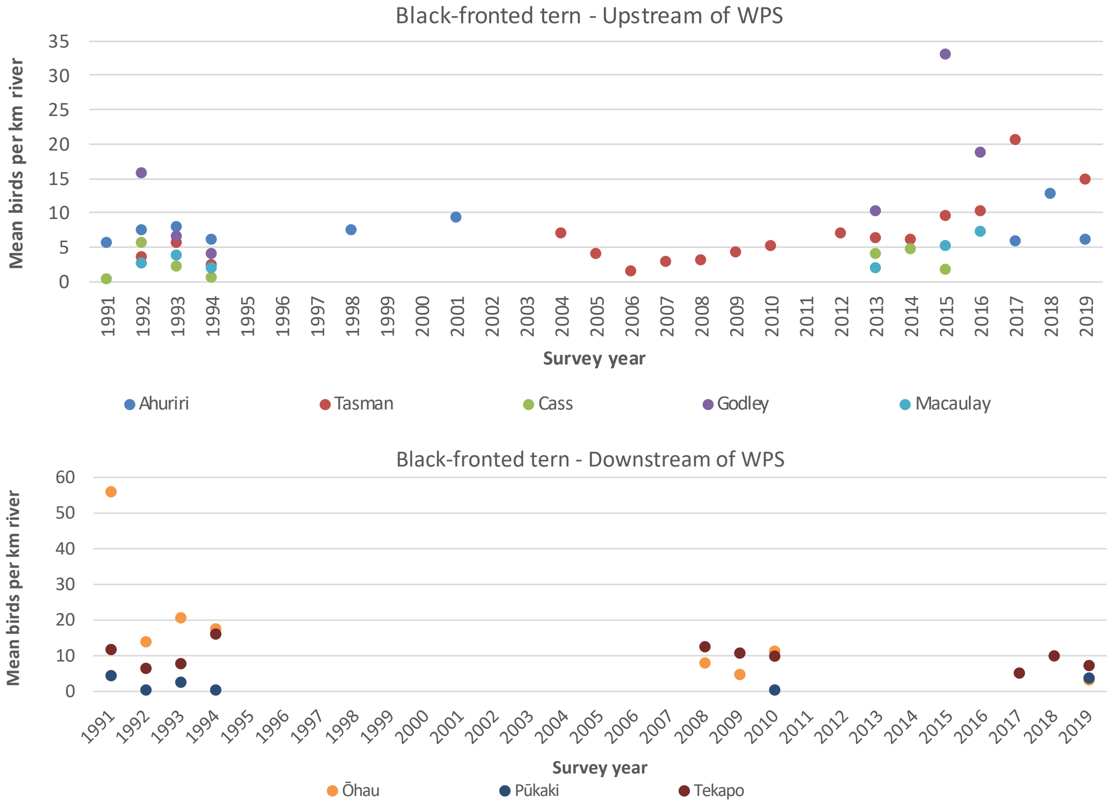
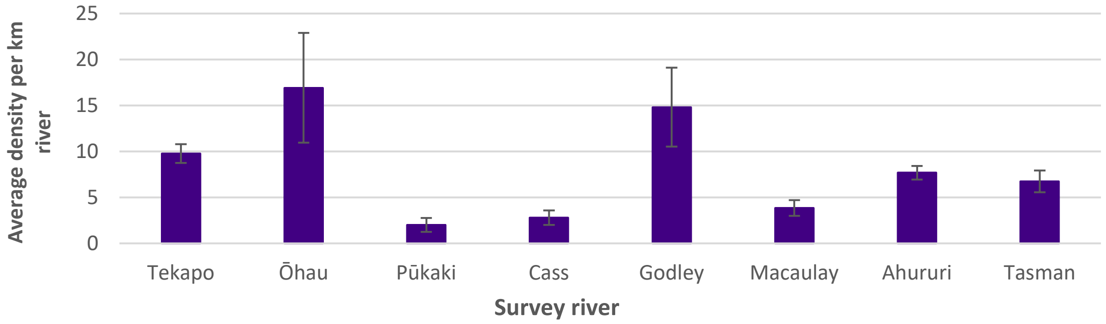


Figure 17: Average density (±SE) (1991-2019) of black-fronted tern recorded per kilometre of surveyed river.



10.4 Kakī

Mean density of kakī was found to differ significantly between all sites (p=0.006), including between the upstream sites (p=0.02), but not between the downstream sites (p=0.61) (Figure 18). Overall, the highest mean density of kakī was recorded in the Godley catchment (Figure 19).

In terms of trends in mean bird densities over time, significant increasing trends were detected for the Godley (upstream of WPS) and Pūkaki (downstream of CWPS) catchments (Figure 18). However, we note that these trends are being driven by single high data points and as such caution should be exercised around these results. In comparison, significant decreasing trends were detected in the Ōhau (downstream of CWPS) catchment (Figure 18).

The low numbers of kakī recorded in many catchments meant that a Chi-square analysis could only be performed for the Ahuriri and Tasman catchments, for which no significant differences were found in the abundance of birds recorded in first and last PRR surveys (Table 8).

Figure 18: Kakī: Mean birds recorded per kilometre of river during PRR riverbird surveys up- and down-stream of the WPS.

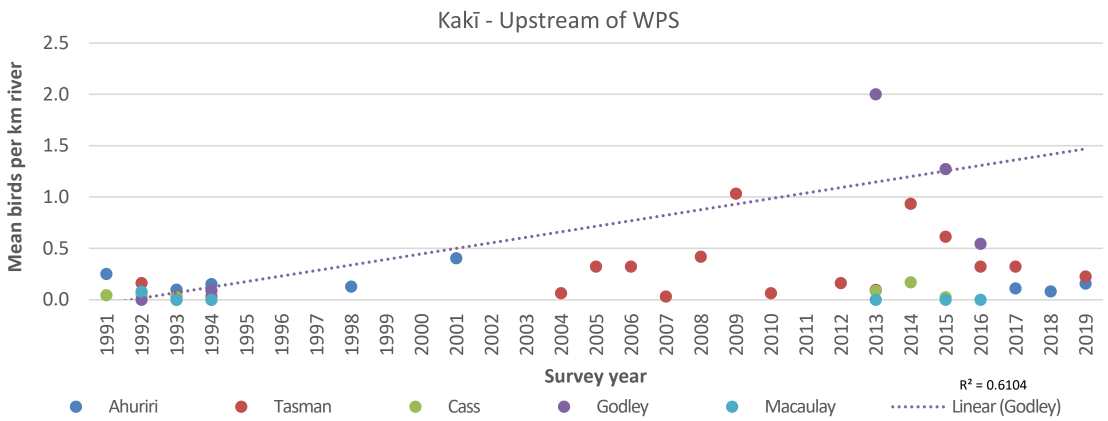


Figure 18: Kakī: Mean birds recorded per kilometre of river during PRR riverbird surveys up- and down-stream of the WPS.

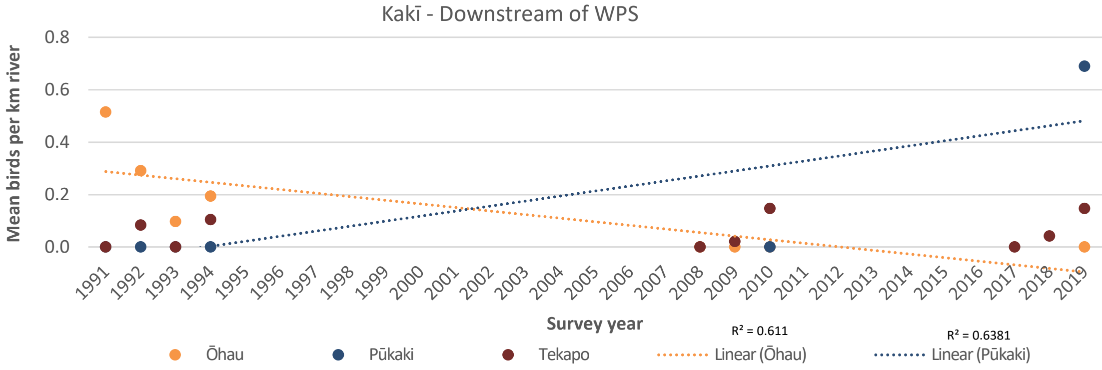
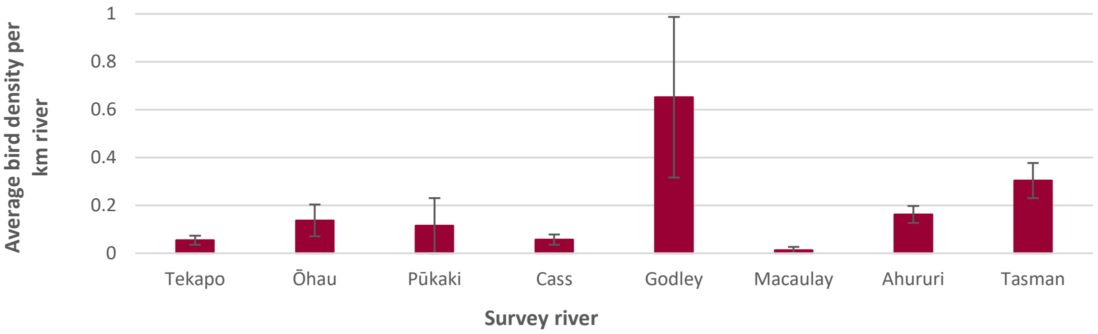


Figure 19: Average density (±SE) (1991-2019) of kakī recorded per kilometre of surveyed river.



10.5 NZ pied oystercatcher

Mean density of NZ pied oystercatcher was found to differ significantly between all sites (p=9.97E^{-16}), including between upstream (p= 6E^{-16}) and downstream sites (p=0.003) (Figure 20). Overall, the highest mean density of NZ pied oystercatcher was recorded in the Godley catchment (Figure 21).

In terms of trends in mean bird densities over time, a significantly increasing trend was detected in the Godley upstream of the CWPS and a significant decreasing trend in the Pūkaki downstream of the CWPS (Figure 20).

Compared to the first PRR count, significantly (χ^2 p < 0.05) lower numbers of NZ pied oystercatcher were recorded in the last PRR count in the Tekapo, Ōhau and Ahuriri catchments (Table 8). Whereas significantly higher numbers were recorded in the last PRR counts in the Cass, Godley and Macaulay catchments (Table 8).

Thus, in the Tekapo, while no significant regression was detected over time (likely due to the variability in counts each survey; refer to Figure 20), there were significantly fewer NZ pied oystercatcher recorded in 2019 compared to 1991.

Figure 20: NZ pied oystercatcher: Mean birds recorded per kilometre of river during PRR riverbird surveys up- and down-stream of the CWPS.

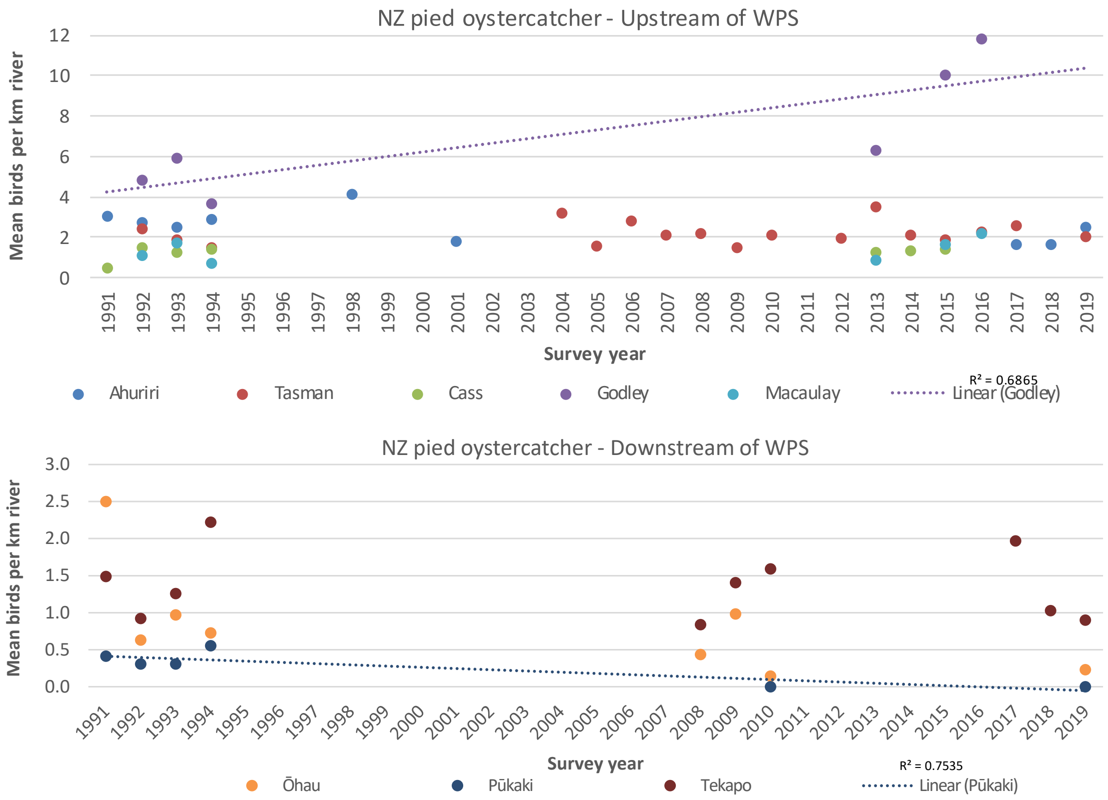
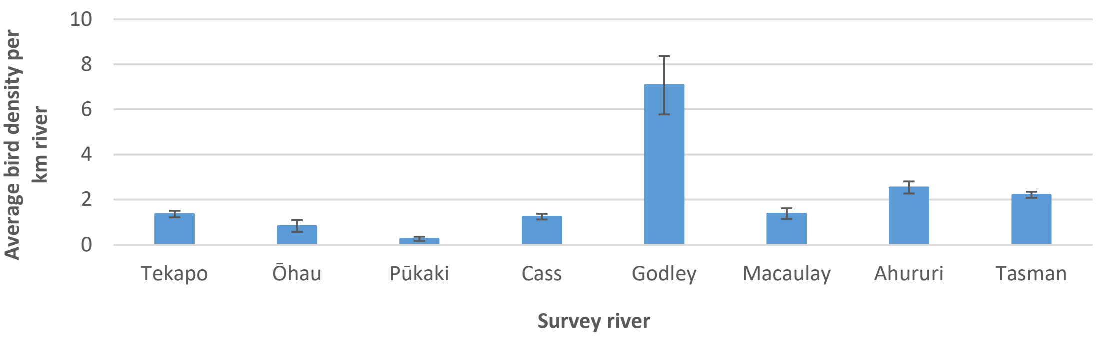


Figure 21: Average density (±SE) (1991-2019) of NZ pied oystercatcher recorded per kilometre of surveyed river.



10.6 Wrybill

Mean density of wrybill was found to differ significantly between all sites (p=1.88E^{-25}), including between upstream sites (p= 1.43E^{-16}), but downstream sites (p=0.31) (Figure 22).Overall, the highest mean density of wrybills was recorded in the Godley catchment (Figure 23).

In terms of mean bird densities over time, significant decreasing trends were detected in catchments both upstream (Ahuriri and Cass) and downstream (Tekapo and Ōhau) of the CWPS (Figure 22). However, a significant increasing trend was detected in the Pūkaki catchment, downstream of the CWPS (Figure 22).

Compared to the first PRR count, significantly (χ^2 $p < 0.05$) lower numbers of wrybill were recorded in the Tekapo, Ōhau, Cass, Godley and Ahuriri catchments in the last PRR counts (Table 8).

Thus, in the Tekapo, a significant decreasing trend coupled with a significant decrease in numbers between 1991-2019 is indicative of an ongoing decline in wrybill at that location.

Figure 22: Wrybill: Mean birds recorded per kilometre of river during PRR riverbird surveys up- and down-stream of the CWPS.

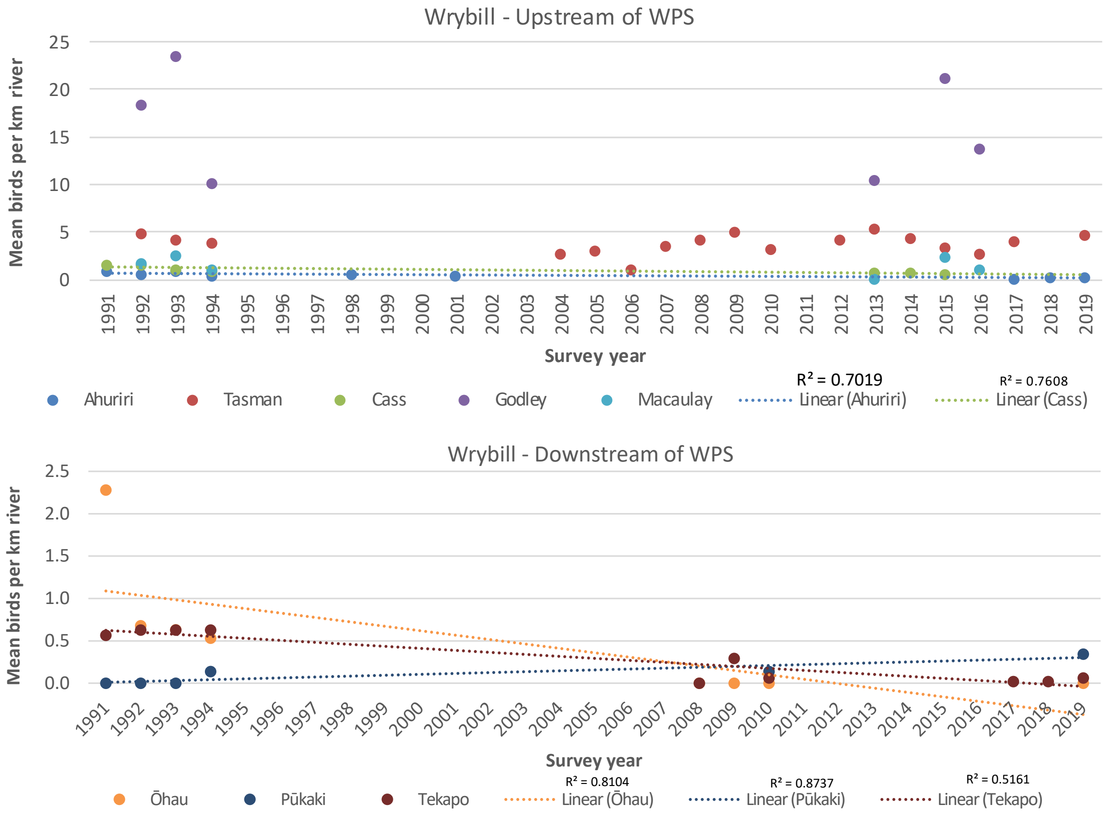
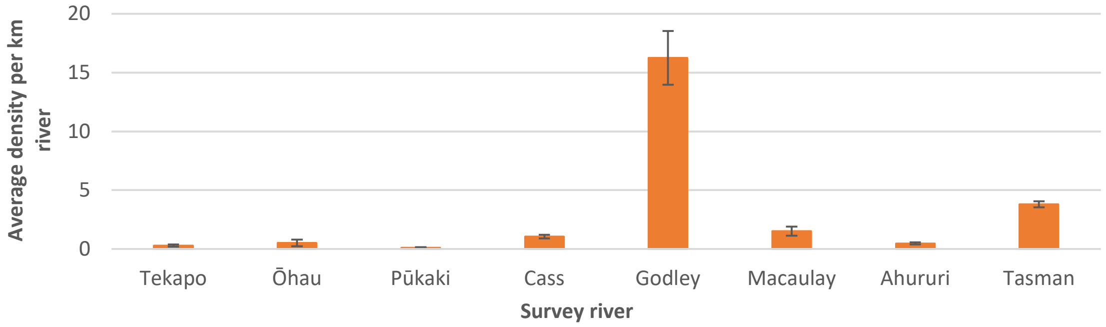


Figure 23: Average density (±SE) (1991-2019) of wrybill recorded per kilometre of surveyed river.



11.0 Conclusions

With regards to changes in water levels in the Takapō River, the frequent operational and management releases through the upper Takapō River currently make this stretch of river not conducive to nesting river birds (refer to Sections 4.1.2, 5.1.2.1 and Photo 1). While birds may establish nest sites downstream ofLake George Scott, flows into the lower Tekapo River over the Lake George Scott weir result from inflow-driven lake level management so are largely out of Genesis' control.

As identified previously, it is not possible to attribute or quantify the potential impacts of the TekPS on the birds due to the inter-related nature of a number of ecosystem variables (refer to Section 5.1.3) and the number of additional factors both within and beyond the Tekapo catchment (refer to Sections 5.2, 5.3, 5.4 and 6.0). Thus, it is only possible to comment on the trends in bird numbers currently being recorded through PRR surveys, rather than attribute these changes to any one factor such as the TekPS.

The construction of the CWPS resulted in the loss of open braided river habitat and swamplands, but increased the amount of open water (lake habitat) and lake shoreline habitat (Wilson, 2000). This pattern in habitat change occurred in the Tekapo catchment and is reflected in the changes in freshwater bird assemblage, with decreasing numbers in braided river specialists and increasing numbers of open water and shoreline birds in the Tekapo catchment (refer to Section 5.2).

PRR operations began in 1991, with the aim to mitigate the impacts of hydroelectric power generation by protecting or restoring braided river and wetland ecosystems in the upper Waitaki Basin in catchments not impacted by the CWPS. Recent PRR measures implemented to benefit specialist braided riverbirds include:

- Weed control that keeps lupins, willows, gorse, broom and wilding trees at near-zero densities in rivers above the glacial lakes (e.g. **Macaulay, Godley, Tasman, Ahuriri**).
- Management of weed species in an economically and ecologically-sustainable manner in river systems below the lakes (e.g. **Tekapo, Pūkaki, Ōhau**).
- Long term (15+ years) catchment-scale predator control programme in the **Tasman** Valley designed to provide benefits for a wide range of braided riverbirds (and other native fauna).

- Small-scale intensive management of predators in the Upper **Ōhau** River for the benefit of black-fronted terns.
- Control of southern black-backed gulls in the **Tasman** River since 2013.
- Continued control of southern black-backed gulls in the **Godley** and **Cass** rivers by TMA, enabling PRR to extend control in three large colonies in the **Tekapo** and lower **Pūkaki** rivers.

Given the focus of PRR efforts in catchments above the CWPS, we would expect to see increasing or stable numbers in those rivers, particularly in the Tasman and Godley catchments which receive a combination of predator control and with weed management.

Our analysis of the difference in abundance of birds recorded in recent comparable surveys to those at the start of PRR, show significant increases over that time for a number of species upstream of the CWPS and where PRR management are occurring. Notably, no increases in abundances were detected in areas downstream of the CWPS. This would suggest that PRR measures are providing benefits for banded dotterel, black-billed gull, black-fronted tern and NZ pied oystercatcher. Of particular note is that significant increase in abundance of NZ pied oystercatcher and banded dotterel recorded in catchments above the CWPS where PRR management is occurring, as these trends are contrary to the national population trends recently reported by Riegen & Sagar (2020) for these two species (refer to Figure 4 and Figure 5 respectively).

The Godley River recorded highest average densities for four species (banded dotterel, kakī, NZ pied oystercatcher and wrybill), and three species with increasing abundances (banded dotterel, black-billed gull and NZ pied oystercatcher). This river system receives both weed and southern black-back gull controls.

Black-billed gull appears to be the species for which the most gains have been achieved above the CWPS over the course of PRR, with significant increases in abundance in four river systems (Cass, Godley, Ahuriri and Tasman). In comparison, significant decreases in wrybill abundance was detected in five river systems (including three above the CWPS; Cass, Godley and Ahuriri). These decreasing trends in wrybill abundance are contrary to the national population trend reported by Riegen & Sagar (2020), for which for which a 33% increase in the winter counts was recorded between 1983-94 and 2005-19 (refer to Figure 6).

From a species perspective, we recommend that additional measures are investigated that would further assist with the conservation efforts for wrybill in the Waitaki catchments. Furthermore, the detection of instances of significant decreases in abundance above the CWPS indicate that additional pressures beyond the power scheme are threatening several populations, particularly in the Ahuriri (in which significant decreases in abundances were recorded for banded dotterel, NZ pied oystercatcher and wrybill). As such, conservation measures should be investigated with DOC for the Ahuriri catchment.

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Appendix 1: Avifauna survey location photos

Photo 2: Boundary Stream mouth survey location.

Photo 3: Lake Takapō wetland area survey location.

Photo 4: Takapō River control gate survey location.

Photo 5: Canal gate survey location.

Photo 6: Patterson's Ponds survey location 1.

Photo 7: Patterson's Ponds survey location 2.

Photo 8: Lake McGregor survey location.

Photo 9: Lake Takapō south-west edge survey location.

Photo 10: Lake Takapō south-west lake edge survey location looking across the dry flats.

Photo 11: Mailbox Enclosure survey location.

Photo 12: Mailbox Inlet survey location.

Appendix 2: 2019 point count surveys

Survey Site	Site Description	Survey Date	Survey Time (h)
1) Mouth of Boundary Stream (Photo 2 in Appendix 1)	Rocky shoreline at the mouth of Boundary Stream approximately halfway up the eastern side of Lake Takapō.	15/10/19 16/10/19 17/10/19	08:41 – 09:01 14:07 – 14:27 08:26 – 08:46
2) Lake Takapō wetland (Photo 3 in Appendix 1)	Open wetland area with some patches of raupo on the southern edge of Lake Takapō adjacent to SH8. Open waterbody in the centre of the wetland.	15/10/19 16/10/19 17/10/19	09:30 – 09:50 13:20 – 13:40 09:14 – 09:34
3) Takapō River control gate (Photo 4 in Appendix 1)	Takapō River mouth and upstream section of the river up to the control gate and bridge across SH8. Rocky lower shoreline. Lupin and willow on the upper banks. Large boulders on the sides of the river mouth3	16/10/19 17/10/19 18/10/19	12:40 – 13:00 09:44 – 10:04 10:40 – 11:00
4) Takapō River upstream of canal gate (Photo 5 in Appendix 1)	Takapō River section directly upstream of the Tekapo canal gate including a large backed up pond of water, gravel riverbed and rocky shoreline. Surrounded by exotic pine plantation and willow trees.	15/10/19 16/10/19 17/10/19	10:08 – 10:28 12:05 – 12:25 10:20 – 10:40
5) Patterson's Ponds 1 (Photo 6 in Appendix 1)	A man-made series of approximately ten freshwater ponds between the Tekapo canal and the western side/true right side of the Takapō River (accessed via Tekapo Canal Road). Areas of raupo within the ponds and bordered by willow and poplar trees. Some sedges along the pond edges. The ponds are fed from and drained into Takapō River.	15/10/19 16/10/19 17/10/19	14:34 – 14:54 08:53 – 09:13 13:45 – 14:05
6) Patterson's Ponds 2 (Photo 7 in Appendix 1)		15/10/19 16/10/19 17/10/19	15:00 – 15:20 08:27 – 08:47 14:10 – 14:30
7) Lake McGregor (Photo 8 in Appendix 1)	Freshwater lake between Lake Alexandrina and Lake Takapō. Surveyed from the middle of the southern lake shore. Surrounded by farmland, willow trees and rocky shoreline.	15/10/19 16/10/19 17/10/19	11:09 – 11:29 11:08 – 11:28 11:01 – 11:21
8) Lake Takapō south-west edge (Photo 9 and Photo 10 in Appendix 1)	Rocky shoreline along the south-west edge of Lake Takapō as well as the dry flat area behind the gravel stop bank that is bordered by Godley Peaks Road to the west.	15/10/19 16/10/19 17/10/19	11:53 – 12:13 10:37 – 10:57 12:02 – 12:22
9) Mailbox enclosure (Photo 11 in Appendix 1)	Fenced off enclosure accessed off Godley Peaks Road. Composed of two large ponds surrounded by farmland.	15/10/19	13:37 – 13:37
10) Mailbox Inlet (Photo 12 in Appendix 1)	Rocky shoreline area on the western side of Lake Takapō, east of Mailbox Enclosure. One small pond and a water seepage feeding into the lake. Surrounded by rocky farmland on a terrace.	15/10/19 16/10/19 17/10/19	12:40 – 13:00 09:55 – 10:15 12:45 – 13:05

Appendix 3: Avifauna species list

The following table lists all the avifauna species recorded within the OSNZ 1985 and 2004 atlas squares encompassing Lake Takapō, Tekapo Canal, Takapō River and margin, as well as from other literature and online sources, and the 2019 point count surveys.

SPECIES		THREAT CLASSIFICATION[7]	HABITAT								OSNZ DATA		OTHER LIT. SOURCES	2019 POINT COUNTS										2019 INCIDENTAL OBS
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	1985	2004		1 Rivermouth	2 Lake Takapō wetland	3 Takapō river control	4 Takapō river upstream	5 Pattersons 1	6 Pattersons 2	7 Lake McGregor	8 Lake Takapō SW edge	9 Mailbox enclosure	10 Mailbox Inlet	
Bellbird	*Anthornis m. melanura*	Not Threatened										✓												
Brown creeper	*Mohoua novaeseelandiae*	Not Threatened										✓												
Kingfisher	*Todiramphus sanctus vagans*	Not Threatened										✓												
Shining cuckoo	*Chrysococcyx l. lucidus*	Not Threatened										✓												
South Island fantail	*Rhipidura f. fuliginosa*	Not Threatened[EF]									✓	✓	✓											✓
South Island rifleman	*Acanthisitta chloris chloris*	Not Threatened										✓												
Yellow-breasted tomtit	*Petroica m. macrocephala*	Not Threatened									✓	✓	✓											
Blackbird	*Turdus merula*	Introduced & Naturalised[SO]									✓	✓	✓											✓
California quail	*Callipepla californica*	Introduced & Naturalised[SO]									✓	✓	✓											
Grey warbler	*Gerygone igata*	Not Threatened									✓	✓	✓											✓
Silvereye	*Zosterops lateralis lateralis*	Not Threatened[SO]									✓	✓	✓											✓
Canada goose	*Branta canadensis*	Introduced & Naturalised[SO]									✓	✓	✓						✓	✓	✓			
Chaffinch	*Fringilla coelebs*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Chukar	*Alectoris chukar*	Introduced and Naturalised[SO Sp]									✓	✓												
Dunnock	*Prunella modularis*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Eastern falcon	*Falco n. novaeseelandiae*	Threatened - Nationally Vulnerable[CR DPS CPT]									✓	✓	✓											
Goldfinch	*Carduelis carduelis*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Greenfinch	*Carduelis chloris*	Introduced & Naturalised[SO]									✓	✓	✓											✓

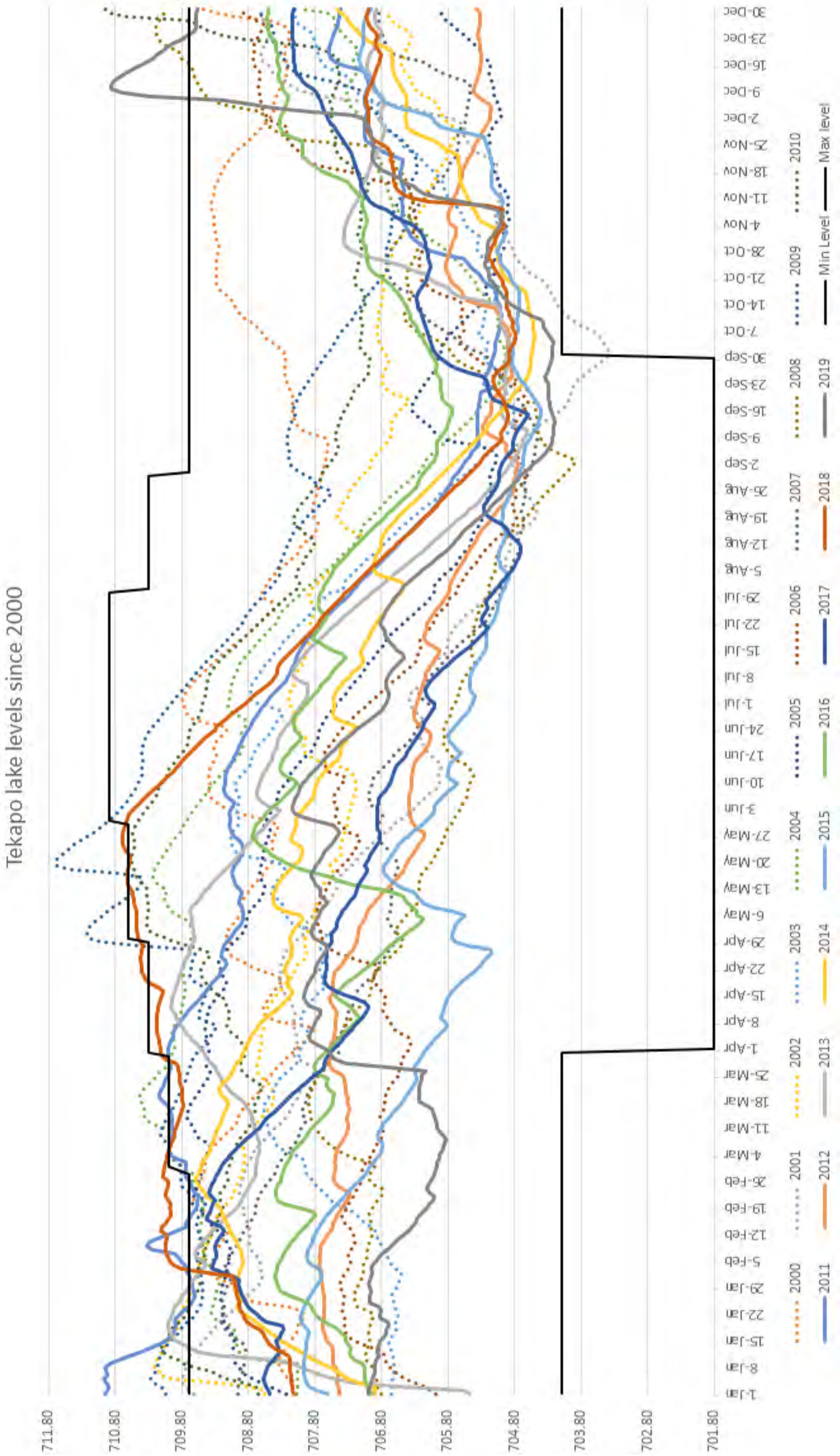
[7] Robertson et al. (2021) with qualifiers (Rolfe et al., 2021): CD=Conservation Dependent (CDB indicates the need for only good biosecurity); CI=Climate Impact; CR=Conservation Research Needed; De=Designated; DPR=Data Poor Recognition; DPS=Data Poor Size; DPT=Data Poor Trend; EF=Extreme Fluctuations; IE=Island Endemic; Inc=Increasing; OL=One Location; PD=Partial Decline; PF=Population Fragmentation; RF=Recruitment Failure; RR=Range Restricted; SO=Secure Overseas; Sp=Sparse; TO=Threatened Overseas.

SPECIES		THREAT CLASSIFICATION[7]	HABITAT								OSNZ DATA		OTHER LIT. SOURCES	2019 POINT COUNTS										2019 INCIDENTAL OBS
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	1985	2004		1 Rivermouth	2 Lake Takapō wetland	3 Takapō river control	4 Takapō river upstream	5 Pattersons 1	6 Pattersons 2	7 Lake McGregor	8 Lake Takapō SW edge	9 Mailbox enclosure	10 Mailbox Inlet	
House sparrow	*Passer domesticus*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Magpie	*Gymnorhina tibicen*	Introduced & Naturalised[SO]									✓	✓	✓											
NZ pipit	*Anthus n. novaeseelandiae*	At Risk - Declining[CI CR]									✓	✓	✓											
Redpoll	*Carduelis flammea*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Skylark	*Alauda arvensis*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Song thrush	*Turdus philomelos*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Spur-winged plover	*Vanellus miles novaehollandiae*	Not Threatened[SO]									✓	✓	✓	✓			✓				✓		✓	
Starling	*Sturnus vulgaris*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Swamp harrier	*Circus approximans*	Not Threatened[SO]									✓	✓	✓											✓
Welcome swallow	*Hirundo n. neoxena*	Not Threatened[SO ST]									✓	✓	✓											
Yellowhammer	*Emberiza citrinella*	Introduced & Naturalised[SO]									✓	✓	✓											✓
Australasian bittern	*Botaurus poiciloptilus*	Threatened - Nationally Critical[CR DPT RF Sp TO]									✓	✓	✓											
Australian coot	*Fulica atra australis*	At Risk - Naturally Uncommon[Inc SO]									✓	✓	✓							✓				
Banded dotterel	*Charadrius bicinctus bicinctus*	At Risk - Declining[CD CI CR DPS PD]									✓	✓	✓	✓	✓						✓	✓	✓	
Black shag	*Phalacrocorax carbo novaehollandiae*	At Risk - Relict[CR DPS DPT SO Sp]									✓	✓	✓	✓							✓			
Black stilt	*Himantopus novaezelandiae*	Threatened - Nationally Critical[CD CR RR]									✓	✓	✓		✓						✓	✓	✓	
Black swan	*Cygnus atratus*	Not Threatened[SO]									✓	✓	✓							✓		✓		✓
Black-billed gull	*Larus bulleri*	At Risk - Declining[CI CR RF]									✓	✓	✓		✓	✓								
Black-fronted tern	*Chlidonias albostriatus*	Threatened - Nationally Endangered[CI CD, PD, RF, Sp]									✓	✓	✓		✓			✓					✓	
Chestnut-brested shelduck	*Tadorna tadornoides*	Vagrant[SO]										✓	✓											
Feral goose	*Anser anser*	Introduced & Naturalised[SO]										✓												

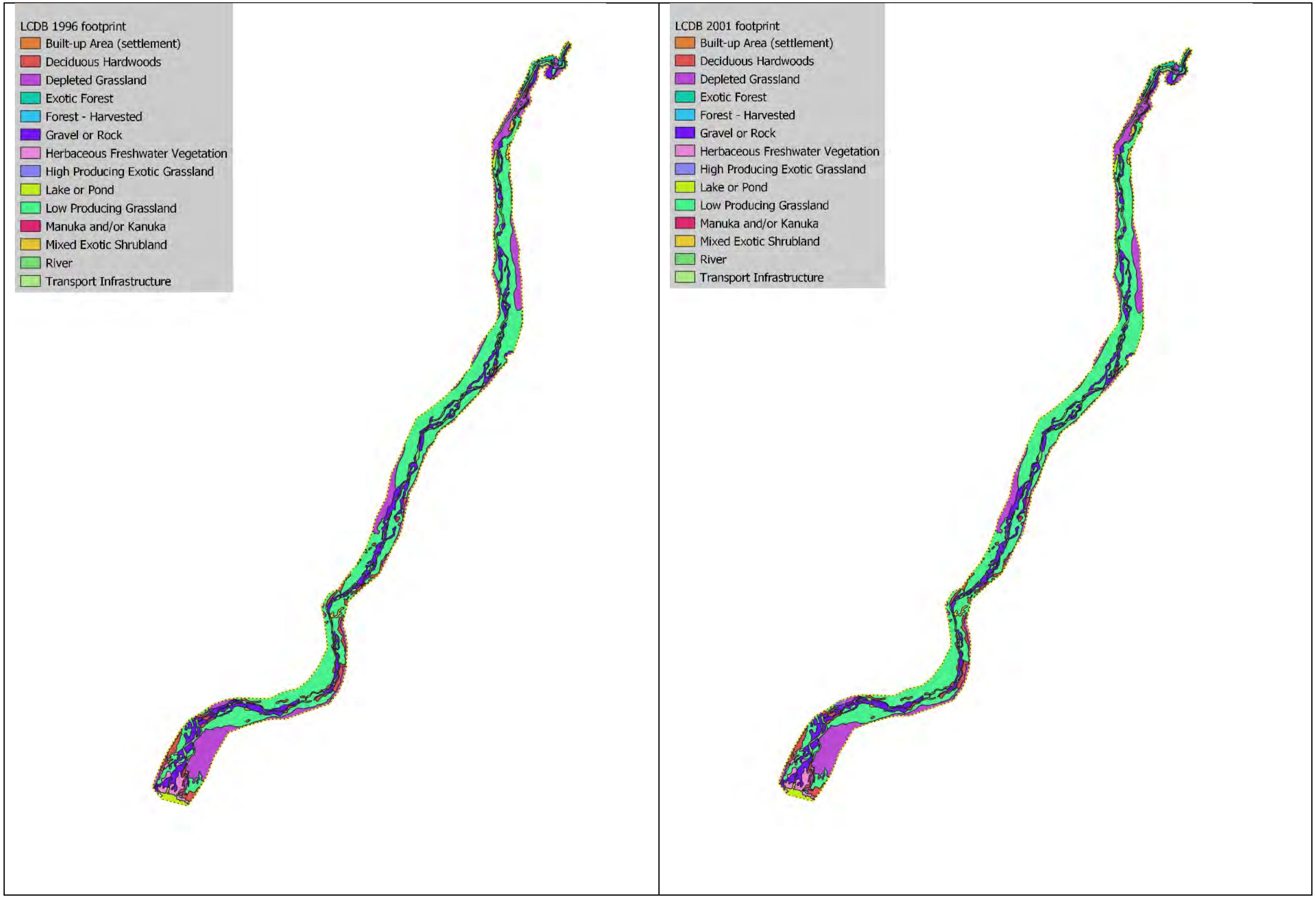
SPECIES		THREAT CLASSIFICATION[7]	HABITAT								OSNZ DATA		OTHER LIT. SOURCES	2019 POINT COUNTS										2019 INCIDENTAL OBS
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	1985	2004		1 Rivermouth	2 Lake Takapō wetland	3 Takapō river control	4 Takapō river upstream	5 Pattersons 1	6 Pattersons 2	7 Lake McGregor	8 Lake Takapō SW edge	9 Mailbox enclosure	10 Mailbox Inlet	
Grey duck	*Anas s. superciliosa*	Threatened - Nationally Vulnerable[CR DPR DPS DPT SO]									✓	✓	✓											
Grey teal	*Anas gracilis*	Not Threatened[Inc SO]									✓	✓	✓		✓	✓	✓	✓	✓		✓		✓	
Little shag	*Phalacrocorax melanoleucos brevirostris*	At Risk - Relict[CR DPT]									✓	✓	✓			✓	✓							✓
Mallard	*Anas platyrhynchos*	Introduced & Naturalised[SO]									✓	✓	✓		✓	✓	✓	✓	✓	✓			✓	
Marsh crake	*Porzana pusilla affinis*	At Risk - Declining[CI CR DPS DPT PF RR]										✓	✓											
Mute swan	*Cygnus olor*	Introduced & Naturalised[SO Sp]										✓	✓											
NZ pied oystercatcher	*Haematopus finschi*	At Risk - Declining[CI]											✓											
NZ scaup	*Aythya novaeseelandiae*	Not Threatened[Inc]									✓	✓	✓	✓							✓	✓	✓	✓
NZ shoveler	*Anas rhynchotis variegata*	Not Threatened									✓	✓	✓			✓	✓	✓	✓	✓	✓			
Paradise shelduck	*Tadorna variegata*	Not Threatened									✓	✓	✓		✓							✓		
Pied shag	*Phalacrocorax varius varius*	At Risk - Recovering[CD]									✓	✓	✓		✓		✓				✓	✓	✓	
Pied stilt	*Himantopus h. leucocephalus*	Not Threatened[SO]																✓		✓				✓
Pukeko	*Porphyrio m. melanotus*	Not Threatened[Inc SO]									✓	✓	✓									✓	✓	
Southern crested grebe	*Podiceps cristatus australis*	Threatened - Nationally Vulnerable[DPS Inc SO]									✓	✓	✓											✓
White heron	*Ardea modesta*	Threatened - Nationally Critical[CR OL SO St]									✓	✓	✓			✓				✓	✓			
White-winged black tern	*Chlidonias leucopterus*	Migrant[SO]									✓	✓												
Wrybill	*Anarhynchus frontalis*	Threatened - Nationally Increasing[RR CD CR]									✓													
Black-backed gull	*Larus d. dominicanus*	Not Threatened[SO]									✓	✓	✓											
Caspian tern	*Hydroprogne caspia*	Threatened - Nationally Vulnerable[CI SO Sp]									✓	✓	✓	✓			✓				✓		✓	
Eastern bar-tailed godwit	*Limosa lapponica baueri*	At Risk - Declining[CI TO]									✓	✓	✓											
Red-billed gull	*Larus novaehollandiae scopulinus*	At Risk - Declining[CI]										✓												

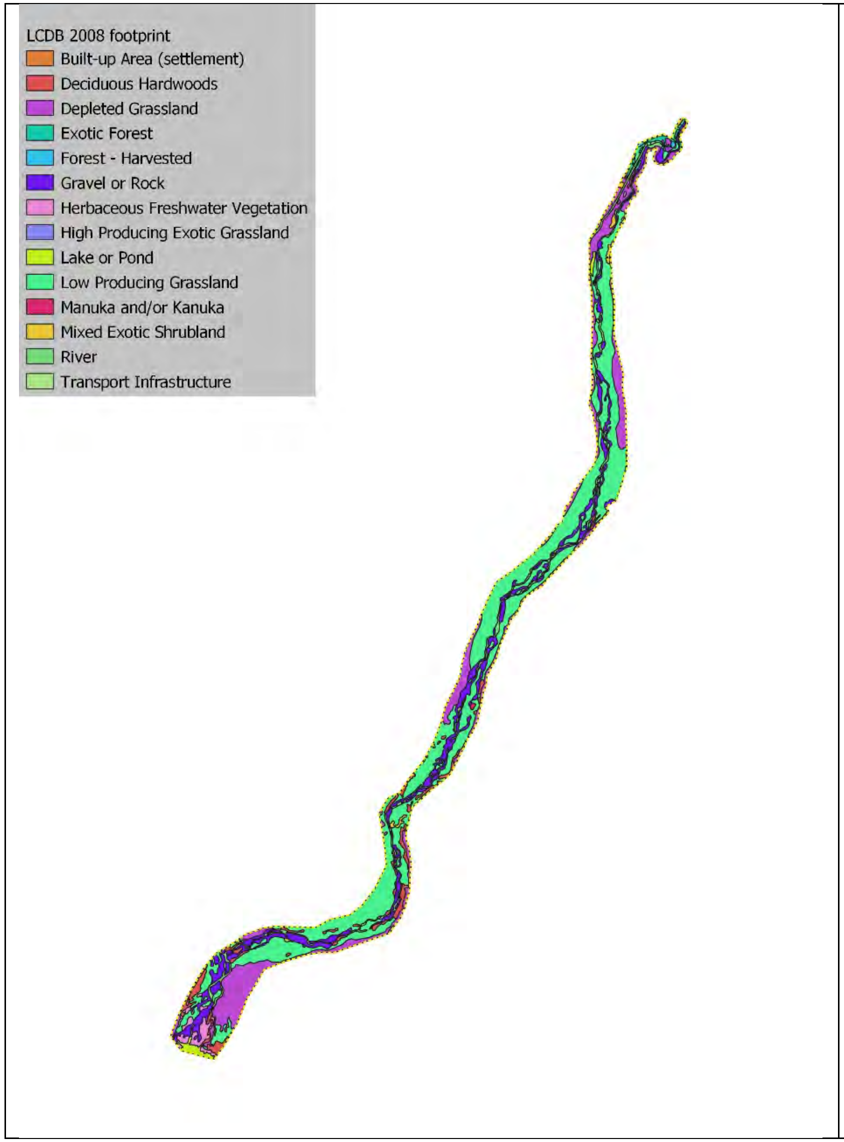
SPECIES		THREAT CLASSIFICATION[7]	HABITAT								OSNZ DATA		OTHER LIT. SOURCES	2019 POINT COUNTS										2019 INCIDENTAL OBS
			Native forest	Exotic Forest	Scrub / shrubland	Farmland / open	Freshwater / wetlands	Coastal / Estuary	Oceanic	Urban/Residential	1985	2004		1 Rivermouth	2 Lake Takapō wetland	3 Takapō river control	4 Takapō river upstream	5 Pattersons 1	6 Pattersons 2	7 Lake McGregor	8 Lake Takapō SW edge	9 Mailbox enclosure	10 Mailbox Inlet	
Royal spoonbill	*Platalea regia*	At Risk - Naturally Uncommon[Inc RR SO Sp]										✓												
White-faced heron	*Egretta novaehollandiae*	Not Threatened[SO]										✓												
Rock pigeon	*Columba livia*	Introduced & Naturalised[SO]									✓	✓	✓							✓				✓
Bellbird	*Anthornis m. melanura*	Not Threatened									✓		✓											

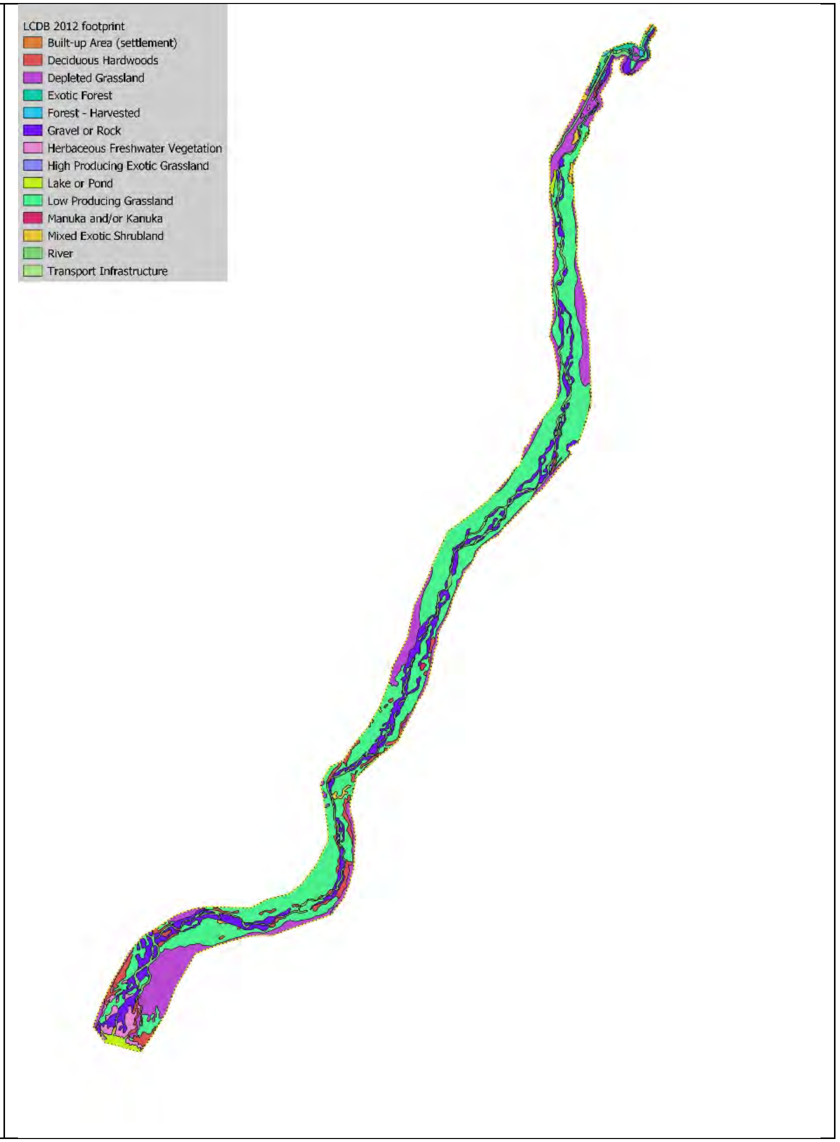
Appendix 4: Lake Takapō water levels 2000-2019

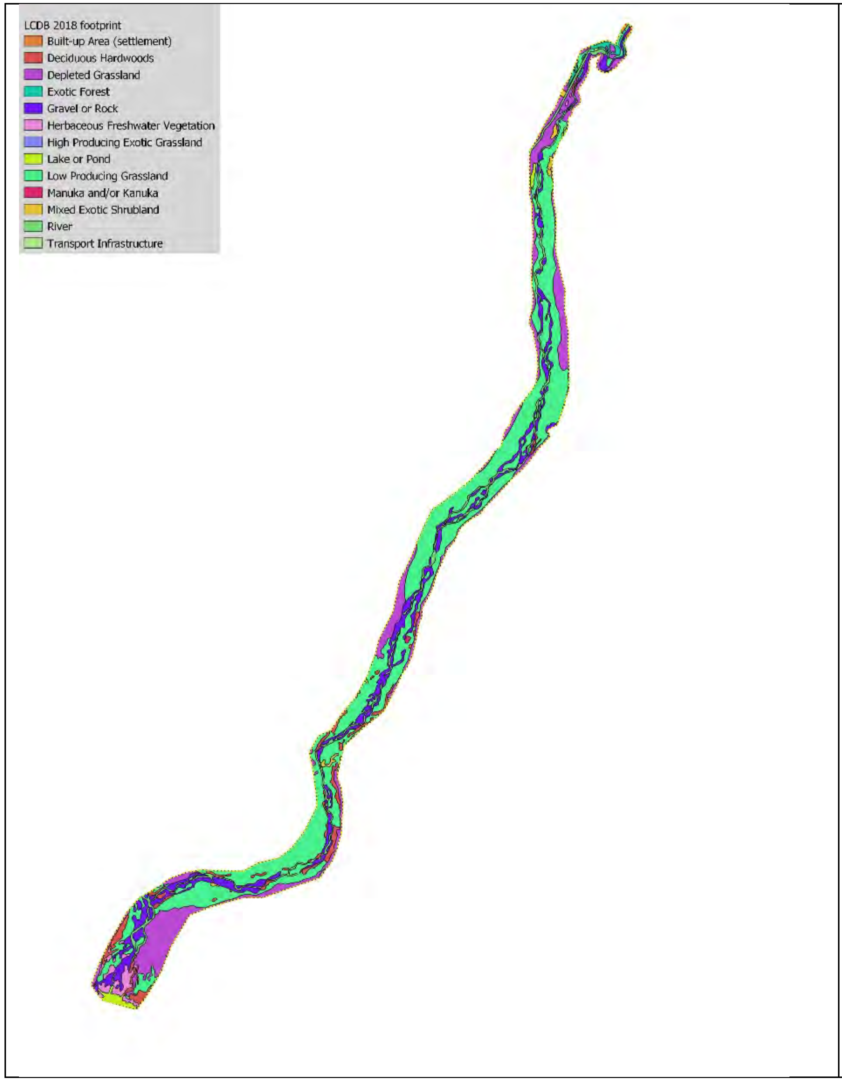


Appendix 5: LCDB land cover (1996 – 2018)


LCDB 1996 footprint
Built-up Area (settlement)
Deciduous Hardwoods
Depleted Grassland
Exotic Forest
Forest - Harvested
Gravel or Rock
Herbaceous Freshwater Vegetation
High Producing Exotic Grassland
Lake or Pond
Low Producing Grassland
Manuka and/or Kanuka
Mixed Exotic Shrubland
River
Transport Infrastructure
LCDB 2001 footprint
Built-up Area (settlement)
Deciduous Hardwoods
Depleted Grassland
Exotic Forest
Forest - Harvested
Gravel or Rock
Herbaceous Freshwater Vegetation
High Producing Exotic Grassland
Lake or Pond
Low Producing Grassland
Manuka and/or Kanuka
Mixed Exotic Shrubland
River
Transport Infrastructure


LCDB 2008 footprint
Built-up Area (settlement)
Deciduous Hardwoods
Depleted Grassland
Exotic Forest
Forest - Harvested
Gravel or Rock
Herbaceous Freshwater Vegetation
High Producing Exotic Grassland
Lake or Pond
Low Producing Grassland
Manuka and/or Kanuka
Mixed Exotic Shrubland
River
Transport Infrastructure


LCDB 2012 footprint
Built-up Area (settlement)
Deciduous Hardwoods
Depleted Grassland
Exotic Forest
Forest - Harvested
Gravel or Rock
Herbaceous Freshwater Vegetation
High Producing Exotic Grassland
Lake or Pond
Low Producing Grassland
Manuka and/or Kanuka
Mixed Exotic Shrubland
River
Transport Infrastructure


LCDB 2018 footprint
Built-up Area (settlement)
Deciduous Hardwoods
Depleted Grassland
Exotic Forest
Gravel or Rock
Herbaceous Freshwater Vegetation
High Producing Exotic Grassland
Lake or Pond
Low Producing Grassland
Manuka and/or Kanuka
Mixed Exotic Shrubland
River
Transport Infrastructure

Appendix 6: Canterbury RPS significance criteria

Regional Policy Statement / APPENDIX 3 – Criteria for determining significant indigenous vegetation and significant habitat of indigenous biodiversity

APPENDIX 3 - Criteria for determining significant indigenous vegetation and significant habitat of indigenous biodiversity

CRIETERIA FOR DETERMINING SIGNIFICANT INDIGENOUS VEGETATION AND SIGNIFICNAT HABITAT OF INDIGENOUS BIODIVERSITY

Representativeness

1. Indigenous vegetation or habitat of indigenous fauna that is representative, typical or characteristic of the natural diversity of the relevant ecological district. This can include degraded examples where they are some of the best remaining examples of their type, or represent all that remains of indigenous biodiversity in some areas.
2. Indigenous vegetation or habitat of indigenous fauna that is a relatively large example of its type within the relevant ecological district.

Rarity/Distinctiveness

3. Indigenous vegetation or habitat of indigenous fauna that has been reduced to less than 20% of its former extent in the region, or relevant land environment, ecological district, or freshwater environment.
4. Indigenous vegetation or habitat of indigenous fauna that supports an indigenous species that is threatened, at risk, or uncommon, nationally or within the relevant ecological district.
5. The site contains indigenous vegetation or an indigenous species at its distribution limit within Canterbury Region or nationally.
6. Indigenous vegetation or an association of indigenous species that is distinctive, of restricted occurrence, occurs within an originally rare ecosystem, or has developed as a result of an unusual environmental factor or combinations of factors.

Diversity and Pattern

7. Indigenous vegetation or habitat of indigenous fauna that contains a high diversity of indigenous ecosystem or habitat types, indigenous taxa, or has changes in species composition reflecting the existence of diverse natural features or ecological gradients.

Ecological Context

8. Vegetation or habitat of indigenous fauna that provides or contributes to an important ecological linkage or network, or provides an important buffering function.
9. A wetland which plays an important hydrological, biological or ecological role in the natural functioning of a river or coastal system.
10. Indigenous vegetation or habitat of indigenous fauna that provides important habitat (including refuges from predation, or key habitat for feeding, breeding, or resting) for indigenous species, either seasonally or permanently.

About BlueGreen

Over the last 20 years we have gathered a high level of knowledge and expertise working on a number of large scale projects of national significance, right from pre-consenting investigations through to Environment Court and Board of Inquiry Hearings. As such we are able to offer our clients proven expertise to assist with a range of ecological challenges, both simple and complex, across various ecosystems.

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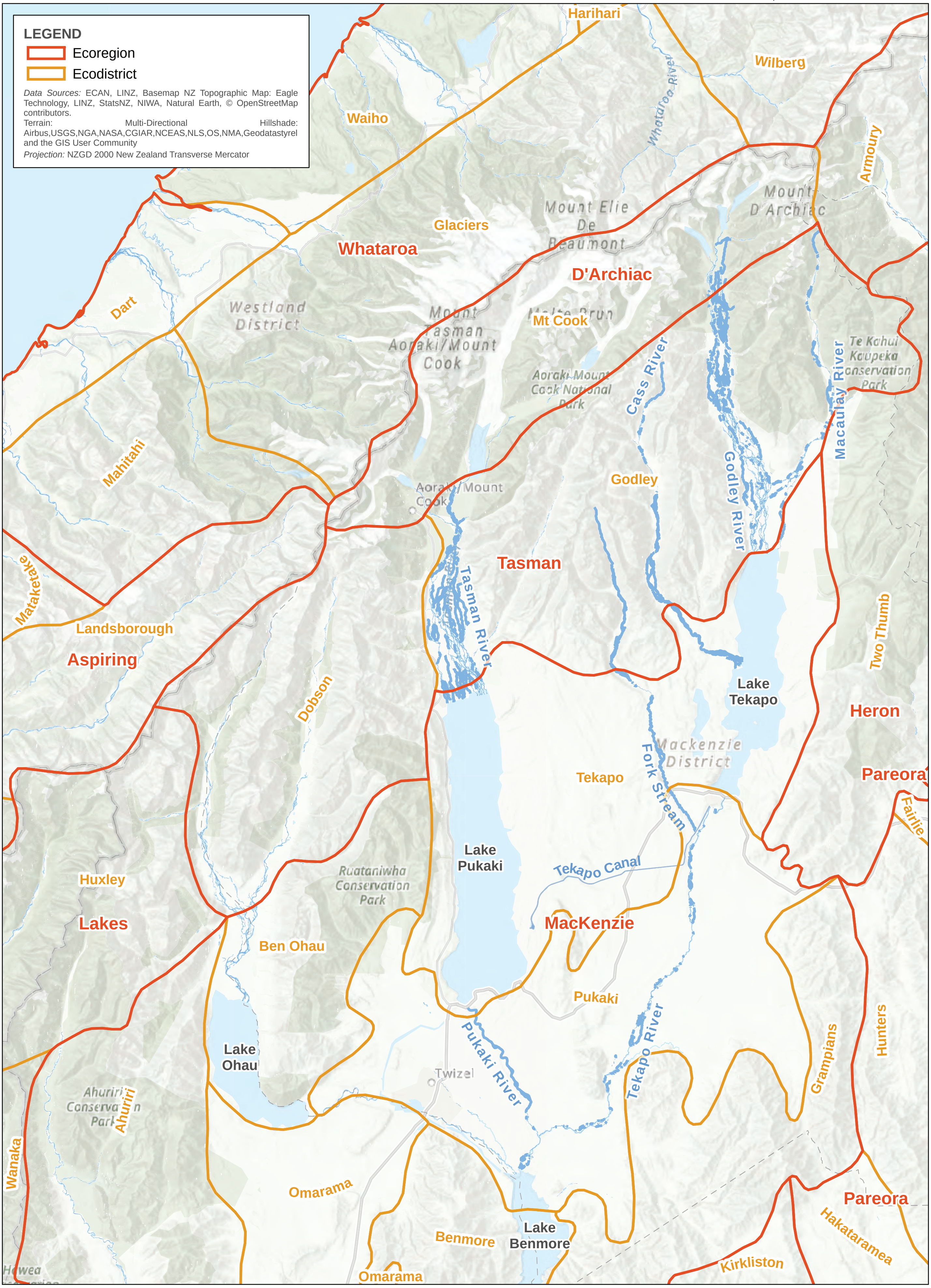
BlueGreenEcology.nz
BlueGreen Ecology Ltd

File Ref: W18107.aprx / W18107_SiteContext_A4P



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0 8 km

1:500,000 @ A4

TEKAPO RECONSENTING AVIFAUNA ASSESSMENT

Site Context

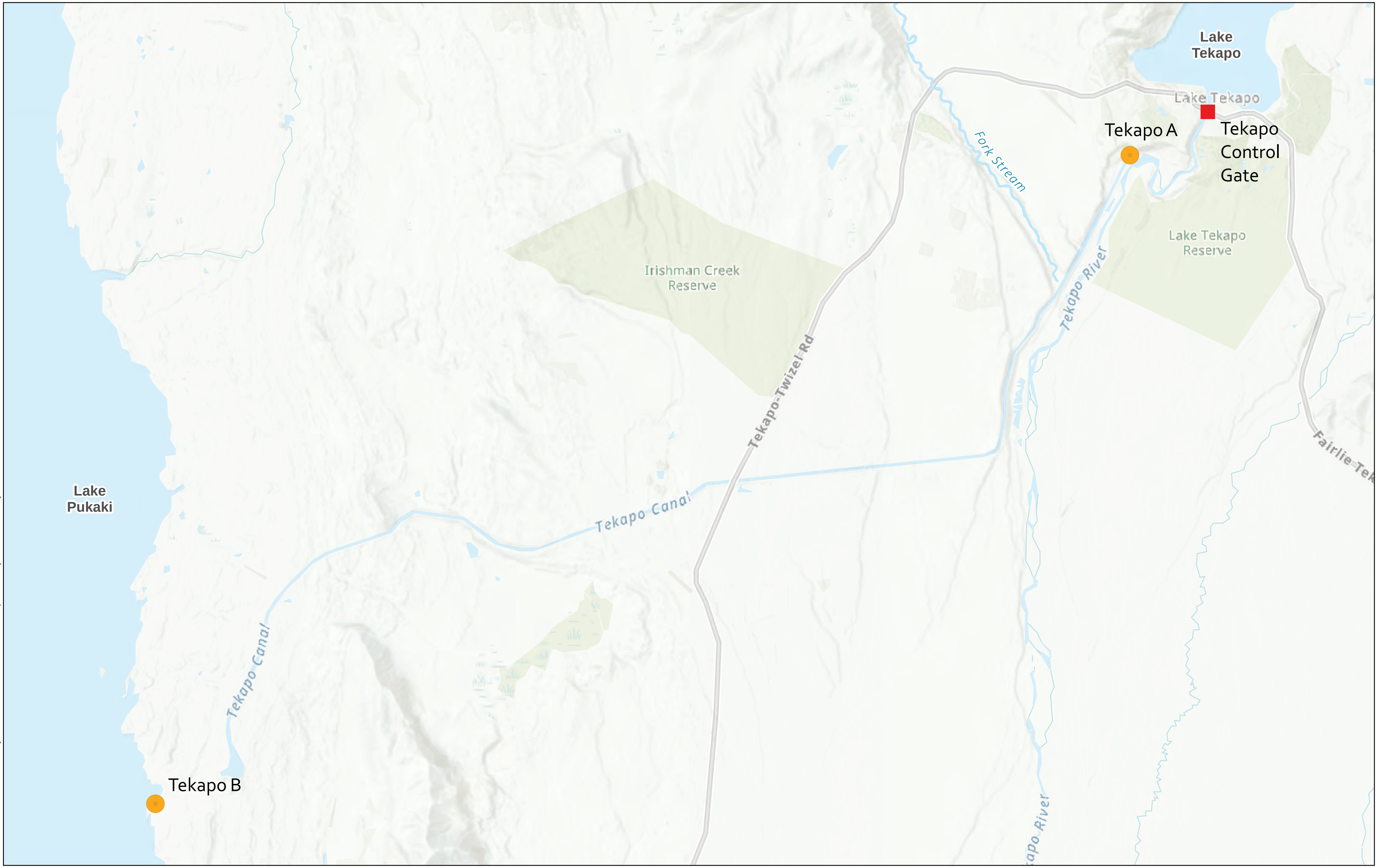
Date: 31 March 2020 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 1

File Ref: W18107.aprx / W18107_TekapoPowerScheme_A4L



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0 2,000 m

1:100,000 @ A4

Projection: NZGD 2000 New Zealand Transverse Mercator

Tekapo Control Gate

Power Station

Data Sources: NZ Topographic Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.
Terrain: Multi-Directional Hillshade: Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GS and the GIS User Community

TEKAPO RECONSENTING AVIFAUNA ASSESSMENT

Tekapo Power Scheme

Date: 31 March 2020 | Revision: 0

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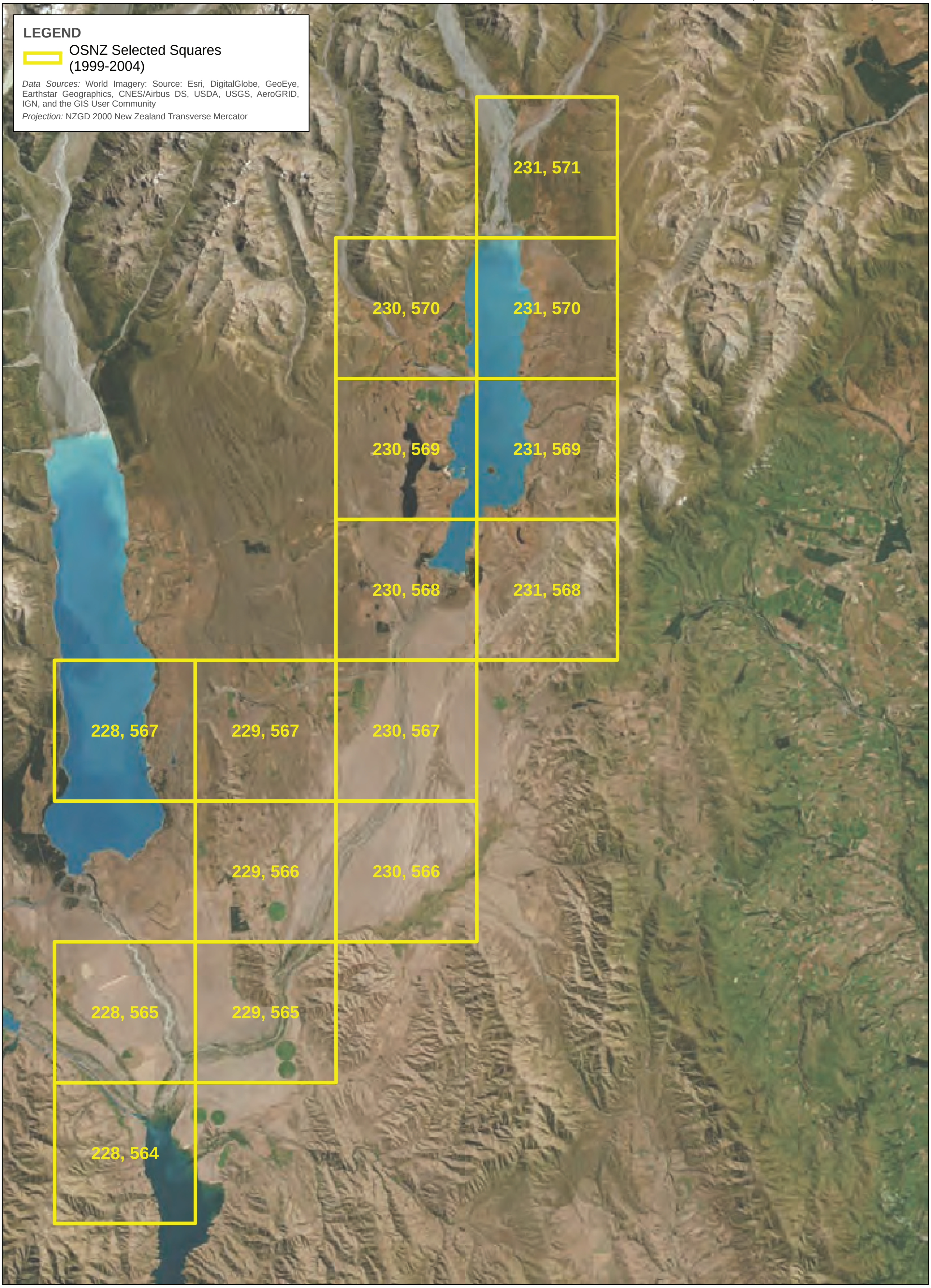
Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: HHu | Checked: LBu

Map 2



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TEKAPO RECONSENTING AVIFAUNA ASSESSMENT

OSNZ (1999 - 2004) Squares

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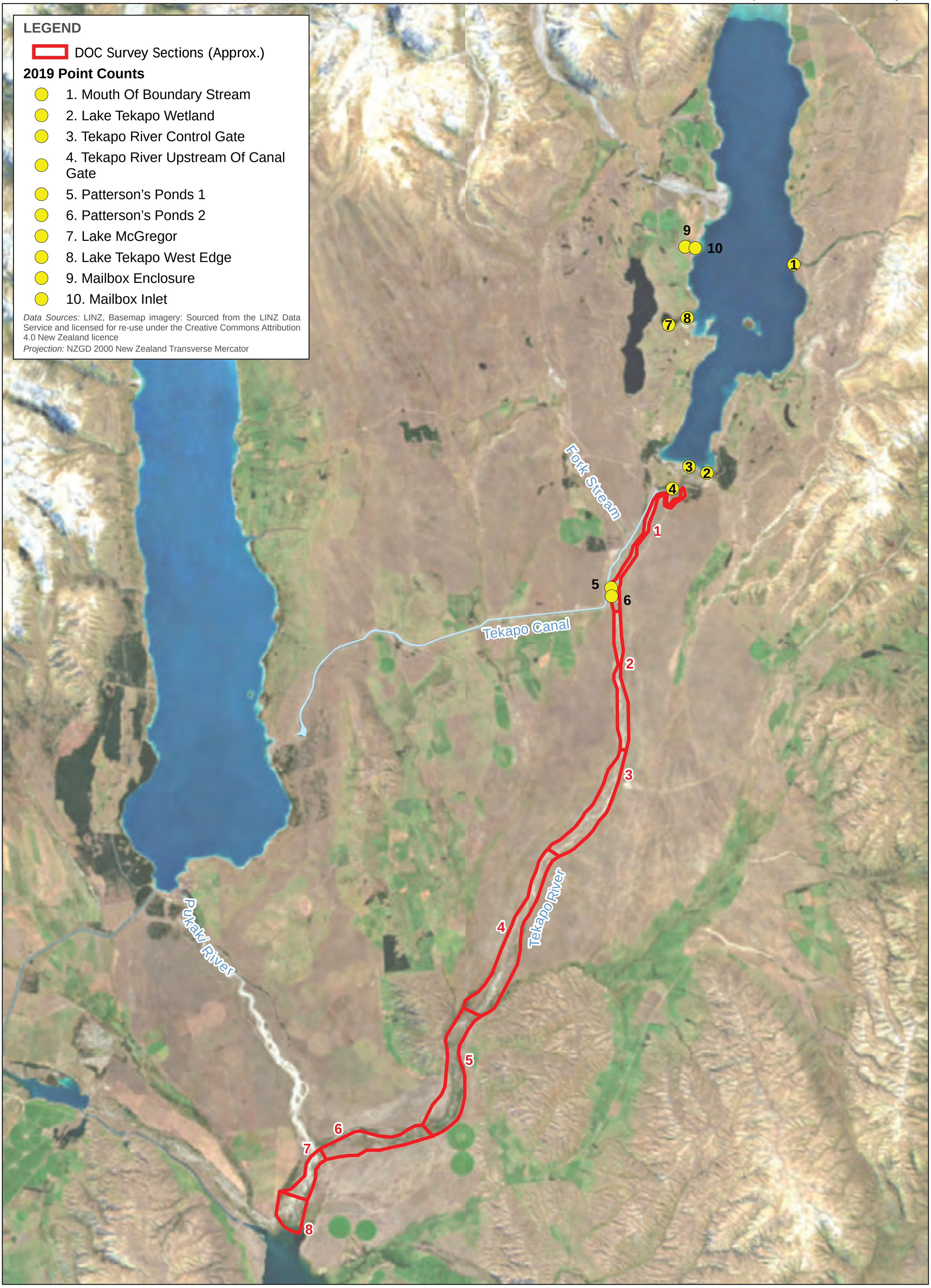
Map 3



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TEKAPO RECONSENTING AVIFAUNA ASSESSMENT

Avifauna Survey Sites

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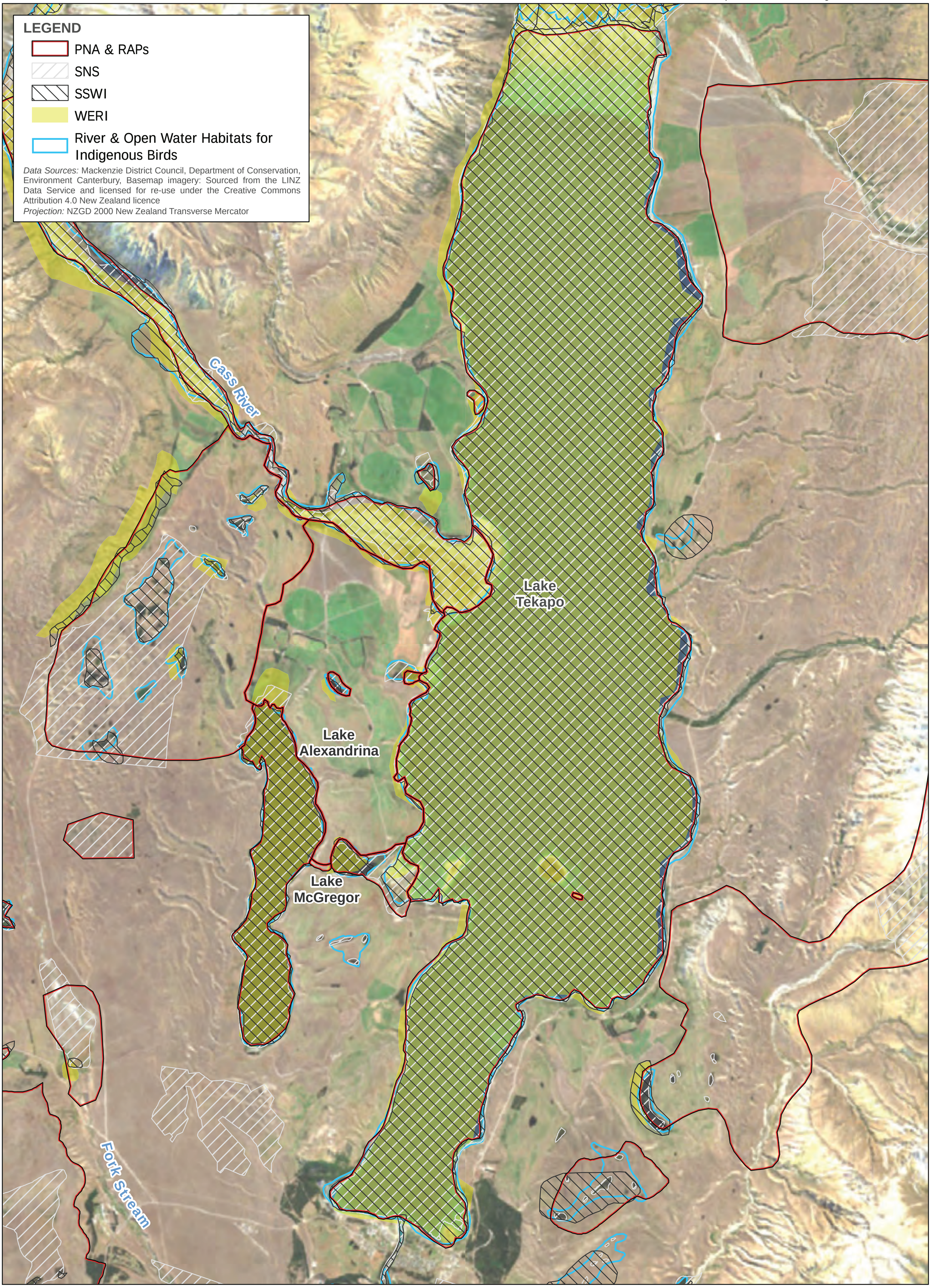
Map 4



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TEKAPO RECONSENTING AVIFAUNA ASSESSMENT

Identified Ecological Sites: Lake Tekapo

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Map 5

File Ref: W18107.aprx / W18107_EcologicalSites_River_A4P

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TEKAPO RECONSENTING AVIFAUNA ASSESSMENT

Identified Ecological Sites

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Map 6