GENESIS ENERGY LIMITED

TEKAPO POWER SCHEME

Assessment of Environmental Effects

May 2024

Ko tā te Waitaki mahi he manaaki i te motu

The generosity of the Waitaki provides for the nation

EXECUTIVE SUMMARY

Introduction

Genesis Energy Limited (trading as "**Genesis**") owns and operates the Tekapo Power Scheme ("**Tekapo PS**" or "**the scheme**"), within the Waitaki Catchment. The scheme operation is authorised by several resource consents (granted by the Canterbury Regional Council) and activities permitted under the Canterbury Land and Water Regional Plan. Resource consents relating to the damming, taking, diverting, use and discharge of water relating the Tekapo PS operation expire in 2025 and replacement resource consents (where the activity is not permitted under the relevant regional plans) are required to allow its continued operation beyond 2025. Genesis is therefore seeking the necessary resource consents to authorise the following activities:

a. The damming of the Takapō River via the Lake Takapō Control Structure ("**Gate 16**") to control and operate the levels of Lake Takapō;

b. The taking, diversion and use of water from Takapō via the Tekapo Intake Structure for the generation of electricity, and ancillary purposes, at the Tekapo A and B Power Stations;

c. The damming of the Takapō River at the Lake George Scott Control Weir to control and maintain water levels in Lake George Scott;

d. The taking, diversion and use of water from the Takapō River via the Tekapo Canal Control Structure ("**Gate 17**");

e. The discharge of water and associated contaminants into Lake Pūkaki;

f. The discharge of water and associated contaminants into the Takapō River from Gate 16 for the purposes of spilling water, to bypass Tekapo A, for Lake George Scott water level maintenance and for recreational release purposes; and

g. The discharge of water and associated contaminants into the Takapō River from the Lake George Scott Control Weir for the purpose of spilling water.

The Tekapo Power Scheme

Since 1935, water in the Waitaki catchment has been used to generate electricity for the national grid.

The Tekapo PS comprises two hydro-electric power stations, referred to as "Tekapo A" (capacity 30 MW), and "Tekapo B" (capacity 160 MW). Water for electricity generation is stored in Takapō by virtue of control gates (Gate 16) where the lake discharges into the Takapō River. Water is then piped via the Tekapo Intake Structure to the Tekapo A power station from where it is released into the Tekapo Canal. Water then passes through the Tekapo B power station, before discharging into Lake Pūkaki.

In addition, the Takapō River is dammed approximately three kilometres downstream of the control gates by a concrete weir, creating Lake George Scott. Water released from Takapō and impounded in Lake George Scott can be discharged into the Tekapo Canal via Gate 17, bypassing the Tekapo A station. Water from Takapō can also flow over Lake George Scott Weir and continue down the Takapō River to Lake Benmore.

Downstream of the Tekapo PS infrastructure, Meridian Energy operates the Waitaki Power Scheme. The Combined Waitaki Power Scheme (incorporating both the Waitaki Power Scheme and Tekapo PS) hydro-electric power stations and associated infrastructure were originally built and managed together. The Combined Scheme includes eight power stations: Tekapo A, Tekapo B, Ōhau A, Ōhau B, Ōhau C, Benmore, Aviemore and Waitaki. The majority of the generation water for the Combined Waitaki Power Scheme is derived from the alpine headwaters feeding three managed natural lakes (Lakes Takapō, Pūkaki and Ōhau) joined via canals and a tunnel. Four artificial lakes (Lakes Ruataniwha, Benmore, Aviemore and Waitaki) are then used to manage generation water before it reaches the Lower Waitaki River, and ultimately the sea. The Waitaki Power Scheme receives water from the Tekapo PS into Lake Pūkaki from Tekapo B Power Station, and Lake Benmore from water diverted into the Takapō River at Lake George Scott.

The Combined Waitaki Power Scheme is the largest hydroelectric generating system in New Zealand generating up to 25% of New Zealand's annual electricity requirements, with Lakes Takapō and Pūkaki providing up to 65% of the country's hydro average storage volume.

Genesis is not proposing to materially change any of the operating parameters associated with the Tekapo PS. However, the rules relating to the operation of the scheme during high inflow conditions have been updated to ensure the safety and integrity of the scheme structures.

Genesis' existing resource consents (which the current application seeks to replace) were granted under the Water and Soil Conservation Act 1967 and are therefore “deemed resource consents” under the Resource Management Act 1991. The scheme operation is also subject to a series of agreements negotiated between Genesis' predecessor organisations and various stakeholders. Those agreements have created tangible environmental improvements and enhanced stakeholder relationships.

Cultural Setting

The cultural setting for these applications is described in the Treaty Impact Assessment prepared by Te Rūnanga o Arowhenua, Te Rūnanga o Waihao and Te Rūnanga o Moeraki (together, “**Manawhenua**” or the “**Waitaki Rūnaka**”) for the Tekapo PS.

In summary, Kāi Tahu has a long association and involvement with the Waitaki catchment and it remains of paramount importance to the iwi. The Crown has recognised this significance in the Ngāi Tahu Claims Settlement Act 1998, including through statutory acknowledgements of various waterbodies in the Waitaki catchment, including for Takapō in Schedule 57 and Lake Pūkaki in Schedule 34.

As Manawhenua, the members belonging to the three Papatipu Rūnanga, Te Rūnanga o Arowhenua, Te Rūnanga o Waihao and Te Rūnanga o Moeraki have a responsibility to assess how the Tekapo and Waitaki Power Schemes (the Schemes) impact their rights, values and practices. Manawhenua have prepared a Treaty Impact Assessment, to:

a. Identify the effects of the Tekapo and Waitaki Schemes on the cultural beliefs, values and practices of Kāi Tahu;

b. Summarise how Meridian and Genesis propose to mitigate those impacts; and

c. As a result, the extent to which the consent applications are consistent with Manawhenua expectations, informed by Te Tiriti o Waitangi.

The Existing Environment

The Tekapo A power station was commissioned in 1951 and Tekapo B was commissioned in 1977. The Tekapo PS therefore forms part of the existing environment. The ‘existing environment’ for the assessments of environmental effects in this report is the current state of the environment, including existing environmental processes. The existing structures and associated water takes, uses, damming and discharges associated with the Tekapo PS form part of that environment. To exclude these aspects from the existing environment would be unrealistic, and an alternative 'without' environment that does not include the Tekapo PS structures and associated takes and discharges would be artificial and fanciful. Under Policy 4.51 of the Canterbury Land and Water Regional Plan ("**CLWRP**"), the existing Tekapo PS is considered as part of the existing environment in recognition of its national benefits in terms of the generation of electricity from a renewable energy source.

The description of the existing environment in this assessment of environmental effects and the technical assessments supporting the applications for resource consent therefore consider the environment with the Tekapo PS in existence. In that regard, the assessment of the actual and potential effects of the Tekapo PS focusses on the effects of the on-going operation of the scheme on the values currently supported by waterways influenced by the operation of the Tekapo PS. The information contained within this assessment of environmental effects does not attempt to compare the current environment with that which was likely present before the development of the Tekapo PS.

Assessment of Effects

The effects of the Tekapo PS, and are summarised in the following table:

Effect	Key Conclusions
Positive effects	The Tekapo PS generates substantial volumes of 100% renewable electricity. In energy terms, the Scheme's average annual output (from both direct and indirect generation) is sufficient to supply approximately 222,000 Canterbury households. Hydro generation such as that provided by the Tekapo PS is important because it has access to stored water in Takapō. This type of generation has the twin benefits of being renewable and controllable, both of which will be increasingly important as New Zealand decarbonises its economy. Electricity is vital in daily New Zealand life, with many social and economic benefits stemming directly from technologies relying on electricity. It is anticipated that electricity will become even more important as New Zealand moves to decarbonise the economy using renewable generation sources. In addition to its contribution to national electricity supply, the Tekapo PS provides power to consumers in the Tekapo Albury region valued at approximately $16 million (present value). The Tekapo PS has also resulted in improved fishery experiences (for introduced species), particularly within the Tekapo Canal.

Effect	Key Conclusions
Cultural	The Waitaki Catchment holds immense significance to Te Rūnanga o Arowhenua, Te Rūnanga o Waihao and Te Rūnanga o Moeraki (Waitaki Rūnaka or Ngā Rūnaka). Waitaki literally means "the waterway of tears" and the name is often said to represent the tears of Aoraki, the ancestor of Ngāi Tahu embodied in the mountain. The wai māori of the valleys and basins of the takiwā of Ngā Rūnaka descend from Aoraki and the mauka of Te Waipounamu to the sea. The awa are the lifeblood of the surrounding land and its peoples. The catchments and streams are the veins of the whenua; a source of nourishment, and a living system connecting the peoples of Ngāi Tahu with their ancestor, with mahika kai, with countless taonga, and with each other. Kāi Tahu are of the view that the effects of the developments in the Upper and Mid Waitaki, and the resultant river flows, allocations and management regimes across the Waitaki have negatively affected Kāi Tahu rights and interests and have adversely affected experiences and opportunities for whānau in the catchment. Waitaki Rūnaka acknowledge the importance of hydro generation as a source of renewable energy, and the benefits it has provided to past, current and future generations. The Waitaki Rūnaka have worked with the Generators to set a pathway whereby, over time, adverse effects will be addressed. Waitaki Rūnaka believe that the consent conditions, the agreed package of interventions and the enhanced relationship negotiated with the Generators will enable an intergenerational response that will result in adverse effects being avoided, remedied or mitigated.
Landscape natural character and visual amenity	In terms of the effects of the Tekapo PS on the natural character, landscape and visual amenity values, its continued operation will not modify the present values and characteristics. Genesis is not proposing to change the nature of the water taken, dammed or diverted or any changes to the operating range of Lake Tekapo. The overall effects of the continued operation of the Tekapo PS would therefore not lead to any additional adverse effects compared to the status quo, and the existing natural character, landscape and amenity values will be maintained.
Hydrology	As no changes are proposed to the Takapō operating regime, no changes to the hydrology of the lake or the Takapō River are expected to occur from reconsenting the Tekapo PS. A number of wetlands and other water bodies border Takapō and the Takapō River. Some of these wetlands/water bodies are influenced by lake and river level fluctuations because of the scheme operation where they are hydraulically connected to the lake or river. However, this pattern of interaction will not be altered from reconsenting the Tekapo

Effect	Key Conclusions
	PS as no changes to the current operating regimes are proposed other than a minor change to the way in which peak (flood) inflows to Takapō are managed.
Freshwater ecology and water quality	As there are no changes to the operation of the Tekapo PS being sought as part of the reconsenting process, no changes to the existing environment are anticipated. Overall, the existing operation of the Tekapo PS: a. Has no effect on the water quality and contributes to the naturally low productivity and restricted food supply for salmonids in Lake Tekapo; b. Provides a productive environment for macroinvertebrates and salmonid fish in the Tekapo Canal supporting a nationally significant (and internationally recognised) and popular fishery; c. Has minor adverse effects, as well as minor positive effects, on water quality and aquatic ecology within the Takapō River; and d. Has no more than minor adverse effects on receiving waters in Lake Pūkaki and Lake Benmore.
Shoreline morphology	The effects of the continued operation of the Tekapo PS on the Takapō physical shore processes are identified as follows: a. Continued but episodic erosion of currently eroding cliffs; b. Continued alongshore transport of sediment from fluvial source (rivers and streams) and backshore erosion; c. Slow landward movement and elevation of barrier beaches; and d. Continued inundation of low-lying land and river and stream mouths at high lake levels. The projected effects on the physical shoreline processes on Lake Takapō of continued operation of the Tekapo PS under the current operating regime are likely to be of the same character and order of magnitude as in the existing environment.
Native fish	Overall, the Takapō River supports the expected range of native fish, given the context of effects within the Waitaki catchment that influences the distribution and abundance of the native fish. In terms of direct negative effects on native fish the flow reduction in the Takapō River created by the Tekapo PS has reduced the available habitat for some species, but other factors rather than habitat are limiting their populations. For the threatened native galaxiids, the present-day distribution indicates that the pre-development Takapō River was unlikely to have supported populations of these fish and the Tekapo PS is unlikely to have any effect on their abundance.

Effect	Key Conclusions
Terrestrial invertebrate	The key ongoing potential effects of the Tekapo PS and reduced severity and frequency of flood events are identified as increased accessibility to predators, exacerbated weed problems, fire (particularly from the added fuel load of weeds), and reduced deposition and maintenance of sandy substrates, which are key habitats for some species. However, the reduced severity of flood events is also a potential positive for the species needing more stable habitat features. The major changes to terrestrial invertebrate communities from managed flow regimes to the Takapō River have already occurred over the preceding decades, and the ongoing changes to the existing communities caused by the Tekapo PS will be relatively small.
Herpetofauna	Three species of native lizard: McCann's skink; Southern Alps gecko; and Canterbury grass skink were found in the Tekapo PS area. Jewelled gecko, scree skink, long-toed skink or Mackenzie Basin skink were not found close to the Tekapo PS activities, nor were exotic lizards or frogs recorded. The level of potential effects of the scheme in terms of loss of ecology values is assessed as 'Very low'. A native biodiversity enhancement programme (similar to Project River Recovery that Genesis and Meridian have funded during the term of the existing consents) is likely to result in beneficial outcomes for native lizards, through its focus on weed control and nesting bird protection across very large areas of the upper Waitaki Basin. Genesis proposes (by way of agreement with the Department of Conservation) the continuation of and increased funding for an indigenous biodiversity enhancement programme to work towards improving the condition, resilience, native biodiversity, ecological processes and other values of the braided rivers and associated environment including the wetlands within the Waitaki Catchment. This programme will provide conservation benefits that greatly exceed the very minor level of adverse effects that may be caused by the re-consenting of the Tekapo PS on native lizards.
Avifauna	Overall, the construction of the Combined Waitaki Power Scheme resulted in the loss of braided river and swamp / wetland habitat but increased open water (lake) and lake shoreline habitat. However, it is not possible to determine the specific effect of the Tekapo PS on avifauna due to the inter-related nature of ecosystem variables and additional factors both within and beyond the Takapō catchment. Based on 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, while the abundance of several native (Not Threatened) and introduced species appear to have

Effect	Key Conclusions
	increased over the same period, including black swan, Canada geese, little shag and white-faced heron. Analysis of specialist river birds has shown a general increase in abundance above the Combined Waitaki Power Scheme, most likely due to Project River Recovery initiatives funded by Genesis and Meridian, and a decrease below. Significant increases in abundance of NZ pied oystercatcher and banded dotterel recorded in catchments above the schemes where Project River Recovery management is occurring, are contrary to national population trends recently reported, while a decreasing trend in abundance of wrybill is contrary to national population trends. The detection of instances of significant decreases in species abundance above the Combined Waitaki Power Scheme indicate that additional pressures beyond the scheme are threatening several populations. The Ahuriri catchment (in which significant decreases in abundances were recorded for banded dotterel, NZ pied oystercatcher and wrybill) would likely benefit from conservation measures.
Vegetation	Since the Tekapo PS was established, the vegetation communities around the scheme have developed under a regime of managed water levels in the lake and managed flows in the Takapō River. The vegetation found there reflects that management and is not expected to be affected to any more than a very low level by continued operation under the same control levels. The overall magnitude of unmitigated local (ecological district) effects range from low to very low. Project River Recovery has made a substantial contribution to maintaining indigenous vegetation in the upper Waitaki catchment, particularly with respect to weed control. In the absence of this project the ecological values of the currently managed areas would slowly degrade over time as exotic species came to dominate as they do in the lower catchment.
Recreation	Takapō supports a wide variety of on-water recreation activities, including boating and angling and has international significance via its scenic values and the contribution these make to the tourism industry. National angler surveys indicate a decline in angling activity on the Takapō River coincident with the arrival of didymo in 2007, a significant increase in activity on the Tekapo Canal and an increase on Takapō. Overall, the Tekapo PS has provided significant recreational opportunities for angling, and the operation of Lake Takapō for hydro generation maintains its traditional recreational and scenic values. Walking and cycling opportunities have developed around generation infrastructure and now provide significant activity opportunities for visitors and residents.

Genesis is not seeking any alterations to the current operational parameters of the Tekapo PS apart from an adjustment to the flood operating rules that is required in order to protect the integrity of the Tekapo PS structures. Therefore, no changes to the environment are expected as part of its continued operation. Given that the existing environment, with the infrastructure and current operating regime in place, is the baseline for the assessment of actual and potential effects of the ongoing operation of the Tekapo PS, there will be no additional adverse effects. Rather, the question is whether the ongoing operation of the Tekapo PS adversely affects an existing value of significance to a degree that warrants and justifies mitigation.

Environmental Mitigation

As a core part of the mitigation of the effects associated within the ongoing operation of the Tekapo PS, Genesis is proposing to increase its indigenous biodiversity funding via agreement with the Department of Conservation ("**DoC**"). Funding to recognise the effects of hydroelectric development on braided rivers and wetlands under the existing consents lead to the establishment of Project River Recovery ("**PRR**") in 1990. Since that time, PRR has successfully improved the condition, resilience, native biodiversity, ecological processes and other values of the braided rivers and associated environment including the wetlands within the Waitaki Catchment.

Genesis is proposing to continue (and significantly increase) its funding to DoC for an indigenous biodiversity enhancement programme as a core part of the replacement resource consents being sought, to mitigate the effects of the Tekapo PS on the environment. Genesis has an agreement with DoC and Meridian that commits the parties to work together towards improving the condition, resilience and ecological processes of indigenous biodiversity and related values of the braided rivers and associated environment including the wetlands within the Waitaki catchment.

1. ENVIRONMENTAL SETTING

1.1 INTRODUCTION

This section provides a summary of the existing physical, social, environmental, and cultural values of the Tekapo PS and surrounding area. This description of the existing environment provides the context against which the environmental effects of the Tekapo PS have been assessed.

Several technical assessments have been commissioned by Genesis to inform the description of the existing environment. These technical assessments are referenced, as appropriate, in the sections below.

1.2 CULTURAL SETTING

The cultural setting for these applications is described in the Treaty Impact Assessment prepared by Te Rūnanga o Arowhenua, Te Rūnanga o Waihao and Te Rūnanga o Moeraki for the Tekapo PS.

In summary, Kāi Tahu has a long association and involvement with the Waitaki catchment, and it remains of paramount importance to the iwi. The Crown has recognised this significance in the Ngāi Tahu Claims Settlement Act 1998, including through statutory acknowledgements of various waterbodies in the Waitaki catchment, including for Takapō in Schedule 57 and Lake Pūkaki in Schedule 34.

Kāi Tahu identified seven lakes as the headwaters of the Waitaki. Historically the river spread out and meandered over the plains of the Upper Waitaki. Many small creeks came tumbling in adding water as the mainstem Waitaki gained in size and power as it moved downstream.

These lakes formed part of the seasonal cycle of gathering. Rotating gathering across multiple sites (over a takiwā), and following seasonal harvesting patterns, were important sustainability measures. Historically there were more than 160 settlements across the Waitaki. Connecting these settlements were land and water based trails. Whanau at the sites – either permanently or temporarily – were sustained by the abundance of resources found in wetlands, streams and the Waitaki itself.

The Waitaki lies under the cloak of Manawhenua rangatiratanga and is cared for and managed by Manawhenua to the greatest extent possible, in a manner consistent with kaitiakitanga. The connections of Kāi Tahu to the lands and waters of the Waitaki remain and represent the foundation of whanau spiritual, social and emotional wellbeing. More specifically, cultural activities, including mahinga kai, continue to be essential to the wellbeing of Kāi Tahu for whom a state of well-being, reflects an ability to thrive and prosper – it reflects the interconnections across past, present, and future generations.

Kāi Tahu have one river that unites all 70,000 iwi members – Ko Waitaki te awa. Many generations of Kāi Tahu leaders are buried on lands within the catchment. Today's generation, their children's children and all the children of the generations to follow will mihi to Aoraki and the Waitaki River and will continue to identify with the importance of this particular catchment within the wider Kāi Tahu rōhe.

1.3 GENERAL SETTING

The Tekapo PS is part of the Waitaki Catchment, which drains from Ka Tiritiri O Te Moana / Southern Alps to the Pacific Ocean. It has a total catchment area of approximately 11,800 km^2. The upper reaches of the catchment near the main divide are over 3,000m high and include several major glaciers. The lower reaches of the catchment comprise of hill country, rolling downlands and gently sloping plains.

The upper Waitaki comprises four major tributary basins being Takapō, Pūkaki, Ōhau and the Ahuriri. With the exception of Ahuriri, all these basins contain large glacially formed lakes being Lake Pūkaki, Takapō and Lake Ōhau. Above and below the lakes the rivers generally have braided gravel beds except where the riverbed is occupied by hydro lakes such as Lake Benmore, Lake Aviemore and Lake Waitaki. The lower Waitaki, which extends from the Waitaki Dam to the Pacific Ocean receives flow from the Hakataramea and Maerewhenua rivers along with a number of smaller tributaries.

In terms of the landscape context, the Tekapo PS is located within the Mackenzie Basin Outstanding Natural Landscape. The Mackenzie Basin forms the largest intermontane basin in New Zealand. Biophysical features include extensive glacial terraces, moraines, lakes and kettle holes, as well as broad fluvio-glacial outwash surfaces. The Mackenzie Basin is a homogenous, highly legible landscape which expresses its formative glacial origins in its current geomorphology. The mountain ranges surrounding the Mackenzie Basin include Aoraki / Mount Cook as part of the Southern Alps to the west, the Two Thumb Range to the north and the Ben Ōhau Range to the south. The Basin contains Lakes Ōhau, Pūkaki and Takapō, which accentuate the openness and vastness of this landscape.

Figure 1 presents an overview of the Waitaki River catchment, the Takapō River catchment and the Takapō catchment.

1.4 SURROUNDING LANDUSES AND DEMOGRAPHICS

A large part of the upper Waitaki area sits within the Mackenzie District. Mackenzie District is the third smallest territorial authority in New Zealand in terms of population size. However, the area of the district is large compared to its population size, with the district comprising of 745,562 hectares.

Within the Mackenzie Lakes statistical area (which includes the Tekapo township), the 2018 census data indicates that 1,182 people usually reside in the area, with a median age of those residents being 31.8 years. Fifty-one (51) people, or 4.3% of the population, identified as Māori. The census found a low unemployment rate of 0.3%. In respect of the Twizel statistical area, there are 1,455 (2018) residing permanently in the area, 9.1% of whom are Māori with a median age of 46.5 years.

Since 2013, growth in the Mackenzie District has significantly exceeded growth projections, which has been driven by growth in the tourism industry. This growth in the tourism sector has attracted both visitors and residents alike.

In terms of growth projections into the future, MDC prepared a growth projections report in 2020[1] that sets out:

1. The usually resident population in the Mackenzie District is projected to grow from 4,950 in 2020 to 9,050 in 2050. In the Mackenzie Lakes area (which includes Tekapo) the usually resident population is expected to increase significantly, growing from 1,142 in 2020 to 2,550 in 2050;

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[1] Mackenzie District Growth Projections – 2020, prepared for Mackenzie District Council by Rationale Limited, August 2020.

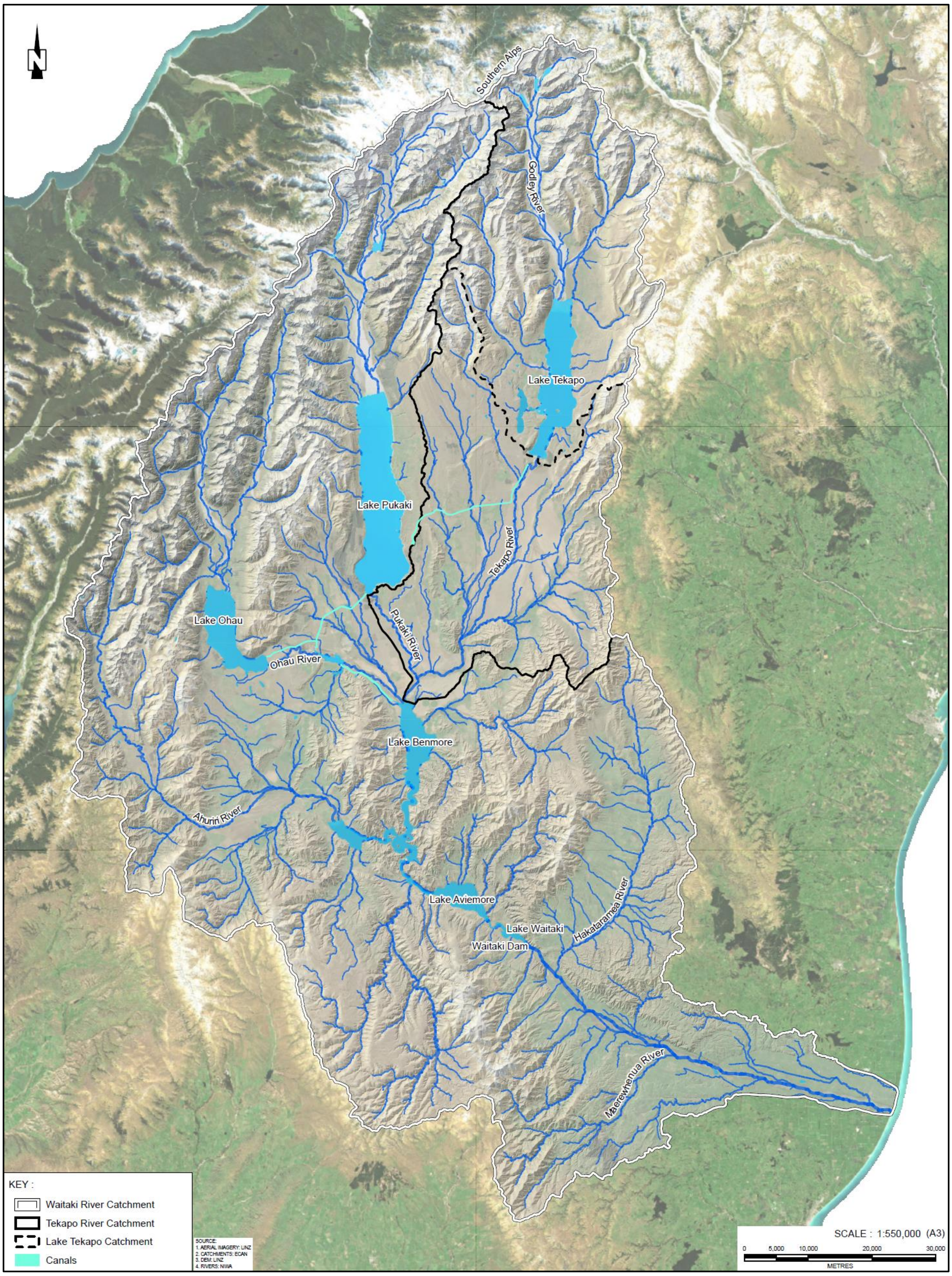

Figure 1: The Waitaki Catchment

2. In terms of Tekapo specifically, the report sets out that in recent years Tekapo has experienced unprecedented growth due to an increase of domestic and international tourism. This has led to an increase in dwellings (both occupied and unoccupied) and significant growth in the usually resident population. Population growth in Tekapo is expected to continue to increase from 504 in 2020 to 1240 in 2050, growing at an annual average rate of 2.3%;

3. As is the case with Tekapo, the population of Twizel is also projected to increase significantly over the next 30 years. Twizel has the largest population in the Mackenzie District at 1,524 usually resident people, and this is projected to grow to 3,395 (at a rate of 2.6% per annum);

4. Tekapo is predicted to reach dwelling capacity in approximately 2030 and Twizel approximately 2040;

5. The peak day visitor nights are projected to grow from 9,239 in 2020 to 32,568 in 2050. The average day visitor nights will increase from 2,363 in 2020 to 8,330 in 2050; and

6. It is likely that the Mackenzie District will experience an impact in respect of COVID-19 job losses larger than other areas around New Zealand. This is due to the importance of the local tourism industry to the economy, and its dependence on international visitors. However, it is likely to recover by around 2025.

The growth identified in the Rationale report indicates a doubling in outdoor recreation participation by residents and a tripling in participation by visitors over a 30-year period which is likely to result in significantly increased pressure on recreation facilities, the potential for increased recreation conflict, and the need for additional recreation infrastructure, management and regulation. While this may imply a shift in emphasis from management of lakes, rivers and canals for hydro-electric purposes towards recreation and tourism purposes, it must equally be recognised that access to the lakes, rivers and canals is facilitated by the existence of the hydro-electric infrastructure and that the value of low-carbon electricity generation will also be increasing simultaneously. This is especially so in relation to tourism where decarbonisation will be vital in future sustainable tourist trends and marketing, as already seen in Queenstown and

Wanaka with a drive to create a carbon zero tourism industry in the district by 2030.[2]

In the Mackenzie District, there are three key industries: agriculture, electricity generation and tourism. The agriculture and electricity generation industries had a gross domestic product ("**GDP**") in the year to March 2019[3] in excess of $60 million each with tourism accommodation almost $35 million, together contributing more than 50% of the district GDP of $293 million. These key industries rely on the ability to utilise freshwater.

1.5 ZONING AND PLANNING FRAMEWORK

The Canterbury Regional Policy Statement ("**CRPS**"), CLWRP and Waitaki Catchment Water Allocation Regional Plan ("**WAP**") collectively identify the area in which Tekapo PS is located as having the following environmental values and characteristics:

1. Both Takapō and Lake Pūkaki are identified as a statutory acknowledgement area in the CRPS (Appendix 1) in accordance with the Ngāi Tahu Claims Settlement Act 1998. The statutory acknowledgement describes the relationship of Te Rūnanga o Ngāi Tahu with these lakes, which includes urupā (resting places of tupuna) and mahinga kai values. The CRPS also notes that mauri is a critical element of the spiritual relationship of Te Rūnanga o Ngāi Tahu with Takapō and Lake Pūkaki;
2. The Mackenzie Basin is listed in the CRPS (Appendix 4) as an outstanding natural feature and landscape at a regional scale. Both Takapō and Lake Pūkaki are specifically identified as having aesthetic and tāngata whenua values which contribute to the outstanding natural feature and landscape values of the Mackenzie Basin. The CRPS acknowledges that the Combined Waitaki Power Scheme ("**Combined WPS**") forms part of the Mackenzie Basin landscape;

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[2] Queenstown Lakes announces intention to be first carbon zero tourism destination in the world, Wednesday 23 November 2022 (Queenstown, NZ). Joint media release from Destination Queenstown, Lake Wānaka Tourism and Queenstown Lakes District Council.

[3] Regional Economic Activity Interactive Tool, owned by Ministry for Business, Innovation and Employment, accessed November 2022.

3. Both Takapō and Lake Pūkaki have a water quality classification of 'Large High-Country Lake' in the CLWRP;

4. The rivers and streams that discharge to Lakes Takapō and Pūkaki have a water quality classification of 'Hill-fed Upland;'

5. Lake George Scott is identified as being a 'Small to Medium High-Country Lake' on the CLWRP planning maps;

6. The Takapō River is identified on the CLWRP planning maps as being a 'Lake-fed Upland River.' The various tributaries of the Takapō River are generally identified as being 'Spring-fed Upland Rivers;'

7. The Tekapo PS is located within the upper Waitaki–Haldon Arm Nutrient Allocation Zone in the CLWRP. This zone is identified as being 'At Risk' of not meeting the water quality guidelines;

8. Lake Benmore (where the Takapō River discharges) is identified as being an 'Artificial On-River Lake' on the CLWRP Planning Maps;

9. The Tekapo PS is identified in the CLWRP as being located over a semi-confined or unconfined aquifer;

10. Tekapo PS infrastructure is located within three Groundwater Allocation Zones in the CLWRP: Waitaki – Upstream Tekapo, Waitaki – Upstream Dam and Waitaki – Upstream Pūkaki;

11. The Tekapo PS is located within the upper Waitaki Freshwater Management Unit, and in the 'Haldon Zone;' and

12. Some areas surrounding Tekapo PS infrastructure are identified areas of 'High Runoff Risk Phosphorus Zone' in the CLWRP.

In respect of the Mackenzie District Plan ("**MDP**"):

1. The majority of the land on which Tekapo PS infrastructure is located is zoned 'Rural Zone;'

2. The Combined WPS, inclusive of the Tekapo PS, is a 'Scheduled Area' (Schedule A in the Rural Zone Rules section of the MDP). This includes Lake Takapō Dam, Tekapo A, Tekapo Canal and the Tekapo B Power Station. The site and zone standards of the Rural Zone section and the rules for Utilities in Section 11 of the MDP do not apply to the operation,

maintenance, refurbishment, enhancement and upgrading of an existing hydroelectric power station or water control structure and related activities and external modification thereof (except where significant external modification or addition to a structural component or building is involved). 'Power station operations' include the operation of penstocks, turbines, generators and switchyard. In addition, booms on the surface of water and their maintenance, fish and elver passes, site investigation works and activities necessary to maintain land and water bodies including activities for the purpose of erosion control, public information and environmental monitoring and enhancement are also permitted activities;

3. The land between Takapō and Lakeside Drive is zoned 'Recreation Passive' in the MDP. The purpose of the zone is to protect areas considered by the MDC to be appropriate for passive recreation;

4. The Tekapo PS, Takapō and Lake Pūkaki are within the Mackenzie Basin Subzone Outstanding Natural Landscape;

5. Takapō is identified in Appendix I of the District Plan as a 'Site of Natural Significance' (Site 56). It notes that the drawdown of the lake in winter exposes shoreline bays and deltas which are particularly important for waterfowl breeding (e.g., black stilt / kakī, banded dotterel, grey teal and shoveler) and feeding. Rare scree skink have also been observed around the shoreline of Takapō, along with large numbers of aquatic and terrestrial insects;

6. Lake Pūkaki is also identified as being a 'Site of Natural Significance' (Site 18). It notes that it is a deep glacial moraine dammed lake with numerous wildlife habitats. Drawdown for hydroelectric power generation during winter exposes the Tasman River delta at the north end and lake margins which provide overwintering areas for black stilt / kakī. It also provides feeding and breeding areas for black stilt / kakī and other waterfowl and waders, as well as habitat for three endemic moth species;

7. The Takapō River is identified as a 'Site of Natural Significance' (Site 45). The plan notes that it is a wide, braided alluvial river bed that provides important habitat and breeding areas for native species;

8. An area adjacent to the Tekapo Canal on the western side (at the north end of the canal) is identified as the Tekapo Flat 'Site of Natural

Significance' (Site 33). This area includes short tussock grassland and a *Brachaspis robustus* (Robust grasshopper) site;

9. An area adjacent to the Tekapo Canal on the eastern side (at the north end of the canal) is identified as the Tekapo Scientific Reserve 'Site of Natural Significance' (Site 52a). The MDP identified that this area is a reserve area which is "currently the subject of research into nature conservation of dry tussock grasslands and intermittent wetlands in the eastern South Island high country;"

10. An area adjacent to the Tekapo Canal on the eastern side and the Takapō River is identified as the Tekapo Terrace 'Site of Natural Significance' (Site 52). This area has large numbers of terrestrial insects present and includes representative habitat for endemic grasshopper *Sigaus minutus* and the nationally endangered *Brachaspis robustus*;

11. There is a 'Scenic Viewing Area' identified adjacent to the Tekapo Canal at the Lake Pūkaki end (SV11A). This site provides views to the Aoraki / Mt Cook area;

12. The area adjacent to Lake Pūkaki is identified as being a 'Lakeside Protection Area' (15);

13. There is a height restriction area and no build area located immediately south of the Tekapo A intake, between Lakeside Drive and SH8;

14. A designation for the Tekapo A Switchyard (ID 4) and a designation for the for the Tekapo B Switchyard (ID 5) for Transpower are identified on the Planning Maps;

15. Appendix U of the MDP contains hydroelectricity inundation hazard area maps which shows the locations adjacent to Tekapo PS infrastructure that are identified as being potential subject to inundation in the event of a dam or canal breach; and

16. Takapō is located in the Aoraki Mackenzie International Dark Sky Reserve, as designated by the International Dark-Sky Association.

1.6 CLIMATE

As detailed in the Pattle Delamore Partners ("**PDP, 2023**") Hydrological and Hydrogeological report[4] the climate in the area is strongly influenced by Kā Tiritiri o te Moana/Southern Alps, with the climate of the region having a marked influence on hydrology. The main rivers that feed into Takapō are partially snow and ice–fed and have their highest discharges during the spring/summer snowmelt season. The streams and rivers which are predominantly rain-fed (such as Mary Burn and Irishman Creek) tend to have their highest discharges in winter and spring.

The Mackenzie Basin is a drier region in the 'rain shadow' of the Southern Alps. Summers are warm and dry, with maximum temperatures averaging 21°C. Winters are cold, with an average maximum temperature of 8°C. On winter nights the temperature often falls below 0°C. Annual sunshine hours at Takapō average more than 2,400, making it one of the sunniest places in the country. North-westerly winds prevail and are often hot and dry in summer.

In respect of rainfall, average annual rainfall near the main divide is approximately 8,000 mm reducing to approximately 500 mm around the mid- and lower reaches of the Takapō River main stem. The mean rainfall at the head of the Godley River in the upper catchment is appropriately 5,000 mm – 6,000 mm. This decreases sharply to around 1,000 mm for Macaulay at Mount Gerald and to 500 mm near the Tekapo township.

In terms of floods and low flows climate change is anticipated to result in:[5]

a. An overall increase in flood flows. Flood flows are anticipated to increase in winter and spring with no or limited change in summer and autumn.

b. Low flows are anticipated to increase due to the increase in rain in winter (when flows are typically low) and increased snow melt. The total number of extreme low flow events is anticipated to decrease.

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4 Tekapo Power Scheme – Hydrological and Hydrogeological Analyses, 2023, reference number A02482505. Report prepared by Pattle Delamore Partners Limited.

5 Tekapo Power Scheme – Hydrological and Hydrogeological Analyses, PDP 2023..

Climate change modelling indicates that the greatest changes in flow characteristics can be expected by the end of the century, beyond the duration of the consents sought.

1.7 TAKAPŌ

1.7.1 Natural Character

A description of the existing environment as it relates to natural character, landscape and visual amenity of waterbodies associated with the Tekapo PS is provided in the Boffa Miskell Natural Character, Landscape and Visual Amenity Effects Assessment ("**Boffa Miskell Landscape, 2023**").[6] This report is summarised below.

a. Overall, the natural character of Takapō is considered to be "Moderate;"

b. The natural levels of Takapō have been modified by the Lake Tekapo Control Structure. The controlled water level regime contributes to the episodic nature of erosion. The changing lake levels can restrict the establishment of vegetation within the lake margin that is influenced by lake level fluctuations;

c. When the lake levels are low relatively large unweathered rocky shoreline margins can be exposed;

d. Structures in the lake include the Lake Takapō intake structure, outlet dam/control gates and SH8 road bridge, pedestrian bridge near the outlet, and a boat ramp. Infrastructure, buildings and roads of Tekapo village also encroach into the margin of the lake; and

e. Takapō is a dominant natural feature of the basin with its turquoise colouring contrasting with the surrounding hills. Experientially the lake appears to retain high levels of naturalness (with the exception of Tekapo Village and the hydro structures at the southern end).

6 Tekapo Power Scheme Reconsenting: Natural Character, Landscape and Visual Amenity Effects Assessment 2023. Prepared by Boffa Miskell Limited.

1.7.2 Hydrology

This section and section 1.7.3 rely on the PDP, 2023 hydrology and hydrogeological report,[7] which is summarised below.

Prior to the development of the Tekapo PS in 1951, Takapō lake levels were controlled by the natural inflows and outflow from the lake. The pre-1951 lake levels varied between 704.4 and 707.1 masl. Genesis now manages the lake within the existing consented minimum and maximum levels.

The main inflows into Takapō are the Godley River, Macaulay River (via the Godley River) and the Cass River. There are no flow recorders on these rivers. However, the daily median inflow into Takapō is estimated by Genesis (based on lake outflows and lake levels) and flow statistics for the period 1926 – 2020 and for the period 1991-2020 are estimated to be 66.8 m^3/s and 67.1 m^3/s respectively.

The following Figure 2 provides an overview of the Takapō mean monthly inflows and outflows:

Figure 2: Takapō Mean Monthly Inflow and Outflow

[7] Tekapo Power Scheme – Hydrological and Hydrogeological Analyses, 2023.

Analyses of the available lake level data by PDP indicates that the lower part of the range has been entered less often since 1991. Minimum lake levels for the periods 1951-1978 and 1979-1990 are 701.7 masl and 702.1 masl respectively. This compares with a minimum of 702.9 masl for the period 1991-2020, primarily due to the setting of a minimum level in the WAP and conservative operating practices to minimise the risk of levels falling below the statutory level. The lake levels that are exceeded 95 % of the time (lowest 5 percent of the lake levels) are also higher for the period 1991 – 2020 compared to the period 1979 – 1990 and 1951 – 1978.

The influence of managing the water levels for hydropower generation is apparent in the data. The natural lake level fluctuation (pre-1951) is approximately 2.6 m. Post 1951 (1951-1978) lake levels are typically in the range between approximately 702.8 (water level exceeded 95 % of the time) and 710.2 masl (water level exceeded 5% of the time). After 1991, water levels are typically in the range between 704.7 and 710.2 masl. The minimum and maximum water levels are 701.7 and 712.6 masl recorded on 28 August 1976 and 23 December 1984, respectively.

The design flood level of 713.05 masl has never been reached. The maximum recorded lake level since the lake was dammed in 1951 is 712.6 masl recorded during the 1984 flood. Since that time, special flood operating procedures were introduced, and lake levels have not exceeded 712.0 masl. Figure 3 provides an overview of the Takapō lake levels between 1925 and 2020:

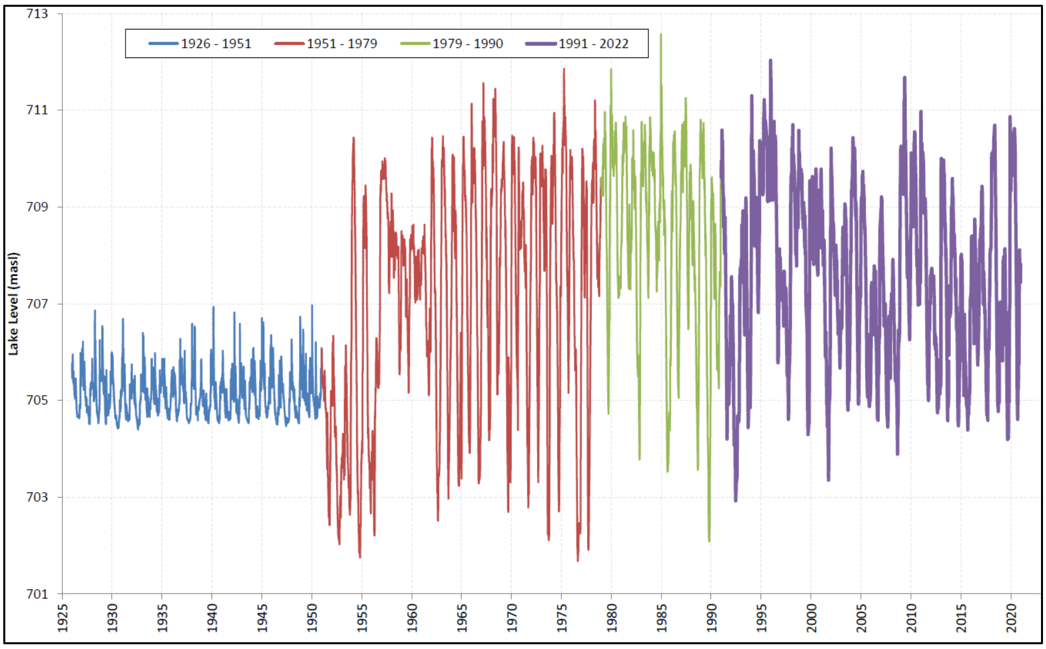

Figure 3: Takapō Lake Levels

In respect of the implication of climate change on Takapō, the available climate change studies[8] indicate an increase in average annual inflow to Takapō for both the mid-century as well as for end century. Flows are likely to increase in winter and autumn due to increased precipitation. The increased precipitation will primarily be as rain in winter with less snow and earlier melt than is currently experienced, while a small decrease in flow in summer is predicted.

Climate change modelling indicates that the greatest changes in flow characteristics can be expected by the end of the century under the 'high emission' scenario. For the low emission scenario there is generally little change in inflow between the baseline period and the mid and end century scenarios.

1.7.3 Hydrogeology

A number of wetlands and other water bodies border Takapō. To understand the effect of water level fluctuations in Takapō on these wetlands/water bodies, PDP, 2023 monitored water levels in seven representative wetlands / waterbodies – Takapō West 3; Lake Alexandrina; Rapuwai Lagoon; Wetland

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[8] For example, *Aotearoa New Zealand climate change projections guidance: Interpreting the latest IPCC WG1 report findings*, Bodeker, G., Cullen, N., Katurji, M., McDonald, A., Morgenstern, O., Noone, D., Renwick, J., Revell, L. and Tait, A. (2022). Prepared for the Ministry for the Environment, Report number CR 501,

16135; Lake McGregor; Godley River Wetland 23; and Takapō East 2. These wetland areas are depicted in Figure 4.

The work undertaken by PDP indicates that wetlands/water bodies that are located above approximately 711 masl are unlikely to be affected by lake levels, except during infrequent events when lake levels exceed the maximum operating levels. Wetlands/water bodies located less than 711 masl are expected to have some degree of hydraulic connection with Takapō, although the degree of connection will vary depending on Takapō water levels. This pattern of interconnection will not be altered as a result of the reconsenting as Genesis is not proposing to change the current operating levels for the lake.

There are a small number of domestic supply bores around Takapō that could potentially be affected by lake level fluctuations. However, these bores have all been installed since 2000 (post-scheme) and Genesis is not proposing to change the current operating levels for the lake so effects on those bores will not change from the status quo.

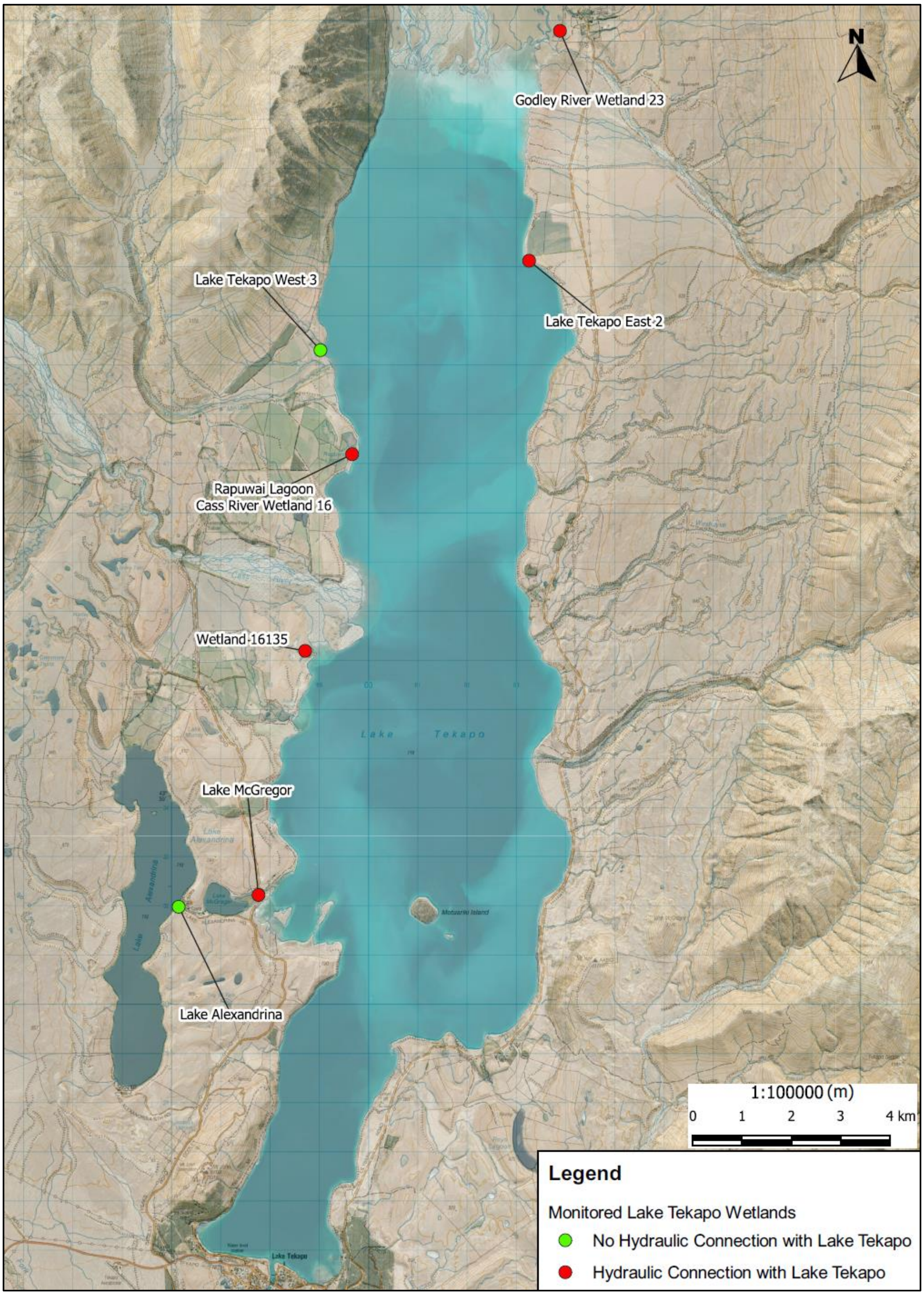

Figure 4: Takapō Wetlands / Waterbodies Monitored by PDP

1.7.4 Water Quality

As detailed in the Cawthron assessment of aquatic environmental effects ("**Cawthron, 2023**"),[9] water quality in Takapō is excellent with low concentrations of nutrients, minimal phytoplankton growth and high dissolved oxygen concentrations, even in the bottom waters of the lake. Water clarity in Takapō has historically been low, due to inputs of glacial flour from the tributaries. Water clarity has increased in recent years, because of reductions of glacial flour within the rivers prior to entering the lake. Clarity is now close to double what it was in the previous decade, likely due to reduced glacial flour resulting from climate change.

Cawthron, 2023 considers that it is unlikely that the construction and operation of the Tekapo PS has resulted in any appreciable changes to water quality within Takapō.

The Cawthron, 2023 report is summarised further below.

1.7.5 Ecological Setting

1.7.5.1 Macrophytes

Phytoplankton and aquatic plant (macrophyte) richness and abundance are naturally low in Takapō (Cawthron, 2023). The existing operation of the Tekapo PS is unlikely to have resulted in any appreciable changes to phytoplankton in Takapō.

The distribution of submerged aquatic plants, which is governed by the depth to which sunlight can penetrate, is typically confined to a relatively thin band around the lake edge in lakes with low water clarity. By increasing the range of water levels in Takapō, the existing operation of the Tekapo PS likely reduced aquatic plant distribution and abundance by exposing macrophytes to wave disturbance and desiccation during low lake levels. However, the maximum depth (the euphotic depth) where aquatic plants are found increased from 2012–2017, likely due to the increasing water clarity allowing sunlight (and plants) to reach greater depths. Given the increasing water clarity of the lake,

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9 Tekapo Power Scheme reconsenting: assessment of aquatic environmental effects, 2023. Prepared by Cawthron Institute. Cawthron Report No. 3688.

the relative effect of the Tekapo PS on macrophytes has reduced and will reduce further if water clarity continues to increase.

1.7.5.2 Macroinvertebrates

Dense populations of macroinvertebrates in lakes are often associated with aquatic plant beds (macrophytes). Macroinvertebrate richness and abundance is relatively low in Takapō (Cawthron, 2023), reflecting the limited aquatic plant growth in the lake (due to the historically naturally low water clarity caused by glacial flour). As for aquatic plants, the Tekapo PS likely reduced macroinvertebrate abundance and diversity due to it increasing the range of water level variation in Takapō. However, given the increasing water clarity of the lake, the relative effect of the Tekapo PS on macroinvertebrate abundance and diversity compared with twenty years earlier has reduced and will reduce further if water clarity continues to increase (as it is assumed to do due to climate change).

1.7.5.3 Native Fish

Water Ways Consulting undertook surveys[10] in Lakes Alexandria, McGregor and Takapō / Tekapo, Rapuwai Lagoon and Patterson Ponds, the results of which are summarised as follows:

a. The surveys found six native fish in the Takapō, Canterbury galaxias, alpine galaxias, kōaro, common bully, upland bully and longfin eel;

b. Canterbury galaxias and upland bully were widespread and generally common, while common bully were more restricted occurring close to Lake Benmore but were more abundant in all lakes surveyed in the catchment;

c. Adult kōaro were common in Lakes Alexandrina and McGregor but rarely caught in Takapō;

d. Alpine galaxiids are common in the upper reaches of tributaries upstream of Takapō, such as Edwards Stream, but were rare with only five individuals found at two sites in the mid-reaches of the Takapō River; and

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[10] Tekapo Power Scheme: Native Fish Assessment, Report 61-2018, 2023. Prepared by Water Ways Consulting Ltd.

e. Large longfin eels were found in a Grays River tributary and in Patterson Ponds, and a single longfin eel was found immediately downstream of the Fork Stream culvert at the upper reaches of the Takapō River.

1.7.5.4 Salmonoid Values

Salmonids such as brown trout, rainbow trout and Chinook salmon are present in Takapō. However, due to the relatively low productivity of the lake, the fishery is naturally restricted. Nevertheless, it is more popular with anglers than Lake Pūkaki (which is highly turbid), but much less popular than Lakes Benmore and Aviemore. Angler use of Takapō has increased since 1994/95, possibly due to increased salmonid abundance in response to the increasing productivity around the shallow margins of the lake as water clarity has improved. While lake level fluctuations associated with the Tekapo PS have affected macrophyte and macroinvertebrate abundance and diversity in the shallow margins of the lake, a trend of increasing water clarity (and associated increase in euphotic depth) is likely to improve productivity in Lake Tekapo and hence improve the conditions for salmonids and the lake's angling values.

1.7.6 Shoreline Morphology

A description of the existing shoreline morphology of Takapō is provided in the Shore Processes and Management Limited lakeshore geomorphology report ("**Shore Processes, 2022**").[11] This report is summarised below.

Takapō occupies a glaciated valley, partially blocked by moraine and outwash deposits. The catchment for the lake is approximately 1,440 km^2, and includes glacial valleys, with the main tributaries being the combined Godley, Macauley and Coal Rivers at the northern end of the lake, and the Cass River on the western flank. Three smaller named tributaries feed into the lake. The lake is long compared to the width, with the long axis running approximately north south.

The southern shore of Takapō is formed into moraine deposits, with terminal moraine along the southern shore fronting Tekapo township, and lateral and glacial edge moraine along the base of Mt John. The eastern and western shores are formed into more recent fluvial deposits and fans resulting from

[11] Tekapo Power Scheme re-consenting: Lakeshore geomorphology and processes Existing environment and future effects, 2022. Prepared by Shore Processes and Management Ltd.

erosion of the surrounding hills. Fluvial deposits from the Godley, Macaulay and Coal Rivers dominate the northern shore. The river mouths combine to form a large deltaic landscape, while the shoreline builds southwards due to the abundant supply of sediment from upstream.

An overview of the geomorphology of Takapō is provided in Figure 5 (northern section) and Figure 6 (southern section).

The overall character of the shore indicates a developing geomorphology. Most of the shore has beaches with sediments that are able to be moved by waves, and are dynamic, adjusting in response to changes in the process environment. There are sites that exhibit active erosional processes, and although these are ongoing, they occur intermittently and are related to periods of high-water levels with strong winds generating erosive waves. Similarly, there are evolving accreting landforms such as barrier beaches and infilling pocket beaches.

Shoreline development on Takapō is related to the natural processes of wind-generated waves causing sediment movement across the beach and along the shore. Waves and nearshore currents work on the shore and backshore sediments. The energy of the waves controls the potential amount of work that can be done. The lake level controls where, with regard to the elevation on the shore profile, that work is done. In respect of waves, the wave processes are topographically channelled along the north – south axis of the lake, with stronger winds generating larger waves from the north than from the south. Wave events from the north are generally of longer duration than those generated from the south. The result is a wave environment that presents waves breaking at a strong angle to the western and eastern shores but breaking nearly parallel to the southern and northern shores.

In respect of lake level, the lake water level and the range of levels within the operating regime on Takapō determine the elevation range where the wave activity acts on the shore profile. Higher lake levels will place the zone of wave activity higher on the profile, and if coincident with high energy waves can cause erosion of the upper part of the beach with deposition of sediment at the limit of wave run-up and lower down the profile in the nearshore. At low levels wave action works on the lower part of the shore profile, removing the upper part of the profile from the zone of wave action, while the nearshore shelf and face are actively worked.

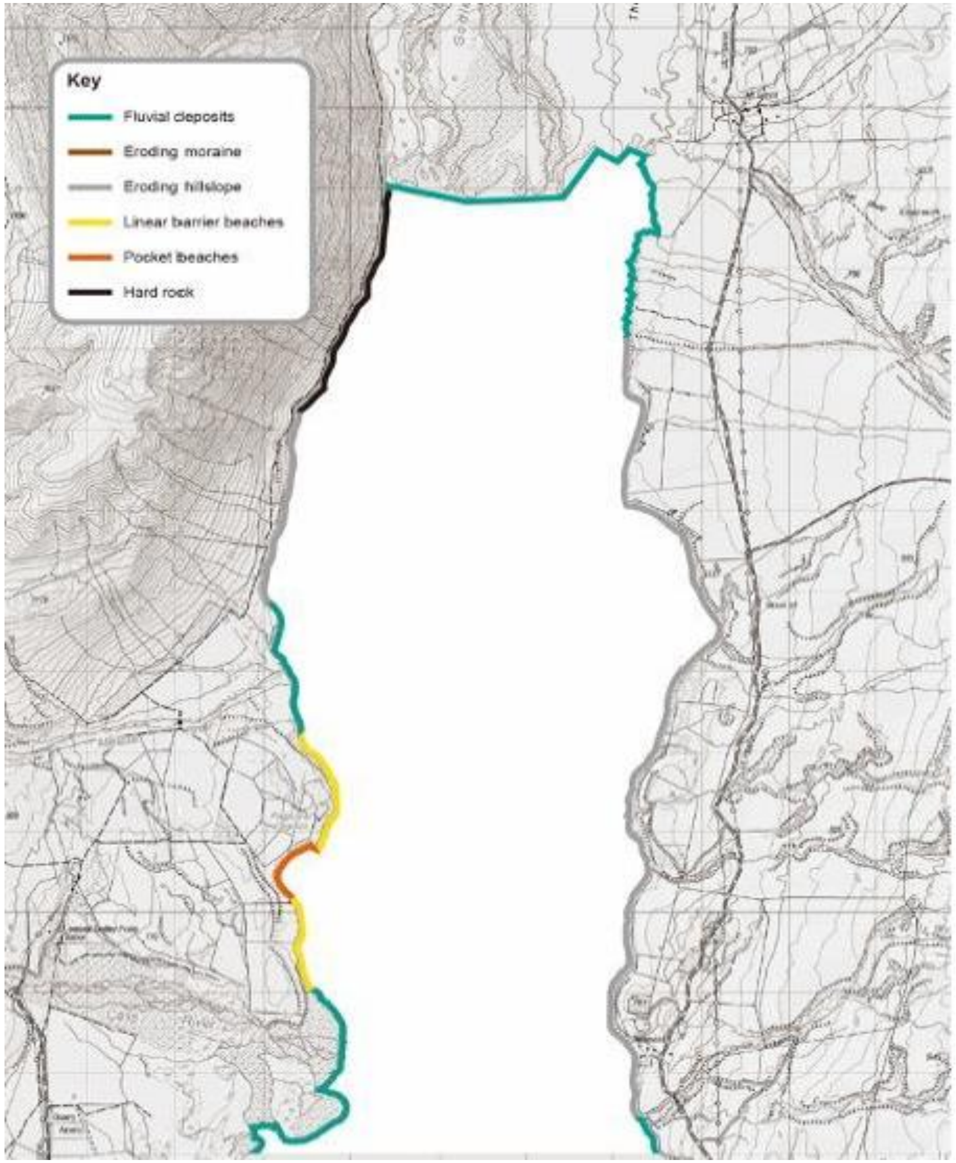

Figure 5: Takapō Geomorphology (Northern Section)

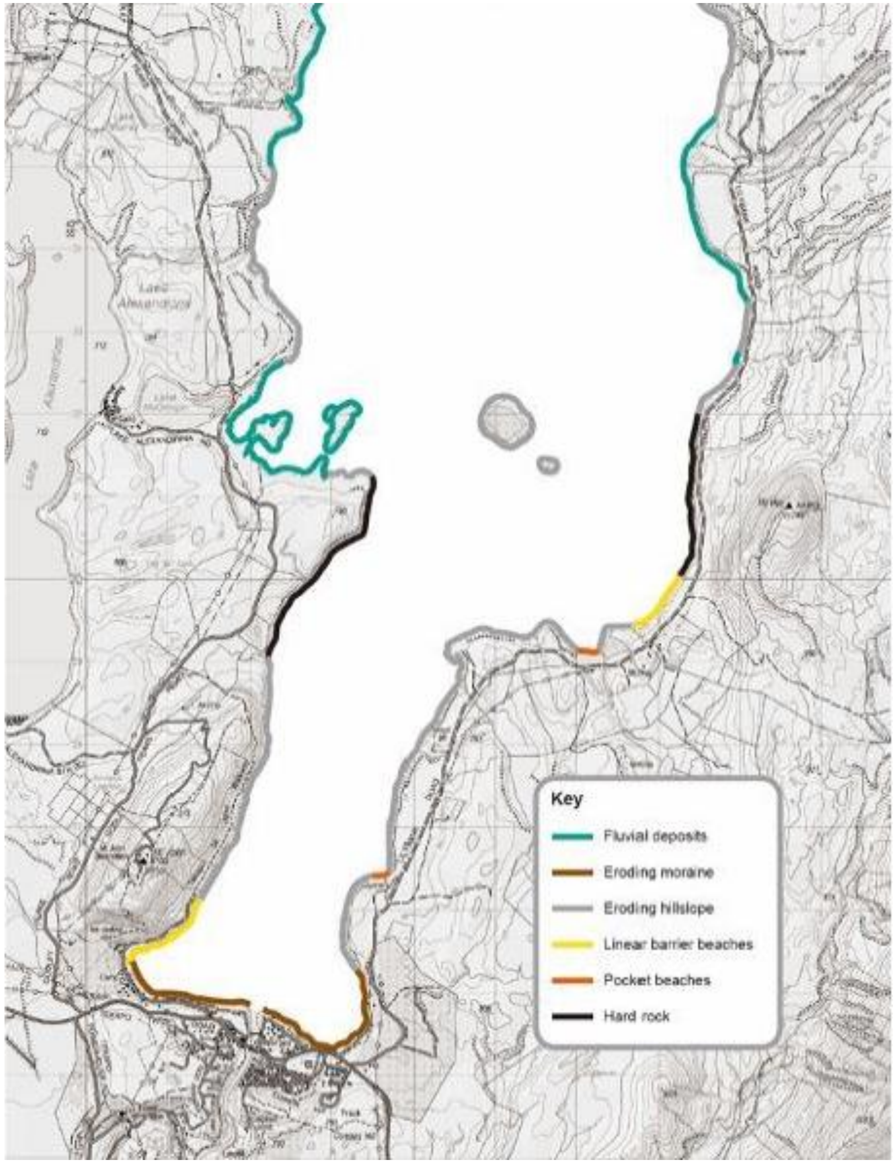

Figure 6: Takapō Geomorphology (Southern Section)

Extension of the lake level range since 1954 has resulted in erosion of the hinterland backshore composed of hillslope, moraine and fluvial deposits. Retreat of the steeper hinterland backshore resulted in near vertical cliffs in some locations. Wave action eroding the base of these slopes during periods of high lake levels has resulted in episodic erosion of the cliff and retreat of the shoreline. Subaerial weathering has also slowly resulted in the retreat of the top of the slope. In addition, the relatively stable water levels (i.e., the few occurrences of low lake levels, and few occurrences of high lake levels) has resulted in stable areas of backshore, where the beach protects the base of steep slopes. However, there are isolated sections of cliffed shore where the base of the cliff is at or below 710 masl, and there is only a narrow beach to dissipate wave energy. These cliffs are actively retreating. Subaerial weathering is an additional cause of erosion of steep cliffs and is part of the ongoing process of shore development.

1.8 TEKAPO CANAL

1.8.1 Natural Character

Overall, the natural character of the Tekapo Canal is assessed as being "Very Low" by Boffa Miskell Landscape, 2023. Whilst a distinctive and recognisable element in the Tekapo landscape that provides a high level of amenity that is associated with fishing and angling, the 25.5km structures are entirely man-made for the purposes of the conveyance of water associated with the operation of the Tekapo PS.

1.8.2 Hydrology

As detailed by PDP, 2023, flows at the Tekapo A and Tekapo B power stations vary depending on several factors including electricity demand, lake levels and Takapō inflows.

Median and mean Tekapo Canal flows are approximately 90 m^3/s and 76 m^3/s respectively for Tekapo B and 84 m^3/s and 69 m^3/s for Tekapo A. The difference is made up by flows sometimes bypassing Tekapo A via occasional releases at the Tekapo Control Structure (Gate 16) into the upper Takapō River and being discharged back into the Tekapo Canal at Gate 17.

Mean monthly flows are typically high in winter, especially July and August (82 m^3/s for Tekapo A and 83 – 84 m^3/s for Tekapo B), when electricity demand is high and low in September and October (56 m^3/s and 57 m^3/s respectively for Tekapo A and 65 m^3/s and 59 m^3/s for Tekapo B) when electricity demand drops off and the level of Takapō increases following “drawdown” in winter. When the lake level is high in summer, higher canal flows reduce the likelihood of spill.

An overview of the mean monthly flows in the Tekapo Canal, at both Tekapo A and Tekapo B is provided in Figure 7.

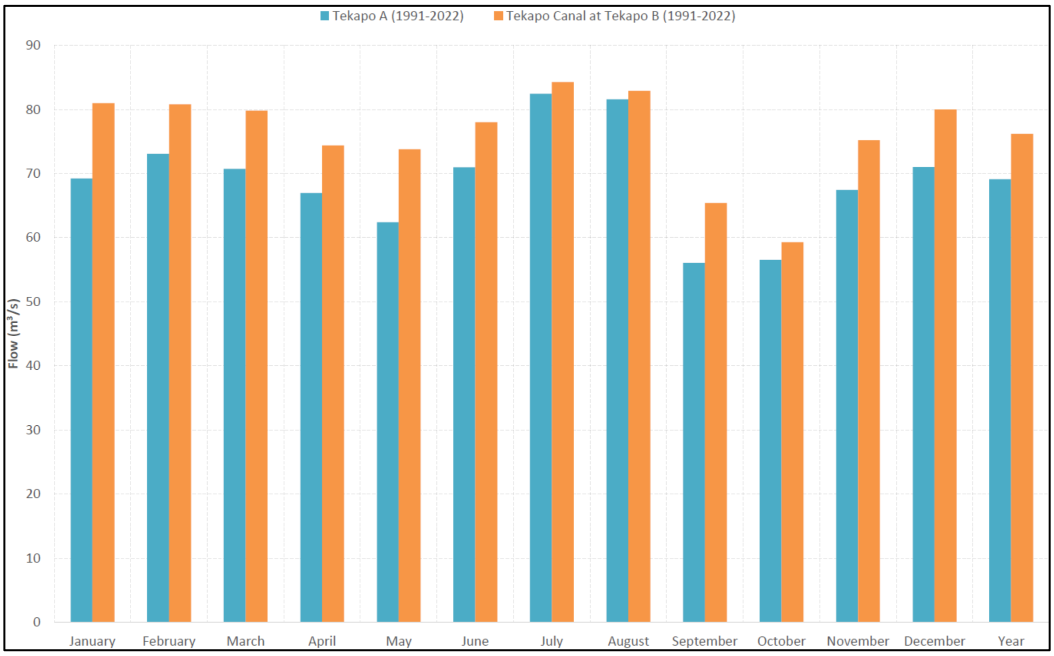

Figure 7: Tekapo Canal Mean Monthly Flows

1.8.3 Water Quality

The water quality in the canal is excellent, reflecting that of Takapō, including being relatively turbid (for a flowing waterbody) owing to naturally occurring glacial flour. Salmon farming occurs in the lower reaches. The operation of the Tekapo PS has not resulted in adverse effect on the water quality within the Tekapo Canal.

1.8.4 Ecological Values

1.8.4.1 Macrophytes

The canal has developed the characteristics of a highly stable, deep river ecosystem. The aquatic vegetation cover in the canal consists of a community of macrophyte beds including both native and introduced species.

1.8.4.2 Macroinvertebrates

The macrophyte beds within the Tekapo Canal support an abundant community of macroinvertebrates with densities observed in the top 15% of rivers throughout New Zealand where comparable data are available.

1.8.4.3 Native Fish

Native fish including common bully, upland bully and longfin eel are present in the Tekapo Canal as discussed in the Water Ways 2023 report. Juvenile kōaro have been observed anecdotally in the Tekapo Canal.

1.8.4.4 Salmonoid Values

The canal supports a nationally significant (and world class) fishery for brown and rainbow trout and Chinook salmon supported by natural recruitment, some stocking, and escapees from the salmon farm. Salmonids in the canal attain sizes and abundances that are significant relative to natural rivers in New Zealand. The canal system is now one of the most popular fisheries in New Zealand; angler usage has tripled since 1994; more than compensating for declines in angler participation that have occurred in the Takapō River after the invasion of didymo.

It was originally considered that the exceptional canal fishery resulted directly from food waste leaving the salmon farms, yet the high macroinvertebrate and bully abundances observed in the canal suggests this is not necessarily the case. To address this, the contributions of farm-derived feed and wild prey to the diet of wild caught trout were quantified using stable isotope analyses by Cawthron 2023. The results suggest that the farm-derived food typically comprised between 16–22% of wild fish diet, although larger fish did have a higher farm-derived diet contribution.

1.9 TAKAPŌ RIVER

Prior to construction of the Tekapo PS, the Takapō River was the outlet for Takapō. As a result of diversion first for Tekapo A (in 1951) and then later into the Tekapo Canal (in 1977), there is usually little or no surface flow in the upper reaches of the Takapō River between the Lake Tekapo Control Structure and its confluence with Fork Stream (approximately 6.6 km downstream).

The flow duration curves for the Takapō Spillway and the Lake George Scott Weir is shown in Figure 8.

The diversion of water from Takapō for the Tekapo PS through the Tekapo Canal resulted in significant changes to the Takapō River, including:

a. Changing the character and landscape values of the Takapō River;

b. Altering the hydrology of the river, including substantially reducing flow in the Takapō River, particularly above the Fork Stream confluence;

c. Increased the water clarity, which is associated with the diversion (via the Tekapo Canal) of glacial flour from Takapō;

d. Providing a stable flow conducive to greater annual production of periphyton and macroinvertebrates; and

e. Physical habitat (depths, velocities and substrate) downstream of the Grays River confluence that are highly suitable for trout food production and trout spawning.

These matters are discussed in the following sub-sections.

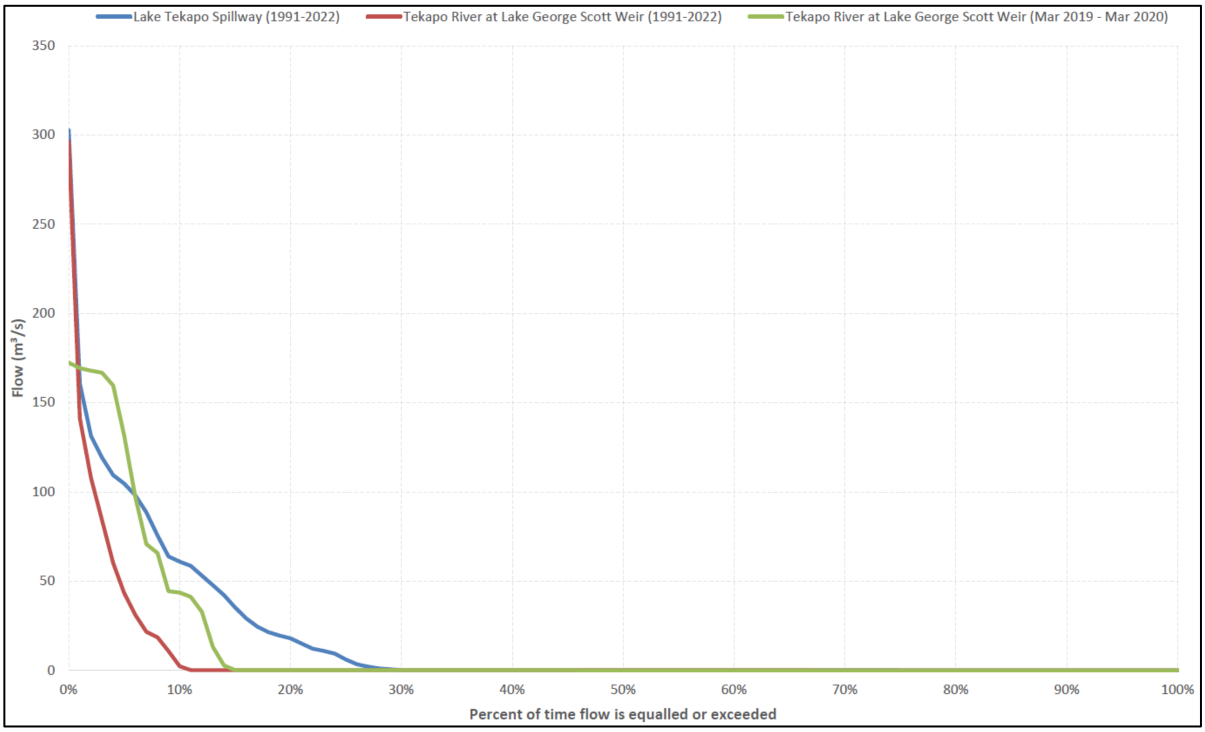

Figure 8: Flow Duration Curves - Lake Tekapo Spillway and Lake George Scott Weir

1.9.1 Natural Character

Boffa Miskell Landscape, 2023 details that the natural character of the Takapō River between its source (Takapō) and Fork Stream is "Low", due principally to its predominantly dewatered state and "Moderate" for the remaining 39km to its mouth at Lake Benmore. The assessment then describes the character of the river, as follows:

a. The upper reach of the Takapō River between the Takapō control gates (Gate 16) and Lake George Scott is generally dry as almost all the water from Takapō is diverted through the Tekapo Canal. This modified flow regime diminishes the extent and quality of freshwater habitat and water quality. Morphologically without the natural flows and seasonal floods the natural dynamics of the whole river system and movement of sediments is restricted;

b. For the first 4 km of the Takapō River, flow can vary from as little as 0 m^3/s to many hundreds of cubic metres during periods of flood. Some minor groundwater inflow is recorded between Lake George Scott and Fork Stream (4-7km). During periods of high flows, the water flows through the river without ponding or creating islands. During periods of low flow, the wetted rocky surface area changes significantly and the difference in flow is more detectable on the banks. These changes in managed flow are considered to reduce the natural character of this part of the reach of the Takapō River; and

c. Below the confluence of Fork Stream, the median flow in the Takapō River increases from approximately 3 m^3/s at the confluence with Fork Stream to approximately 10 m^3/s at the CRC flow recorder site downstream of the Mary Burn. As a result, levels of natural character increase beyond Fork Stream, to a moderate degree, noting that the flow regime of the lower Takapō River is still restricted.

1.9.2 Hydrology

1.9.2.1 Upper Takapō River

The CRC operates a flow recorder on the Takapō River just downstream of the Lake Tekapo Spillway (installed in 1968). This recorder has data available for two periods being 1968 until 1978 and 1993 until 2020. In addition, Genesis records flow at the Takapō control gate (Gate 16). Flow data from this site is available from 1957 through to 2020. Release flows from Lake George Scott to the Takapō River are also monitored by Genesis.

The upper reaches of the Takapō River generally have no or very little flow. Water is typically only discharged from Takapō (via Gate 16) to manage high lake levels, to top up Lake George Scott or if Tekapo A needs to be bypassed or to provide recreational flows. A review of the available flow data for the Lake Tekapo Spillway by PDP 2023 indicates that there is no or very little flow for approximately 72% of the time for the period 1991 to 2020. Lake George Scott Weir has no flow over the weir to the Takapō River for approximately 90% of the time. Some minor groundwater inflow is recorded between Lake George Scott and Fork Stream.

1.9.2.2 Mid Takapō River

The Takapō River has a permanent flow downstream of the confluence with Fork Stream. The data indicates that the median flow in the Takapō River increases from approximately 3 m^3/s at the confluence with Fork Stream to approximately 10 m^3/s at the CRC recorder site downstream of the Mary Burn.

This is predominantly due to flow contributions from tributaries such as the Grays River, Mary Burn and Irishman Creek (via the Mary Burn).

1.9.2.3 Lower Takapō River

As detailed in PDP 2023, the lower 4 kilometres of the Takapō River is influenced by flow from the Pūkaki River. Like the upper reaches of the Takapō River, the Pūkaki River generally has no or only a very limited amount of flow due to the Pūkaki Spillway only releasing water when required to lower Lake Pūkaki water levels during and following a flood. Meridian also releases water for recreational (kayaking) purposes. This typically occurs two weekends of the year resulting in a flow of approximately 45 m^3/s for approximately 10 hours per day.

The following table provides an overview of the median monthly flows in the lower Takapō River:

Table 1: Lower Takapō River Median Monthly Flows

Month	Fork Stream at Balmoral (m^3/s)	Takapō River at Downstream Mary Burn (m^3/s)
January	3.4	8.8
February	2.4	9.0
March	2.1	7.0
April	2.0	6.8
May	2.3	8.7
June	2.1	10.0
July	1.7	11.1
August	1.7	11.6
September	1.9	9.9
October	3.3	10.1

Month	Fork Stream at Balmoral (m^3/s)	Takapō River at Downstream Mary Burn (m^3/s)
November	4.7	13.0
December	4.8	9.7

1.9.2.4 Groundwater – Surface Water Interaction

As detailed by PDP 2023, the Takapō River typically has relatively stable flows in the upper reaches with some flow being lost to groundwater above the Grays River confluence. A significant flow increase typically occurs due to the Mary Burn and Grays River inflows, although there is an additional gain in flow that can be attributed to groundwater inflows immediately downstream of the Mary Burn and Grays River confluences. In the lower reaches as the river enters the Twizel Basin but upstream of the Pūkaki River confluence, an overall loss of river water to groundwater typically occurs.

1.9.2.5 Fresh and Flood Flows

In respect of freshes and flood flows, the PDP 2023 description of the existing environment summarises that:

a. The Takapō River between the confluence with Fork Stream to the confluence with the Grays River receives reasonably regular fresh and flood flows of 3 times the median flow (on average around 4 times per annum). Flows of 6 times the median or greater occur infrequently (on average less than 2 times per annum);

b. The Takapō River between the Mary Burn confluence and Pūkaki River confluence receives infrequent fresh and flood flows of all magnitudes (3, 6 and 10 times the median). The average frequency of these fresh and flood flow events is less than 3 times per annum;

c. The Takapō River downstream of the confluence with the Pūkaki River has a much greater fresh and flood flow frequency than the two upstream reaches (especially for flows 3 times the median) due to the Lake Pūkaki release flows. The average frequency of fresh and flood flow events is around 6, 4 and 3 per annum for flows with a magnitude of 3, 6 and 10 times the median respectively;

d. Mean and maximum accrual times are long, particularly for the larger flood events with a magnitude of 6 times the median or greater. Accrual times of all magnitudes (3, 6 and 10 times the median) are long for the Takapō River at Mary Burn; and

e. The flow data indicates that the frequency of fresh and flood flows in the cooler months (May – September) is relatively low compared to the warmer months (November – April), such that the accrual time is relatively long in winter compared to the warmer summer months.

1.9.3 Hydrogeology

The Takapō River is bordered by a number of bores, wetlands and other water bodies throughout the Takapō River Basin. PDP 2023 undertook monitoring of water levels within a number of these bores, wetlands and other water bodies throughout the Takapō River Basin for the purpose of understanding groundwater and surface water interaction and how these interactions change with flows/stage height in the Takapō River. An overview of the monitoring sites is provided in Figure 9.

Water levels were monitored within two wetlands east of the Takapō River and in five wetlands located west of the Takapō River (the locations of which are shown on the figure above). The data collected indicates that there is generally no clear hydraulic connection to most wetlands located more than approximately 1 km from the river. For wetlands closer to the river, there may be some influence from the Takapō River flow and stage height. This is because permanent flow in the river is expected to be interacting with/contributing to groundwater surrounding the river and therefore wetland levels close to the river will respond more clearly to changes in river flows and levels. The area where wetlands appear to be affected by Takapō River flow variations is generally where the alluvial strata is younger/more permeable and compared to the older/less permeable strata further away from the river.

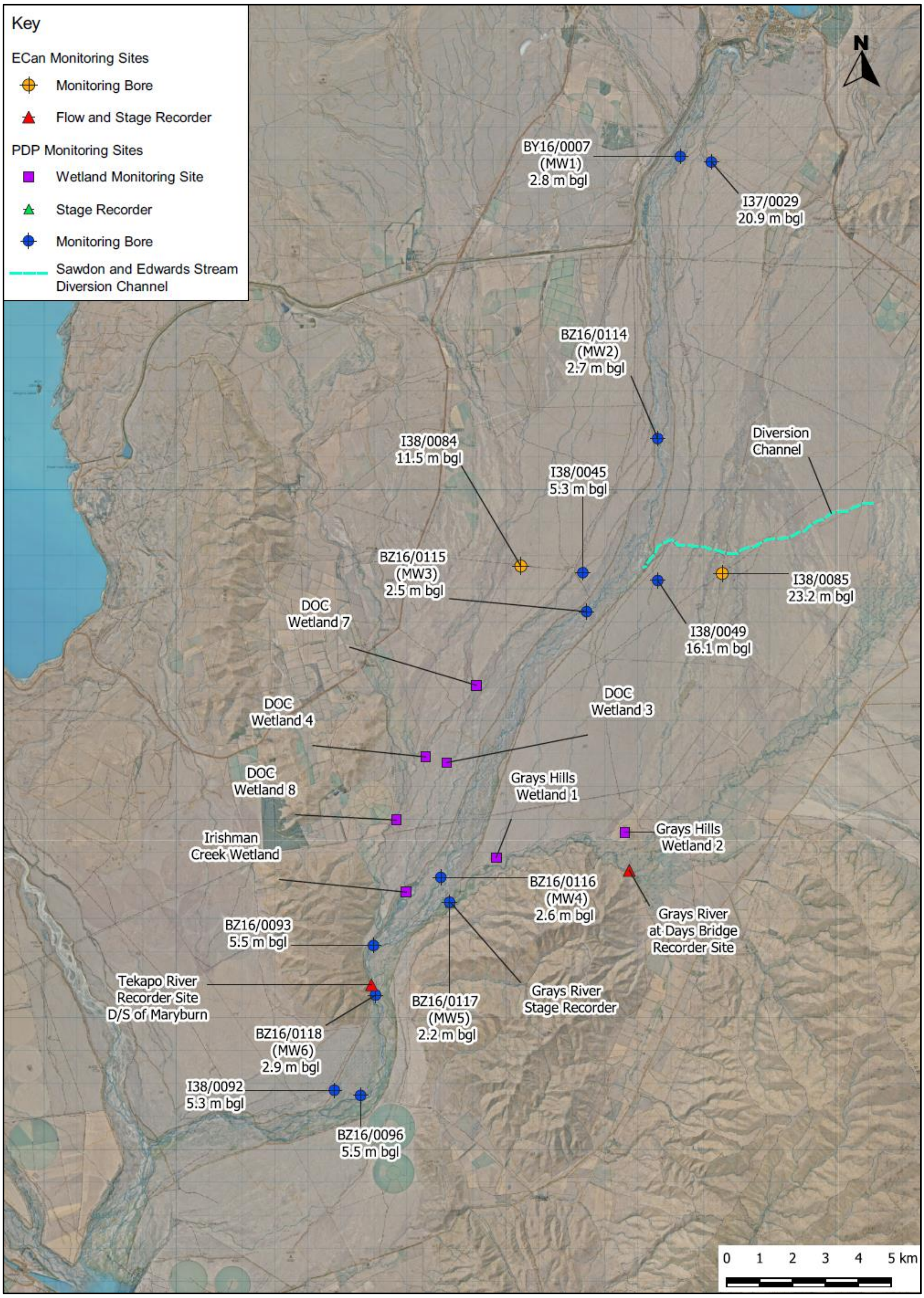

Figure 9: Takapō River Basin Water Level Monitoring Sites

1.9.4 Water Quality

The CRC monitors water quality in the Takapō River at a site just upstream of the confluence with the Pūkaki River (at the Steel Bridge). Overall, water quality is high at this site: the median suspended sediment concentration is less than 2 mg/l and the average turbidity of the water (1.2 NTU) is about a third of that in Takapō (3.9 NTU). However, the recent intensification of land use in the Mary Burn, Irishman Creek and Grays River catchments (unrelated to the Tekapo PS) is leading to a trend of higher nitrate and phosphate levels in the Takapō River downstream of the confluences with these tributaries. Water quality is still considered to be high in the lower Takapō River, despite increases in dissolved nutrients since 2000.

The existing operation of the Tekapo PS has resulted in the water quality of the Takapō River largely reflecting that of tributaries rather than the glacial water from Takapō. Water quality is good in the Takapō River and largely meets the targets of the National Policy Statement for Freshwater Management ("**NPSFM**") and the CLWRP. The only exception to this is where the night-time dissolved oxygen drops to around 80% saturation, which is likely due to a high biomass of didymo (Cawthron, 2023) compared with the CLWRP target of 90%. Relatively high daily fluctuations in dissolved oxygen concentration (with associated relatively low daily minima) are caused by the relatively high biomass and cover of periphyton, which often exceed guidelines for the protection of trout habitat and general recreational aesthetic guidelines.

1.9.5 Ecological Setting

1.9.5.1 Macrophytes

As detailed in Cawthron 2023, despite the Takapō River having low nutrient concentrations, periphyton cover assessments by the CRC undertaken between 2006 and 2014 show that periphyton cover regularly exceeds the Ministry for the Environment guidelines for the protection of recreational and aesthetic values.

The periphyton mats in the river include native algae and cyanobacteria, and didymo, which proliferates particularly in the upper and lower sections of the river. Didymo arrived in the catchment in 2007 and rapidly established itself.

Didymo commonly reaches nuisance levels in natural lake-fed rivers due to the stable flow regimes, immobile substrate, and low sediment supply allowing it to accrue with little bed disturbance. The results of Cawthron's longitudinal survey and the monthly sampling suggest that existing periphyton biomass occurs at 'nuisance' levels throughout the year. The long periods of steady flow that are experienced in the Takapō River contribute to the accumulation of high biomass of periphyton. The ongoing operation of the Tekapo PS results in a stable flow regime in the Takapō River, providing good conditions for periphyton (including didymo) proliferation.

1.9.5.2 Macroinvertebrates

The macroinvertebrate communities in the Takapō River have moderate ecosystem health scores (MCI – macroinvertebrate community index) indicative of a moderately nutrient/organically enriched river with abundant periphyton on the riverbed, reflecting the stable flow regime and presence of didymo. Despite some indications of negative effects from catchment land use intensification and proliferations of didymo based on ecosystem health metrics, the macroinvertebrate communities in the Takapō River provide an abundant food resource for fish and birds. The macroinvertebrate communities achieve moderate to high densities and biomass, with a typical mix of both large and small invertebrates. The effects of the existing operation of the Tekapo PS on macroinvertebrates in the Takapō River prior to the arrival of didymo were likely positive, with reduced fine sediment and increased water clarity (due to diversion of glacial lake water to the canal) and a stable flow regime. However, these conditions also provide good habitat for didymo, which has likely increased the proportion of pollution-tolerant macroinvertebrates, many of which are small and less preferred as food for fish and birds.

1.9.5.3 Native Fish

A description of the existing environment as it relates to native fish is provided in the Water Ways 2023 report. This report is summarised below.

a. Native freshwater fish surveys were undertaken by Water Ways Consulting in the Tekapo catchment during the summers of 2018-19 and 2019-20. In the first summer these surveys concentrated on fishing sites in the Takapō River between Lakes Takapō and Benmore. In the second summer the surveys targeted longfin eel;

b. The surveys found six native fish in the Takapō River, Canterbury galaxias, alpine galaxias, kōaro, common bully, upland bully and longfin eel. Canterbury galaxias and upland bully were widespread and generally common. Common bully was more restricted occurring close to Lake Benmore and in the various lakes of the catchment. Kōaro was widespread but occurred sporadically. Alpine galaxias was rare with only five individuals found at two sites in the mid-reaches of the Takapō River. A single longfin eel was found immediately downstream of the Fork Stream culvert at the upper reaches of the Takapō River;

c. Two species, common bully and kōaro, are benefiting from the hydro-electric power scheme developments in the Waitaki catchment. The creation of the new lakes such as Lake Benmore has created new larval fish rearing habitat for these species assisting them to expand their distribution. Kōaro, and possibly common bully have, most likely, also benefited from the reduction in longfin eel abundance as both species are prey of large longfin eels;

d. The longfin eel surveys of the second summer found large longfin eels but no smaller eels and elvers. These large eels were only found in a Grays River tributary and in Patterson Ponds;

e. The threatened native fish species in the Takapō catchment are the upland longjaw galaxias 'Waitaki,' the lowland longjaw galaxias 'Waitaki' and bignose galaxias which are all reported from the Takapō catchment but are found in the upper reaches of tributaries of the Takapō River and Takapō. These include Fork Stream, where conservation programmes partially funded by Project River Recovery are creating predator free streams by removing salmonids and placing fish passage barriers in the streams to prevent reinvasion. The restriction of these fish to small headwater streams with long reaches of unoccupied stream between the populations and the Takapō River indicate that the downstream limits for these species are set by factors, such as salmonids, rather than the flow alteration in the Takapō River. The fish survey work also failed to locate habitat for these species along the Takapō River channel. Therefore, it is concluded that the flow changes produced by the Tekapo PS have not affected the fish or the availability of their habitat, rather other factors limit the distribution of these three threatened galaxiids;

f. The majority of native fish populations in the Takapō River appear healthy. Upland bully is common and found along the length of the river and the river provides good habitat for this species; and

g. The Canterbury galaxias is widespread along the Takapō River and is abundant in riffle habitat. This species is affected by the presence of didymo, salmonids and kōaro and given these negative biotic factors the limiting factor for Canterbury galaxias is not expected to the river flow created by the Tekapo PS. Longfin eel abundance is limited, not by the Takapō River flow reduction reducing available habitat rather the lack of recruitment.

Overall, Water Ways Consulting considers that the Takapō River supports the expected range of native fish.

1.9.5.4 Salmonoid Values

As detailed in Cawthron 2023, as with other fisheries in the Waitaki catchment, the Takapō River contains brown and rainbow trout. Sockeye salmon also occur in the river periodically, as they run up from Lake Benmore to spawn. Salmonid habitat in the Takapō River is usually limited to below the Fork Stream confluence where there are substantial permanent flows.

Prior to the arrival of didymo, the Takapō River supported a very popular and highly regarded trout fishery. During that time, the existing operation of the Tekapo PS likely had positive effects on salmonid abundance in the Takapō River, due to reduced fine sediment and improved water clarity resulting from diversion of glacial Takapō water. Angler use has declined since the appearance of didymo, but the Takapō River continues to be a moderately popular fishery compared with other rivers throughout New Zealand. The decline in angling use aligns with the result of a survey of trout abundance in the Takapō River in 2021 which showed trout abundance was about half of that reported prior to didymo arrival.

However, despite these adverse changes associated with didymo, trout abundance in the Takapō River is still in the top 30% of New Zealand rivers where comparable data are available.

1.10 LAKE PŪKAKI

1.10.1 Natural Character

Boffa Miskell Landscape, 2023 consider that the natural character of Lake Pūkaki is “Moderate”, with the assessment noting that Lake Pūkaki is a modified natural lake, due to structures and lake level variability as its use for hydro-electricity storage. The artificial management of the lake levels for hydro storage (by Meridian) mask the natural seasonal level fluctuations. Modifications to the lakebed and margin including the outlet from the Tekapo Canal (Tekapo B) and outflow from the Canal to Meridian’s Ōhau Power Stations.

As with Takapō, Lake Pūkaki is a dominant natural feature of the basin with its bright turquoise colouring contrasting with the surrounding hills. Experientially, the lake retains moderate natural character (with the exception of the area around the structures associated with the Tekapo PS and WPS).

1.10.2 Water Quality and Ecological Values

Water levels in Lake Pūkaki are managed by Meridian Energy for electricity generation purposes. The lake receives water discharged from the Tekapo Canal. The lake is microtrophic (very low nutrient levels) and, like Takapō, has naturally high turbidity owing to glacial flour in the water derived from the large proportion of glaciation within the catchment.

Lake Pūkaki has low macroinvertebrate diversity and supports native fish populations including kōaro, upland and common bullies, and a remnant population of longfin eels. Brown and rainbow trout are also present, and land-locked sockeye salmon – which have become more abundant in recent years. Water entering the lake via the Tekapo Canal has excellent water quality, slightly better than that of the receiving environment.

1.11 LAKE BENMORE

Water levels in Lake Benmore are also managed by Meridian Energy. The lake consists of two, essentially independent, flooded river valleys, the Ahuriri Arm to the south (receiving water from the Ahuriri River) and the Haldon Arm to the north. The Haldon Arm receives water from the Takapō River as well as water from the Ōhau Canal (a Meridian Energy asset).

Water quality in Lake Benmore is generally good. The lake has a ten year mean trophic level index ("**TLI**") score of 2.18, classifying it as oligotrophic. The possibility that didymo and other periphyton sloughed from the Takapō River during large flow releases affects water quality in the Haldon Arm was modelled as reported in Cawthron 2023. The modelling assessed a 'worst case scenario' for didymo biomass in the Takapō River and assumed very high scouring and transport rates. The results showed that there is negligible risk from didymo and other periphyton accumulations to dissolved oxygen in Lake Benmore.

1.12 LANDSCAPE AND VISUAL AMENITY

Boffa Miskell Landscape, 2023 provides detail of the existing environment in respect of landscape and visual amenity values as it relates to the Tekapo PS as a whole. The landscape values are summarised below:

a. The characteristics and values of the wider Mackenzie Basin area include: the openness and vastness of the landscape; tussock grasslands; the lack of houses and structures; residential development limited to small areas in clusters; the form of the mountains, hills and moraines encircling and/or located in the Mackenzie Basin and undeveloped lakesides and SH8 roadside;

b. These characteristics have been influenced over hundreds of years of human modification. Takapō, Lake Pūkaki and the Tekapo Canal, whilst being a man-made feature, are prominent and act as defining, legible and memorable features of the Mackenzie landscape. The natural dynamics of the Takapō River system are modified by an artificial flow regime, throughout the river's entire length, and noticeably within the first 7km, where no minimum flow is established. However, whilst modified, the lakes and canal system provide moderate aesthetic values, as does the river;

c. The canals are also popular for sports such as fishing (salmon and trout), with kayaking occurring in the upper Takapō River and slalom course during flow releases. Furthermore, the lake margins prove popular for recreational activities, with walking and biking tracks along some of the banks;

d. The hydro schemes were developed with landscape design input at the engineering design stage, and significant landform and grassland reinstatement in the construction phase which resulted in the high degree of landscape integration now seen; and

e. The hydro schemes themselves hold historical association for the local area.

Visual amenity describes the pleasantness and aesthetic coherence of a place and comprises the visual and aesthetic aspects of amenity with the following matters to be considered in respect of visual amenity:

a. **In river** – flow level, wetted surface / dry channel, substrate / rock material, water clarity, water colour, water movement and light reflection;

b. **River / lake margins** – vegetation, levels of human modification, (e.g., structures, buildings), seasonal colour, nature of exposed river / lake margin (e.g., substrate of margin, algal proliferations), sounds and smells associated with the waterbodies; and

c. **Visibility and viewing audience** – the nature and size of the viewing audience, with some reaches / areas more accessible and visible than others; their sensitivity e.g., recreational / residential audiences have a greater level of sensitivity than passing traffic or workers.

The aspects of the operation of the Tekapo PS that change the natural processes and have the potential to affect the visual amenity are:

a. Noticeable drop in river / lake water level and / or a change in the regular pattern of level fluctuations;

b. Any changes to the clarity of the water in the lake or river resulting from operation of the scheme (which may include sedimentation, periphyton or an increase in the extent of a muddy shoreline); and

c. Changes to the character of the lake and riverbanks through flooding, erosion or debris.

Boffa Miskell Landscape, 2023 details that the Mackenzie Basin as a whole displays very high levels of visual amenity, recreational and perceptual values. This is reflected in the area's predominantly broad natural appearance, expansive views and relative low levels of apparent modification, where modifications (including the hydro scheme and farming practices) contrast with the predominance of natural elements.

The upper Takapō River is largely dry and has been since the commissioning of the scheme in 1951. Occasional flows do pass through this reach, but they are only of a limited duration. Some minor groundwater inflow is recorded between Lake George Scott and Fork Stream. Beyond Fork Stream, permanent flow within the Takapō River considerably improves the natural amenity values, where open views of the wider river corridor are appreciated.

The key landscape and visual amenity values associated with the area include:

a. Views of Takapō, Mount John, the mountains and the glacial lakes;

b. The Alps to Ocean walking and cycling track follows alongside the Tekapo Canal and Lake Pūkaki, and forms part of the Te Araroa Trail, enabling good views to the river and lakes for recreationalists that can be enjoyed away from busy public roads and viewpoints;

c. The relatively open, settled, rural landscape means that views incorporating Takapō and surroundings are pleasantly scenic; the expansive views provide an experience of openness with an attractive mountain backdrop; and

d. Rich transient values associated with the seasons and changes of the lake levels and river flow. The impressive weather and cloud patterns of the Mackenzie sky are renowned together with the distinctive night sky.

1.13 GEOLOGY AND GROUNDWATER

1.13.1 Geological setting

As detailed by PDP 2023, the Mackenzie Basin is a tectonic depression, which has been infilled as a result of the erosion of greywacke and schist associated with uplift of the alpine fault.

The basement rocks are predominantly greywacke, associated with the Torlesse Supergroup, which outcrops in the surrounding ranges. This is overlain by weathered greywacke conglomerate (associated with the Glentanner Formation), which is in turn overlain by glacial deposits, consisting of glacial tills and glacial outwash gravels, deposited during four major advances. There are alluvial deposits at surface in places (post glacial), which occur predominantly within and around present-day river systems, including the Takapō River. Around Takapō, the predominant geology is glacial till, with alluvial deposits around the inflowing rivers and sand and gravel beach deposits bordering the lake in places.

1.13.2 Groundwater Flows and Levels

Groundwater, both vertically and laterally in the deeper system, is likely to be highly variable and it is unknown whether the groundwater system is connected at depth. The CRC's interpreted groundwater contours on Canterbury Maps show groundwater flow to generally be parallel to the Takapō River and Lake Benmore.

Water level monitoring was undertaken by PDP in six existing bores located more than 400 m from the Takapō River that were all deeper than 6 m. The monitoring shows that:

a. Bores closer to the river displayed strong responses to flow (and corresponding stage height changes) in the Takapō River compared to bores located further away from the river;

b. Water levels within the deeper monitoring bores responded strongly to diverted flows from Edwards and Sawdon Streams within a manmade diversion channel located upgradient of two bores monitoring by PDP, likely as a result of flow losses to ground in this area of the basin. The changes in water levels within these bores as a result of the diverted flow were much larger compared to the smaller effect of changes in flow within the Takapō River;

c. To the west of the Takapō River, a similar response to flow/stage height within the nearby reach of Irishman Creek caused increases in water level within a monitored bore, although no response appeared to occur from changes in flow in the Takapō River. A small response (around 0.07 m) was observed in a bore located around 1 km west of the Takapō River, from flow changes in the Takapō River but the response measured in this bore was considered to be smaller than the natural water level variations observed in this bore; and

d. Groundwater monitoring was undertaken in eight shallow (<6 m deep) bores located within 160 m of the Takapō River. The water level monitoring data measured in these bores showed that they all generally displayed a strong response to flow and corresponding stage changes in the Takapō River.

PDP also undertook piezometric surveys which shows that groundwater flows parallel to the Takapō River from the middle reaches to downstream of Grays Hills. Along the upper reaches, directions are more complex indicating that groundwater flows toward the Takapō River with groundwater tending to flow more parallel to the river further downstream.

1.13.3 Groundwater Quality

Takapō

There is limited groundwater quality information around the lake. However, the Tekapo PS scheme is not considered to have a direct influence on groundwater quality and any indirect influence, for example a reduction in the unsaturated zone at higher lake levels.

Takapō River

A review of existing groundwater quality data was undertaken by PDP which indicated that groundwater quality within the Takapō River Basin is relatively good, although slightly elevated concentrations of some parameters, (*E.coli*, nitrate-N) have been observed occasionally in some bores but likely reflect localised upgradient land use unrelated to the Tekapo PS.

1.13.4 Groundwater Users

Takapō

There are a small number of domestic supply bores around Takapō that could potentially be affected by lake level fluctuations. However, these bores have all been installed since 2000 (post-scheme).

Takapō River

PDP 2023 reviewed the CRC database, and notes that there appear to be no recorded bores used for taking water near the Takapō River such as drinking water supply or irrigation use near the Takapō River, with the exception of a surface water take (for irrigation of crops and pasture) via an infiltration gallery on the lower reaches of the Takapō River. This consent was granted on 7 May 2007, a significant time after the Tekapo PS was already in place, meaning the infiltration gallery and take was designed based on the current flow pattern in the Takapō River and groundwater levels.

There are no other surface water take consents along the main stem of the Takapō River.

1.14 TERRESTRIAL ECOLOGY

1.14.1 Terrestrial Invertebrates

A description of the existing environment as it relates to terrestrial invertebrates is provided in the terrestrial invertebrate report[12] prepared by Entecol ("**Entecol 2023**"). This report is summarised below.

A range of invertebrates with known conservation significance have been recorded from the wider Takapō and Lake Pūkaki area, with a subset of these associated with braided rivers and most likely to be affected by the Tekapo PS. This includes spiders, stiletto and robber flies, grasshoppers, Tekapo ground weta, moths, and some true bugs. The storage and diversion of water associated with the Tekapo PS alters natural flow regimes and sediment transfers downstream. The river systems of the Tekapo PS are braided rivers, and braided rivers naturally undergo repeated perturbation of the riverbed. Reduced flows and flood attenuation from hydro schemes can modify natural sedimentation and channel forming processes. This in turn may adversely affect downstream biota that have adapted to live in braided river environments, including terrestrial invertebrate species.

Invertebrate communities within the Mackenzie Basin generally have been affected by many factors, particularly habitat loss through expanding agricultural activities such as pastoralisation and irrigation.

An overview of the species of known conservation significance identified as being present within the Mackenzie Basin (along with their respective conservation status) is set out below:

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12 A Review of Terrestrial Invertebrate Information for the Tekapo Power Scheme Resource Consents, Entecol Report: ENT-063, 2023. Prepared by CP Ong & RJ Toft (Entecol Limited) for: Genesis Energy Limited.

Spiders:	Wolf spider *Anoteropsis arenivaga* (At risk – naturally uncommon); and Gnaphosid spider *Matua festiva* (Data deficient).
Beetles:	Darkling beetle *Artystona lata* (At risk – naturally uncommon); Ground beetles *Holcaspis falcis* (At risk – declining) and *Holcaspis bidentella* (Threatened – nationally critical); and Scarab beetles *Prodontria matagouriae* (At risk – naturally uncommon), and *Prodontria minuta* (At risk – naturally uncommon).
Stiletto Flies:	*Anabarhynchus albipennis* (Data deficient), *Anabarhynchus indistinctus* (Data deficient) and *Anabarhynchus harrisi* (At risk – naturally uncommon).
Robber Fly:	*Neoitamus smithii* (At risk – naturally uncommon).
Grasshopper:	*Brachaspis robustus* (Threatened – nationally endangered) *Sigaus minutus* (Threatened – nationally vulnerable); and *Phaulacridium otagoense* (At risk – declining).
Weta:	Mountain stone weta *Hemideina maori*; and Tekapo ground weta *Hemiandrus "furoviarius"* (Threatened – nationally endangered).
Moths:	Lichen tuft moth *Izatha psychra* (Threatened – nationally endangered); Carpet moth Xanthorhoe bulbulata (Threatened – nationally critical); Plains jumper moth *Kiwaia* 'plains jumper' (Threatened – nationally endangered); Grays River grass moth *Orocrambus fugitivellus* (Threatened – nationally critical); Diurnal looper moth *Paranotoreas fulva* (At risk – relict); and

Eurythecta robusta (At risk – naturally uncommon), *Graphania tetrachoa* (Data deficient) and *Pasiphila* sp. 'Olearia' (Threatened – nationally vulnerable).

Seed bugs: *Lepiorsillus tekapoensis* (Data deficient), *Rhypodes triangulus* (Data deficient) and *Nysius liliputanus*.(At risk – naturally uncommon).

Mirid bug: *Pimeleocoris roseus* (Threatened – nationally critical).

Entecol 2023 also notes that even if the Tekapo PS was not operating, weeds and predators would still exist as major threats to terrestrial invertebrates on braided rivers.

1.14.2 Herpetofauna

RMA Ecology Ltd 2023[13] provides an assessment of the existing reptile and amphibian values (together, 'herpetofauna') of the Tekapo PS, and focusses on the land areas within the existing Tekapo PS footprint (for canal areas), within 200 m of the Takapō River, and 50 m of the Takapō and Lake Pūkaki margins. This report is summarised below.

Twenty individual sites were assessed by RMA Ecology, covering lakeside, canal, and Takapō River margins. Together these sites covered an area of around 100 ha. An estimated 40 ha of that area was searched for lizards to detect presence (based on the percentage searched of each site). A total of 200 lizards were recorded from within the sites.

The assessment's findings were as follows:

a. Three species of native lizard were recorded – McCann's skink, Southern Alps gecko and Canterbury grass skink;

b. Southern Alps gecko and McCann's skink were found across most sites; relative abundance differed between sites but was generally inversely related to the level of past disturbance of the site;

c. At the Takapō River margin sites, Southern Alps gecko and McCann's skink occupied all habitat areas including river bank, terrace, riser, pebble

13 Tekapo Power Scheme re-consenting, Tekapo Herpetofauna Effects Assessment, Job 2004, 2023. Prepared by G Ussher (RMA Ecology Ltd).

and boulder-bank areas. Populations of these species along the margins of the Takapō River and its associated dry channels, floodplain areas and historic terraces would likely number in the 1,000’s per kilometre of river;

d. Canterbury grass skink was found at one site – along the riparian margins of a minimally disturbed section of the Mary Burn near a culvert section of the Tekapo Canal;

e. No other lizard species were recorded; jewelled gecko, scree skink, long-toed skink or Mackenzie Basin skink were not found within the study locations; for all of those species, habitat quality within the survey areas was poor and generally lacked key habitat aspects with which these species are usually associated; and

f. No exotic lizards or frogs were recorded.

1.14.3 Avifauna

An assessment of existing avifauna is provided in the Boffa Miskell avifauna report (“**Boffa Miskell Avifauna, 2023**”)[14]. This report is is summarised below.

Takapō River, Takapō and surrounding areas provide 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. Due to the nature of the Tekapo PS, the Boffa Miskell Avifauna, 2023 assessment focuses on waterbird species as they are the group most likely to be affected by the Tekapo PS. Therefore, of 63 species recorded, 38 of those are affiliated with freshwater environments.

The following table, reproduced from the Boffa Miskell Avifauna, 2023 assessment, provides an overview of the birds recorded in Takapō, the Takapō River and the surrounding environment.

[14] Tekapo Re-Consenting: Assessment of Ecological Effects – Avifauna, 2023. Prepared by Boffa Miskell Limited.

Table 2: Freshwater Birds Associated with Takapō, Takapō River and the Surrounding Environment.

Species	Threat Classification	Primary Freshwater Habitat
Australasian bittern	Threatened – Nationally Critical	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Black-billed gull	Threatened – Nationally Critical	Rivers & Estuaries, river mouths and bar-type lagoons
Black stilt / Kakī	Threatened – Nationally Critical	Rivers & Estuaries, river mouths and bar-type lagoons
Grey duck	Threatened – Nationally Critical	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
White heron	Threatened – Nationally Critical	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Black-fronted tern	Threatened – Nationally Endangered	Rivers & Estuaries, river mouths and bar-type lagoons
Banded dotterel	Threatened – Nationally Vulnerable	Rivers & Estuaries, river mouths and bar-type lagoons
Caspian tern	Threatened – Nationally Vulnerable	Rivers & Estuaries, river mouths and bar-type lagoons
Southern crested grebe	Threatened – Nationally Vulnerable	Lakes and ponds
Wrybill	Threatened – Nationally Vulnerable	Rivers & Estuaries, river mouths and bar-type lagoons
NZ pied oystercatcher	At Risk – Declining	Rivers & Estuaries, river mouths and bar-type lagoons
NZ pipit	At Risk – Declining	Rivers & Estuaries, river mouths and bar-type lagoons
Red-billed gull	At Risk – Declining	Estuaries, river mouths and bar-type lagoons
Pied shag	At Risk – Recovering	Estuaries, river mouths and bar-type lagoons
NZ dabchick	At Risk – Recovering	Lakes and ponds
Black shag	At Risk – Naturally Uncommon	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Royal spoonbill	At Risk – Naturally Uncommon	Estuaries, river mouths and bar-type lagoons

Species	Threat Classification	Primary Freshwater Habitat
Marsh crake	At Risk – Relict	Lakes and ponds & Estuaries, river mouths and bar-type lagoons
Black-backed gull	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Black swan	Not Threatened	Lakes and ponds & Estuaries, river mouths and bar-type lagoons
Grey teal	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Kingfisher	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Little shag	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
NZ scaup	Not Threatened	Lakes and ponds
NZ shoveler	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Paradise shelduck	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Pied stilt	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Pukeko	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Spur-winged plover	Not Threatened	Rivers & Estuaries, river mouths and bar-type lagoons
Welcome swallow	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
White-faced heron	Not Threatened	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Australian coot	Coloniser	Lakes and ponds

Species	Threat Classification	Primary Freshwater Habitat
Canada goose	Introduced & Naturalised	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Feral goose	Introduced & Naturalised	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Mallard	Introduced & Naturalised	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Mute swan	Introduced & Naturalised	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
Chestnut-breasted shelduck	Vagrant	Lake and ponds, Rivers & Estuaries, river mouths and bar-type lagoons
White-winged black tern	Migrant	Rivers & Estuaries, river mouths and bar-type lagoons

Of the waterbirds recorded associated with Takapō, Takapō River and surrounds, four endemic species have evolved on braided rivers (wrybill, black stilt / 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.

There are six specialised river bird species of high conservation value for which the Tekapo PS has likely to have affected following its construction due to the changes to foraging and / or breeding habitat, as follows:

a. Aerial hunting gulls and terns: Black billed gull and Black-fronted tern;

b. Deep water waders: Black stilt / kakī and NZ pied oystercatcher; and

c. Shallow water waders: Banded dotterel and Wrybill.

Overall, the Boffa Miskell Avifauna, 2023 assessment details that the construction of the Tekapo PS resulted in the loss of braided river and swamp / wetland habitat but increased open water (lake) and lake shoreline habitat. This remaining habitat forms part of the existing environment.

It is also noted that PRR has played a role in increasing the numbers of specific water birds in the catchment, in the catchments upstream of the Tekapo PS.

Boffa Miskell's avifauna analysis of the difference in abundance of birds recorded in the most recent comparable surveys to those at the start of PRR, shows significant increases over that time for a number of species upstream of the Tekapo PS and where PRR management is occurring. During the same time period, there were no increases in abundances detected in areas downstream of the WPS. 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 the significant increase in abundance of NZ pied oystercatcher and banded dotterel recorded in catchments above the Tekapo PS where PRR management is occurring, as these trends are contrary to the national population trends recently reported (which showed declining trends).

1.14.4 Vegetation

A description of the existing environment as it relates to vegetation is provided in the Ecological Solutions vegetation report ("**Ecological Solutions 2023**").[15] This report is summarised below.

Takapō and surrounds, along with most of the Tekapo Canal, are located within the Tekapo Ecological District. The north-western edge of the lake and the Godley River immediately upstream of the lake are within the Godley Ecological District, while the area south of the outlet of Takapō, including a short section of the canal and the Takapō River and surrounds, are located in the Pūkaki Ecological District. The Mackenzie Ecological Region comprises seven ecological districts (Tekapo, Pūkaki, Grampians, Benmore, Omarama, Ahuriri and Ben Ōhau) and extends from the northern side of Takapō, south to the ranges on the southern side of the Ahuriri River.

In order to describe the vegetation surrounding the elements of the Tekapo PS surveys were undertaken in various plots around the lake edge, along the Takapō River and in specific wetlands as reported in Ecological Solutions 2023. The results are summarised as follows:

Lake Edge Vegetation

1. Taken together, the average cover of the 32 lake edge plots comprised approximately 65% rock and/or gravel, 4.5% silt and/or sand, 1.6% moss,

15 Tekapo Power Scheme Reconsenting Assessment of Effects – Vegetation, 2023. Prepared by Ecological Solutions Limited.

0.9% algae and 2.2% litter. Of the remaining 26%, approximately 6% comprised indigenous vegetation and 20% comprised exotic vegetation; and

2. The lake edge vegetation varies in quality from low (sparse, predominantly exotic e.g., exotic herbs growing between cobble and boulders) to moderate (includes more native species, representative and demonstrates ecological gradients e.g., matagouri shrubland or some turf vegetation).

Wetland Vegetation

1. The majority of wetlands in the upper Waitaki area (85%) have been subjected to significant modification;

2. A total of 83 species were recorded in the 28 wetland plots surveyed by Ecological Solutions. Generally, the wetland plots included a higher proportion of native species cover (36%) than either the lake edge or river edge plots;

3. The average percentage cover of native species per plot was approximately 22%, with rock occupying 4%, bare soil 7.4%, moss 8.6%, water 1.9%, litter 10.2% and the remainder (56%) comprising exotic vegetation; and

4. The average wetland condition index was 19.3 out of a possible 25, with the average pressure score of 16.1 out of a possible 30. This is indicative of comparatively good quality wetlands with a low degree of modification and low – medium external modification pressures. On that basis the wetlands are typically of high – very high ecological value.

Takapō River Vegetation

1. Dewatering the upper Takapō River has affected the adjacent river flats and wetlands within the floodplains by reducing (or removing) water supply. The reduction in flood events will have reduced the natural process of erosion – deposition – aggradation within those sections of the braided river, which will in turn have created a more stable environment for vegetation, altering the frequency of disturbance and allowing species composition to change. This has resulted in a more stable river bed with reduced reconfiguring and therefore reduced creation of newly disturbed

gravel habitats for early colonising species relative to the pre-existing state. River training and other activities (not undertaken by Genesis) intended to prevent flooding, erosion and the natural meander of watercourses have also affected the natural character and dynamics of the Takapō River, but the full extent of works carried out there is unknown;

2. Thirty-three species were recorded from the ten plots along the Takapō River reported in Ecological Solutions 2023 which averaged 59% rock and/or gravel, 9.5% silt and/or sand, 1.5% moss, 1.4% litter and 28.6% vegetation. Six of the species recorded (18%) were native. The vegetation averaged 9.1% native vegetation (mostly comprising small-leaved pohuehue, 8.5%) with a variety of native grasses or sedges (*Austroderia richardii, Rytidosperma* sp., Poa sp., Carex sp.) present as a minor component. The only native herb present was *Raoulia* sp., possibly R. *parkii*, which was present in one plot; and

3. Riverine vegetation was typically sparse and predominantly (~70%) exotic and of low ecological value.

In terms of plant species of conservation interest, only one species which is regarded as "threatened (nationally vulnerable)", *Carmichaelia corrugata*, dwarf common broom, was detected during the surveys, in short tussock grassland near the Tekapo Canal. In addition, nine species which are regarded as "at risk (declining)" were detected including coral broom (*Carmichaelia crassicaulis*), *Carmichaelia petriei*, *Coprosma brunnea*, *Coprosma intertexta*, matagouri, *Colobanthus brevisepalus*, *Raoulia parkii*, *Raoulia australis* and Buchanan's sedge (*Carex buchananii*). The majority of these species, including the dwarf common broom, were seen in short tussock grassland or other habitats near the Tekapo Canal. One specimen of R. *parkii* was detected on the roadside and a second in cobble habitat near the Takapō River. Matagouri was more widespread and was detected in habitats around Takapō and Lake Pūkaki as well as along the Takapō River. Matagouri commonly co-occurred with brier rose and mikimiki and with depleted hard tussock grassland at some locations.

1.15 RECREATION AND TOURISM VALUES

An assessment of the existing recreational and tourism environment relating to Takapō, the Takapō River and the Tekapo Canal was undertaken by Rob

Greenaway & Associates and their report ("**Rob Greenaway & Associates 2023**")[16] is summarised below.

a. Salmon and trout fishing are popular throughout the Mackenzie Basin. Fishing within the Tekapo Canal is particularly popular in close proximity to the salmon farm and Tekapo A. The Waitaki catchment accounts for around 80% of all angler activity in the Central South Island Fish and Game Region in the 2014/2015 season, and in that same season 30% of all angler days in the region occurred on hydro canals (of which the Tekapo Canal is one);

b. Recreational activities on Takapō include sightseeing, the Alps 2 Ocean Cycle Trail, swimming, boating and water skiing and angling;

c. Takapō has generally a low level of ecological productivity due to the glacial flour. It fishes best at low levels when anglers can access the more stable and productive parts of the water. At high levels, shore-based anglers are fishing over bare cobbles with little plant or insect life;

d. The appeal of water skiing in the catchment, specifically at Takapō, is the scenery and the ease of access to the lake. Additionally, there is a large area that a lot of boats and other recreational users can use. Over the past 20 years the number of visitors to Takapō has steadily increased, and more make use of the water, especially boaters – potentially due to an increase in launching options. It has become more difficult to water ski in some parts of the lake as new navigation bylaw restrictions reduce the amount of water than can be used, and with an increase in the number of boats and the introduction of a swimming bay where water ski slalom was normally held;

e. There is a perception that lake levels are more variable and tend to be held lower for longer since Genesis has been operating it. This impacts negatively on water sports and boat launching, along with exposing more sub-surface hazards. High lake levels are preferred. Lake levels can affect the scenic value of Takapō; for example (for aerial flights) a lake

[16] Tekapo Hydro Scheme Reconsenting Recreation Review, 2023. Prepared by Rob Greenaway & Associates.

level reduction of two to three metres in the water level results in the lake appearing significantly smaller;

f. The Takapō River has been substantially modified by the Tekapo PS and, as a result, has become an important trout angling setting below Fork Stream (albeit prior to the problems associated with didymo which has been discussed in previous sections of this AEE);

g. Fishing in the Takapō River occurs wherever there is water, but Fork Stream is the normal upper limit for activity – and Fork Stream is a fishery in itself;

h. Between 8 and 15 annual water releases are made into the Tekapo Whitewater Course administered by the Tekapo Whitewater Trust. Funds can also be made available for course development. It is understood that prior to the development of the Tekapo PS, the Takapō River had good white water over the first 7km, whereas the lower river was prone to willow obstructions in the braided river channels;

i. Based on interviews, it is considered that the dry upper Takapō Riverbed is seen as an "eyesore," with opinions indicating that a continuous minimum flow may resolve this;

j. The Tekapo Canal is one of the most popular sports fisheries for trophy trout and salmon, and it is highly productive. The Canal also has high scenic value;

k. The upper 7 km and lower 4 km of the Tekapo Canal Road is open to public vehicles. The whole length of the Tekapo Canal Road is open to the public for pedestrian and cycle access. The canal road is primarily used by people cycling the Alps 2 Ocean cycle route, walking the Te Araroa Trail, visiting the salmon farm or wanting to utilise the canal for fishing, or access to the upper Takapō River. Swimming and boating within the Tekapo Canal are prohibited; and

l. Genesis also provides and maintains permanent toilets for public use at several locations along the Tekapo Canal Road.

Table 3 summarises the significance of the waterbodies influenced by the operation of the Tekapo PS by activity at the regional, national and international level.

Table 3: Recreation Significance by Waterbody

Waterbody	International Significance	National Significance	Regional Significance
Takapō	Scenic Values	A range of activities, including boating and angling	
Takapō River			Angling, jet boating and kayaking
Tekapo White Water Course		Kayaking	
Tekapo Canal		Angling, cycling and walking	

Based on the analysis and interviews undertaken by Rob Greenaway & Associates 2023, the operation of the Tekapo PS has been consistent from 1990 up until the past three to five years. These include perceptions of more frequent and lower levels at Takapō, attributed to environmental factors, increased demand and changes resulting from Genesis ownership.

Construction of the intake gate for the Tekapo A Power Station and canal re-lining works have been associated with short-term loss of kayaking opportunities on the Tekapo White Water Course and the Takapō River. It has also been associated with increased siltation in Lake George Scott.

Otherwise, the study area has been viewed as stable, besides major weather-related events causing site-specific erosion events.

1.16 OTHER WATER USERS

The Upper Waitaki Zone Implementation Plan ("**ZIP**") provides an overview of the types of activities within the upper Waitaki:

a. The ZIP details that the Waitaki Catchment is of national importance for power generation and security of supply. The ZIP notes that the WPS has combined generation capacity of over 1,700 MWh and an annual output of about 7,700 GWh, contributing nearly 20% of New Zealand's annual electricity requirements and 30% of New Zealand's total hydro generation. It is noted that one of the outcomes developed by the Zone Committee is to maintain (or increase) the Zone's existing contribution to New Zealand's electricity supply;

b. The MDC provides water reticulation to the Tekapo, Twizel and Fairlie townships. In addition, MDC holds a number of resource consents for "domestic and stockwater supply;"

c. Many homes in the rural areas obtain their water from small private community schemes, individual private bores and surface water takes; and

d. There is approximately 9,000 hectares of irrigation in the zone, and the ZIP sets out that the WAP provides an allocation for irrigation[17] that could irrigate a further 25,000 hectares (subject to meeting water quality and landscape/ecological constraints). About half the existing irrigation is spray irrigation and half is border dyke. One of the outcomes developed by the Zone Committee is to maintain or increase the contribution to the Zone's economy from agriculture and aquaculture (in particular sustainable farming systems).

[17] The Tekapo Canal infrastructure enables access to water for irrigation, subject to agreement with Genesis regarding access. Genesis does not provide water for irrigation and the consents sought by Genesis do not include water for irrigation. Irrigators must obtain their own resource consents and manage their operations in accordance with those resource consents.

2. ASSESSMENT OF ENVIRONMENTAL EFFECTS

2.1 INTRODUCTION

This section addresses the actual and potential effects associated with the operation of the Tekapo PS on the existing environment described in the previous section. Again, it is noted that the assessment of the actual and potential effects focusses on the effects of the on-going operation of the scheme on the values currently supported by waterways influenced by the operation of the Tekapo PS.

Several technical assessments have been commissioned by Genesis to inform this assessment. The various technical assessments are summarised and referenced, as appropriate, in the applicable sub sections. This report should be read in conjunction with the technical assessments.

In summary, section 2 addresses the following matters in respect of the waterbodies within the area of influence of the Tekapo PS:

a. Decarbonisation and economic effects;

b. Cultural effects

c. Natural character, landscape and visual amenity effects;

d. Hydrological effects;

e. Freshwater ecology and water quality effects;

f. Shoreline morphology;

g. Terrestrial ecology effects;

h. Dam safety and flood management; and

i. Recreation effects.

Several measures to avoid, remedy or mitigate the potential effects of the ongoing Tekapo PS activities are identified in this section. These measures are captured in the indicative draft consent conditions proposed by Genesis.

2.2 DECARBONISATION AND ECONOMIC EFFECTS

The decarbonisation and economic benefits provided by the Tekapo PS contribute significantly to local, regional and national communities. The Tekapo PS has been part of the environment of the Mackenzie Basin for several decades and directly provides (on average) approximately 980 GWh[18] of electricity generated to the national grid. The continued operation of the Tekapo PS, in the manner sought by Genesis, would enable these benefits to be maintained.

The utilisation of water diverted from the Takapō River by the Tekapo PS for the sustainable generation of electricity positively contributes to New Zealand's renewable energy productivity, and the continued operation of the Tekapo PS would ensure that Genesis can maintain at least the present level of electricity generation from renewable energy sources.

The Tekapo PS and the combined WPS are of national importance, and their operation are critical to achieving New Zealand's climate change aspirations, New Zealand's target to reduce net GHG emissions to 50 per cent below gross 2005 levels by 2030 as its Nationally Determined Contribution to international efforts to tackle climate change,[19] the 90% renewable electricity target by 2025 that is set out in the present New Zealand Energy Efficiency and Conservation Strategy,[20] the Matters of National Significance set out in the NPSREG and aspirations to achieve 100% renewable electricity.

The electricity sector benefits derived from the Tekapo PS have been assessed in Concept 2023,[21] and summarised below.

Electricity is vital in daily New Zealand life, with many social and economic benefits stemming directly from technologies relying on electricity. It is

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[18] This only includes electricity generated at the Tekapo A and B stations and does not include additional generation by Meridian Energy using water that has passed through the Tekapo PS that would not otherwise be available to the Meridian power stations.

[19] Government press statement (Rt Hon Jacinda Ardern and Hon James Shaw), 31 October 2021.

[20] *Unlocking our energy productivity and renewable potential,* New Zealand Energy Efficiency and Conservation Strategy 2017 – 2022, Ministry of Business, Innovation & Employment and the Energy Efficiency and Conservation Authority.

[21] Tekapo Power Scheme – electricity sector benefits, 2023. Prepared by D Hunt (Concept Consulting Ltd).

anticipated that electricity will become even more important as New Zealand moves to decarbonise the economy using renewable generation sources.

To meet its decarbonisation objectives, New Zealand will in future need to develop new generation sources at an unprecedented rate. Much of that generation will be from wind and solar power. Although these are very cost competitive, their output is subject to fluctuations due to weather, etc.

While batteries are expected to help in smoothing out much of the very short-term fluctuation in supply from these sources, they are not suitable for addressing variations which occur from week to week or longer so other sources of flexibility are required. This will include hydro generation that has access to stored water which has the twin benefits of being renewable and controllable, both of which will be increasingly important as New Zealand decarbonises its economy. The Tekapo PS provides both.

The Tekapo PS generates substantial volumes of 100% renewable electricity, with an average annual output (from both direct and indirect generation) sufficient to supply approximately 222,000 Canterbury households.

Replacing the Tekapo PS output with alternative renewable sources would impose additional costs on society of around $100 to $125 million per year. Furthermore, it would take time to construct the alternatives, likely creating a need for increased thermal generation in the meantime. The annual costs for that generation would be approximately $160-$310 million per year. Increased thermal generation would also significantly raise New Zealand's GHG emissions, by the equivalent of 400,000 to one million cars per year while it was operating.

An important feature of the Tekapo PS is that there is significant ability to vary the energy output to match system conditions. This helps to maintain reliable electricity supply to consumers. The cost estimates above are expected to be conservative because they do not account for the economic premium that applies to controllable generation sources. Furthermore, this premium is expected to rise as the need for renewable controllable generation increases with decarbonisation of the economy.

In addition to its contribution to national electricity supply, the Tekapo PS provides power to consumers in the Tekapo Albury region when that area is periodically cut-off from the rest of the grid. Without the Tekapo A station, an alternative electricity source would need to be developed as a local back-up. This would be expected to cost around $16 million in present value terms, otherwise consumers in the local area would likely experience power cuts for 200 to 250 hours per year.

In addition to electricity related benefits, the Tekapo PS has also resulted in improved fishery experiences (for introduced species) in the Takapō Catchment, particularly within the Tekapo Canal and other opportunities for recreational experiences that attract visitors to the area.

2.3 CULTURAL

Cultural matters relating to these applications are described in the TIA prepared by Te Rūnanga o Arowhenua, Te Rūnanga o Waihao and Te Rūnanga o Moeraki for the Tekapo PS.

The TIA emphasises that:

a. Kāi Tahu have one river that unites all 70,000 iwi members – Ko Waitaki te awa. Kāi Tahu tupuna go back untold generations and many leaders are buried on lands within the catchment. Today's generation, their children's children and all the children of the generations to follow will mihi to Aoraki and the Waitaki River and will continue to identify with the importance of this particular catchment within the wider Kāi Tahu rohe.

b. The issues and impacts presented in the TIA are not concerned with maintaining the existing environment. Maintaining the current state of a highly modified catchment is not an option as the Waitaki Rūnaka firmly believe that the lands and waters of the Waitaki need to be restored, enhanced and protected. However, their concern is that a narrow focus on the rivers most affected by infrastructure and its operation to produce electricity, could result in many of the opportunities for Manawhenua and options for restoration and enhancement of mahika kai and Kai Tahu connections with whenua and wai in the catchment as a whole, being lost or limited.

c. When assessing the impacts of the Schemes on their rights beliefs and practices, Kāi Tahu cannot only focus on the impact of the Schemes on today's generation. Using mahika kai as an example; Kāi Tahu have the right to benefit from mahika kai sourced from the catchment as long as they protect forever the integrity of what makes the Waitaki a mahika kai. A key focus therefore had to be how to enable future generations to thrive in the catchment.

When assessing the impacts of the scheme, Manawhenua realised that many of the effects of the scheme are permanent given the technology that exists at this point in time. Some whānau want to see the dams removed but know that this is not feasible and, if it becomes feasible, is not likely to give back the braided Waitaki River.

Particular effects in the Waitaki include:

1. Wāhi tapu and wāhi taoka have been inundated and lost resulting in named and active associations being broken and Kāi Tahu relationship with areas and the taoka they are supposed to sustain being weakened and damaged – in some places irrevocably.

2. Previously valuable mahika kai have been similarly destroyed and, in some instances, access to existing resources has also been adversely affected.

3. Fish movement within river systems has been disrupted; both of juveniles into the system and of mature adults attempting to leave the system. The long-term effectiveness of recent attempts to mitigate these effects on fish passage – through trap and transfer – is still uncertain.

4. Artificial lake systems are typically adopted enthusiastically by recreational users who then develop these areas as recreational fisheries and boating areas. This results in the further dilution of Kāi Tahu rights and interests in these areas.

5. As with existing water allocation regimes in waters throughout the Kāi Tahu rohe, Kāi Tahu property interests in the ownership, management, usage and access to freshwater resources are not recognised or prioritised and are subordinate to economic interests, in particular agriculture and tourism. Mahinga kai is also often incorrectly interpreted as limited to ‘instream’ values.

6. The natural character of the catchment is irrevocably altered.

7. The “minimum” flows are not considered adequate for the maintenance of the mauri of rivers.

8. Dam construction can have serious environmental implications and can damage fishery and other mahika kai interests, sometimes irrevocably.[22]

9. Dams have interrupted the continuity of water flow from the mountains to the sea, which conflicts with the Kāi Tahu philosophy of “Ki Uta, Ki Tai”.

10. Dams trap sediment and coarser materials needed to replenish the eroding coastal environments, which are heavily used by whānau.

In relation to the Takapō system:

a. The mauri of the Takapō system has been adversely impacted.

b. Manawhenua do not know the impact of river changes on puna and repo in the Lower Takapō River.

c. Sites (including rock art) were inundated by raising lake levels in the case of the Upper Waitaki lakes and creation of new lakes in the Mid Waitaki.

d. Taoka species have been adversely impacted, especially tuna.

e. Use of the Takapō River by Manawhenua has been lost.

f. The lake environs now support uses that disconnect Manawhenua, for example increased use of motorised watercraft.

g. The lake environs now support activities that generate impacts that (over time) have become priorities for agencies, for example recreation and tourism.

In relation to the Pūkaki system:

a. The lake was raised 9m in 1952, and another 37m in 1976.

b. The tears of Aoraki do not flow unimpeded – they are now dammed.

c. The mauri of Pūkaki has been negatively impacted.

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[22] Although dam removal is an option being explored internationally this is not seen as an option in the Waitaki at present.

d. Sites have been inundated – "All our mahika kai lining along the lake shore were drowned".[23]

e. The Tasman Delta is directly impacted.

f. Taoka species have been impacted.

g. Manawhenua use of the Pūkaki River has been lost.

As a controlled activity, Manawhenua know the Schemes will be reconsented. Within the consenting process Kāi Tahu have been committed to developing directly with Generators initiatives that start everyone on a pathway to:

1. Protecting Aoraki and kā roimata o Aoraki;
2. Supporting abundant mahika kai, particularly in important wetlands, side braids, backwaters, tributaries and the Waitaki River itself;
3. Protecting the quality of the waters of the Waitaki;
4. Conserving remaining rock art sites;
5. Protecting other wāhi tapu / wāhi taoka;
6. Protecting cultural landscapes;
7. Developing more appropriate flow regimes across the catchment;
8. Ensuring variability in river flows;
9. Providing a sufficient buffer, or safety margin, to mitigate against the adverse effects of changing land uses on the waters of the Waitaki;
10. Undertaking the restoration, enhancement and creation of wetland areas, to act both as flow moderators and kōhaka for mahika kai species;
11. Enhancing access for cultural use throughout the river system;
12. Addressing issues relating to changing land uses in the catchment, in particular the increase in dairying; and
13. Protecting habitats in the lagoon.

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23 A comment by Trevor Howse during the tenure review process.

Kāi Tahu believe that the consent conditions, the agreed package and the enhanced relationship negotiated with Genesis and Meridian will enable them to adopt an intergenerational response that will enable the following adverse effects to be avoided, remedied or mitigated:

a. Any deterioration to the quality of water in the mainstem and the tributaries;

b. Unnatural changes to the sediment flow and patterns of deposition in the main river channel and at the coastal area;

c. Any encroachment of adjacent land uses onto the Waitaki riverbed;

d. The residual flow regime in the mainstem resulting in extended periods of low flows with limited flow fluctuations;

e. Residual flow regimes that fail to recognise the property interests of Kāi Tahu;

f. Any further dewatering or loss of tributaries, wetlands, side braids, springs, backwaters, adjacent to or surrounding mahika kai throughout the lower catchment;

g. Any desecration of urupā within the valley;

h. Any further loss of rock art;

i. Any further loss of access to sites of significance, especially remaining mahika kai;

j. Any further loss of mahika kai in particular habitats essential for taoka species;

k. Any reductions in the size of the lagoon, and unnatural changes to the nature and composition of the river mouth;

l. Any loss of wāhi tapu and wāhi taoka;

m. Changes in water temperature at key mahika kai affecting mahika kai; and

n. Impacts on the lakes and tributaries of the Mid and Upper Waitaki.

Waitaki Rūnaka have therefore worked collaboratively with the Generators during the consenting process to develop a package that includes:

1. Conditions that are to be attached to the resource consents that:

    a. Address issues of concern to Waitaki Rūnaka;

    b. Monitor through agreed measures issues of concern to Waitaki Rūnaka; and

    c. Collect data needed to increase understanding of the operation of the scheme in order to make informed choice for future changes.

2. A package of initiatives that will run for the duration of the consent that will provide funding for rock art conservation and eel management (including an expanded trap and transfer programme); and

3. An enhancement relationship agreement between Genesis and Meridian and Waitaki Rūnaka; and

4. A funding package.

The four components of this package recognise that Te Mana o te Wai implementation requires time, capacity, commitment, collaboration and importantly resourcing. Collectively the components recognise that Waitaki Rūnaka are realistic in how far and how fast they can move towards implementing Te Mana o te Wai and realising their aspirations, without compromising on what their long-term aspirations are. The package agreed with Generators enables Manawhenua to derive benefits while the nation retains access to the use of freshwater for renewable electricity generation.

2.4 TAKAPŌ

2.4.1 Natural Character

As detailed in Boffa Miskell Landscape, 2023, Takapō retains a variety of natural character values, from moderate for the lakes to low and moderate-low for the connecting Takapō River. The areas of highest natural character tend to be in areas furthest from modifications (which is not unexpected). In particular, the braided river deltas of the Tasman and Godley Rivers provide very high natural character at the heads of Takapō and Lake Pūkaki. The extent to which flows and levels are managed generally has an effect on the natural character of the shoreline of the lakes, reducing the natural character of the lake margins through the modification of natural patterns and processes.

Lake level is one factor that is considered to contribute to peoples' experience of lake environments. When the Takapō lake level is low greater areas of the gravel banks and lakeshore vegetation are visible, that would otherwise typically be submerged. While fluctuations in the levels also occur naturally, the extent of the lake level modification resulting from the operation of the Tekapo PS is greater than that which occurred pre-scheme construction. Boffa Miskell Landscape, 2023 considers that low lake levels in Takapō are typical indicators of the operating range which has led to a reduction in natural character.

Genesis is not proposing through these consent applications to change or introduce any new elements into the Tekapo PS and there will be no alterations through this process to the existing infrastructure or changes to the permanent Tekapo PS footprint. Genesis proposes to maintain the existing operating ranges and resultant lake levels with no further modification to lake shore processes.

Based on this, Boffa Miskell Landscape, 2023 considers that the ongoing operation of the Tekapo PS will have no adverse natural character effects or effects on significant sites in comparison to the status quo.

2.4.2 Hydrological Effects

As detailed in the Hydrology and Hydrogeology Assessment by PDP 2023, no changes to the hydrological operation of the Tekapo PS are proposed. As such, the hydrological and hydrogeological effects of the Tekapo PS will remain unchanged. In particular, the reconsenting and continued operation of the Tekapo PS will not result in alterations to any existing fluctuation patterns for hydrologically connected wetlands, or domestic water supply bores around Takapō.

2.4.3 Freshwater Ecology and Water Quality Effects

Cawthron 2023 identifies that the main effect of the Tekapo PS on Takapō is increased water level fluctuations, which reduces the extent of macrophytes in the literal zone. The littoral zone plays a disproportionately large role in supporting the ecology in low nutrient lakes such as Takapō, and the extent of the littoral zone is determined by the maximum depth that light can penetrate (the euphotic depth).

Prior to the construction of the Tekapo PS, the lake level fluctuated over a 2.6 m range (PDP, 2023), where it is estimated that 74% of the potential euphotic zone (the euphotic depth being 10.2 m) supported a stable and productive littoral ecosystem. The current operating range for Takapō leaves approximately 14% of the potential euphotic zone supporting a stable and productive littoral ecosystem.

However, the previously discussed reduction in glacial flour load has doubled the water clarity and increased the euphotic depth to > 20 m. A recent macrophyte survey showed that the maximum macrophyte depth has increased to 21.3 m (from 10.2 m prior to the construction of the Tekapo PS). The increase in euphotic depth means that there is now a stable productive littoral zone of around 12.5m that is not exposed by water level fluctuations. Considering the current water clarity of the Takapō as the baseline, the effect of the Tekapo PS through water level fluctuation, removes around 41% of the potential productive littoral zone. By comparison, 26% of the productive littoral zone was affected prior to scheme commissioning in the 1950s, and 88% was affected since the 1970s until the onset of the recent trend of reduced glacial silts.

Cawthron 2023 notes that it is difficult to determine the attribution of effects in this context. The assessment sets out that 41% of the potential littoral extent is affected by water level fluctuations, however, this is within the upper and lower extent of lake levels. On the other hand, the extent of littoral habitat below the variable zone is greater than it was historically. The annual range of water level fluctuations is not proposed to change with the current consent therefore there will be no change to the effects on Takapō.

Overall, Cawthron 2023 considers that it is unlikely that the construction and operation of the Tekapo PS has resulted in any appreciable changes to water quality within Takapō and concludes that the continued operation of the Tekapo PS will have no effects on the water quality and contributes to the naturally low productivity and restricted food supply for salmonids in Takapō.

Lakes McGregor (709.2 masl) and Alexandrina (711.9 masl) are within the Takapō catchment. Analysis by PDP 2023 showed that water levels in Lake Alexandrina are not influenced by the Tekapo PS; therefore, it has no effect on this lake. At times, the Tekapo PS can have minor effects on the water level on Lake McGregor, when Takapō is filled to its maximum operating level (710.9

masl). However, the minor effect on water levels is expected by Cawthron to have a negligible effect on the ecology of Lake McGregor.

2.4.4 Shoreline Morphology

Shore Process 2022 details the effects of the Tekapo PS on the physical lake shore processes and geomorphological changes of Takapō. Extending the water level range of Takapō to approximately 3 m lower and 5 m higher than the range prior to the completion of the Tekapo PS has resulted in the development of a "new" shoreline. The initial change to the Takapō shore was relatively rapid, and likely occurred within the first ten years after raising the maximum water level. Gradual change to the upper limit of the beach is ongoing but is associated with high or flood levels coincident with wind-wave events. Erosion, and retreat of backshore cliffs is an ongoing process related to the development of the shore to the modified water level range. It occurs at a slower and episodic rate in comparison to initial shore development. Cliff retreat is mainly evident where the backshore deposits are relatively erodible by subaerial processes and by wave run-up at high water levels, and where buffers of sediment protecting the base of the backshore slope after initial erosion has been removed.

In respect of future potential effects of the ongoing operation of the Tekapo PS, the likely effects on the Takapō physical shore processes are as follows:

1. Continued but episodic erosion of currently eroding cliffs;

2. Continued alongshore transport of sediment from fluvial source (rivers and streams) and backshore erosion;

3. Slow landward movement and elevation of barrier beaches, and

4. Continued inundation of low-lying land and river and stream mouths at high lake levels.

The following figures and table provide an overview of the anticipated areas of further shoreline development and change. Three types of shore development are indicative of accretional change (delta growth, spits, forelands and barrier beaches, and landward movement of the beach). Cliff and hillslope erosion are indicative of landward retreat of the shoreline and are of particular importance where erosion may affect resource use of the shore. Areas where inundation is likely to occur in the future are based on existing areas of inundation. Also indicated on the figures are two locations where there is existing shore protection through rock revetment structures.

The following table provides further detail on the potential future changes to lake shore morphology (with the site number in Table 4 corresponding to the numbers in the subsequent figures).

In summary, likely future effects on the physical shoreline processes on Takapō of continued operation of the Tekapo PS under the current operating regime are likely to be of the same character and order of magnitude as in the existing environment. In terms of climate change, the projected higher inflows in spring and autumn but lower inflows in summer may result in greater coincidence of high lake levels with strong equinox wind events from the northwest quarter. However, as the current lake level operating range was designed to largely avoid these types of conditions, there is unlikely to be any increase in erosion due to climate change related changes.

The effects of continued Tekapo PS operation will not change the physical shoreline processes from those presently existing and observed over the period that Genesis has owned and operated the scheme.

Table 4: Potential Changes in Lake Shore Morphology

Site	Shore Description	Potential Effect of the Tekapo PS
1	Low-lying, with large trees, picnic area and walking/cycling tracks	Regular inundation of land below 711 m, and occasional inundation of land between 711 to 712 m. No change to current character of area.
2	Gravel pits between shore and road	Potential for erosion due to groundwater flow from pit to shore. No change to current character of area.
3	Cliffs within ~50 m of road, gravel beach	Ongoing episodic erosion of cliff at slow rate. No hazard to the road. No change to current character of area.
4	Cliffs within ~50 m of road, rock at base	Probably stable but winnowing of fine sediments from wave splash at high lake levels may lead to slope instability. No change to current character of area.
5	Fine gravel beach with willow trees near top of main operating range	Additional sediment to beach due to alongshore transport from the north. No change to current character of area.

Site	Shore Description	Potential Effect of the Tekapo PS
6	Barrier beach with low, swampy area to landward	Slow landward movement of barrier, reduction in size of swampy area. Inundation of low-lying swamp area at high lake level. No change to current character of area.
7	Beach scattered with large rocks and backed by pine trees	Continued erosion of backshore at high lake levels, addition of gravels to beach and loss of fine sediments from the nearshore shelf. No change to current character of area.
8	Trees and scrub at low elevation, low-lying wide beach	No change to current character of area.
9	Rock hazards to boats	Boating hazard at higher levels when rocks are partially covered. No change to current character of area.
10	Road close to cliff edge but at high elevation	Ongoing episodic erosion of cliff at slow rate, offset by sediment contribution to the beach from Boundary Stream and adjacent streams. Possible long-term hazard to Lilybank Road. No change to current character of the area.
11	Steep hillslope near stream mouth	Ongoing episodic erosion of cliff at slow rate, offset by sediment contribution to the beach from Boundary Stream and adjacent streams. No change to current character of the area.
12	Perched barrier beach and low-lying hinterland	Slow landward movement and increased height of barrier beach. Occasional inundation of hinterland. No change to current character of the area.
13	Active cliff erosion, with cliffs >5 m high	Ongoing episodic erosion of cliff at slow rate. Occasional re-activation of cliff erosion where presently stable. Supply of sediment to alongshore transport. No change to current character of the area.
14	River fan and low-lying delta	Continued deposition of sediment at stream/river mouth, growth of delta/fan and supply of sediment for alongshore transport by waves. No change to current character of the area.
15	Richmond Station – rock structure lakeward of farm building; “Folly” near top of operating range	Potential for wave run-up to small building (“Folly”). Ongoing potential for erosion around base of revetment. No change to current character of the area.

Site	Shore Description	Potential Effect of the Tekapo PS
16	Road on steep hillslope with numerous slips; fractured rock basement and hard, rock cliff	Ongoing hillslope erosion, gullying and slumping. Potential earthquake landslip hazard to road and impulse wave generation in Takapō. Ongoing slow removal of sediment at base of active slips. No change to current character of the area.
17	Hillslope failure undercut by lacustrine processes	Ongoing hillslope erosion, gullying and slumping. Potential earthquake landslip hazard to road and impulse wave generation in Takapō. Ongoing removal of sediment at base of active slips during southerly wave conditions and potential hazard to Godley Peaks Road. Continued delta accumulation from the Godley River. No change to current character of the area.
18	Rapawai Lagoon behind low barrier beach ridge	Slow landward movement of barrier beach. Occasional flooding of lagoon. No change to current character of the area.
19	Low-lying farmland	Beach at elevation nearly equal to elevation of lower slopes of farmland. No change to current character of the area.
20	Pierces Pond situated behind low barrier beach	Slow increase in barrier beach height and width due to continued sediment supply from the shore to the north. No change to current character of the area.
21	Shoaling gravel and sand deposits at about 706 masl elevation	Area will continue to shoal due to alongshore transport of sediment from the north, with an increase in the elevation of shoal surface. Medium to long-term hazard to boating. No change to current character of the area.
22	Gravel beach at base of stable cliff – concrete bunker at limit of wave run-up	Continued beach development due to alongshore sediment transport from south and north. Occasional inundation of old building in flood events (over 711 masl). No change to current character of the area.
23	New houses on terrace above active beach 725 masl terrace elevation, with access road on lower terrace 718 masl elevation	Continued beach development due to alongshore sediment transport from south and north. No change to current character of the area.
24	Gravel beach at base of stable cliff and house	Continued beach development due to alongshore sediment transport from south and north.

Site	Shore Description	Potential Effect of the Tekapo PS
	on high terrace 720 – 725 masl elevation	Possible increase in elevation of top of beach with foreland accumulation of sediment. No change to current character of the area.
25	Low-lying channel mouth from Lake McGregor with willow trees on banks	Continued occasional inundation of low-lying channel. Growth of beach due to accumulation of sediment from alongshore transport, and landward movement of the barrier beach. Possible enhancement of existing processes of change due to sediment pulses arriving at this section of shore.
26	Low-lying flat area with mobile barrier beach fed by gravels from south and north	Continued mobility of barrier beach gravels and growth of tombolo landforms joining high lake level shore to outlying high paleo-ridge lines. Continued slow movement of barrier beach towards Godley Peaks Road. Potential for occasional inundation of informal camping area lakeward of Godley Peaks Road. Ongoing boating hazard by extended area of shoaling around islands at high lake levels. Possible enhancement of existing processes of change due to sediment pulses arriving at this section of shore.
27	Rock outcrops along eroding cliffs in Mt John Formation gravels and base rock, with stream channels to lake	Mainly stable shoreline, with some alongshore transport of gravels from north to south. No change to current character of the area.
28	Very fractured and erodible rock cliff	Continued slow episodic erosion of the cliff backshore with periods of stability when the base of the cliff is protected from waves by accumulations of beach sediments. No change to current character of the area.
29	Mt John Observatory walkway within 10 m of cliff edge	Continued episodic erosion of cliff. Threat to walkway stability and short to medium-term to users of the walkway due to close proximity of cliff. No change to current character of the area.
30	Northern end of 4WD track along southwestern shore	Ongoing episodic erosion and inundation of low-lying land at the end of track. Areas of sediment accumulations due to alongshore sediment transport from the north. No change to current character of the area.
31	Low-lying swampy area lakeward of car park	Regular inundation of land below 711 m, and occasional inundation of land between 711 to 712 m. No change to current character of area.

Site	Shore Description	Potential Effect of the Tekapo PS
32	Boat ramp on gravel beach	Ongoing intermittent sediment movement across ramp requiring maintenance removal for boat launching. No change to current character of area.
33	Takapō Intake Structure and revetment along length of shore	Placed rock revetment structure with mobile gravels along lakeward edge. No change to current character of area. Ongoing maintenance of structure at base and ends due to undermining by abrasion and loss of fine sediments, and end effect on the structure of waves at lake levels above 709 masl respectively.
34	Large rocks on upper foreshore below the developed hinterland	Stable shore, subject to inundation at high operating range. No change to current character of area.
35	Beach ridges at limit of old high water events 712 masl elevation	Beach ridge deposits in the backshore that indicate the limit of high lake level events and extreme wave processes. No change to current character of area.

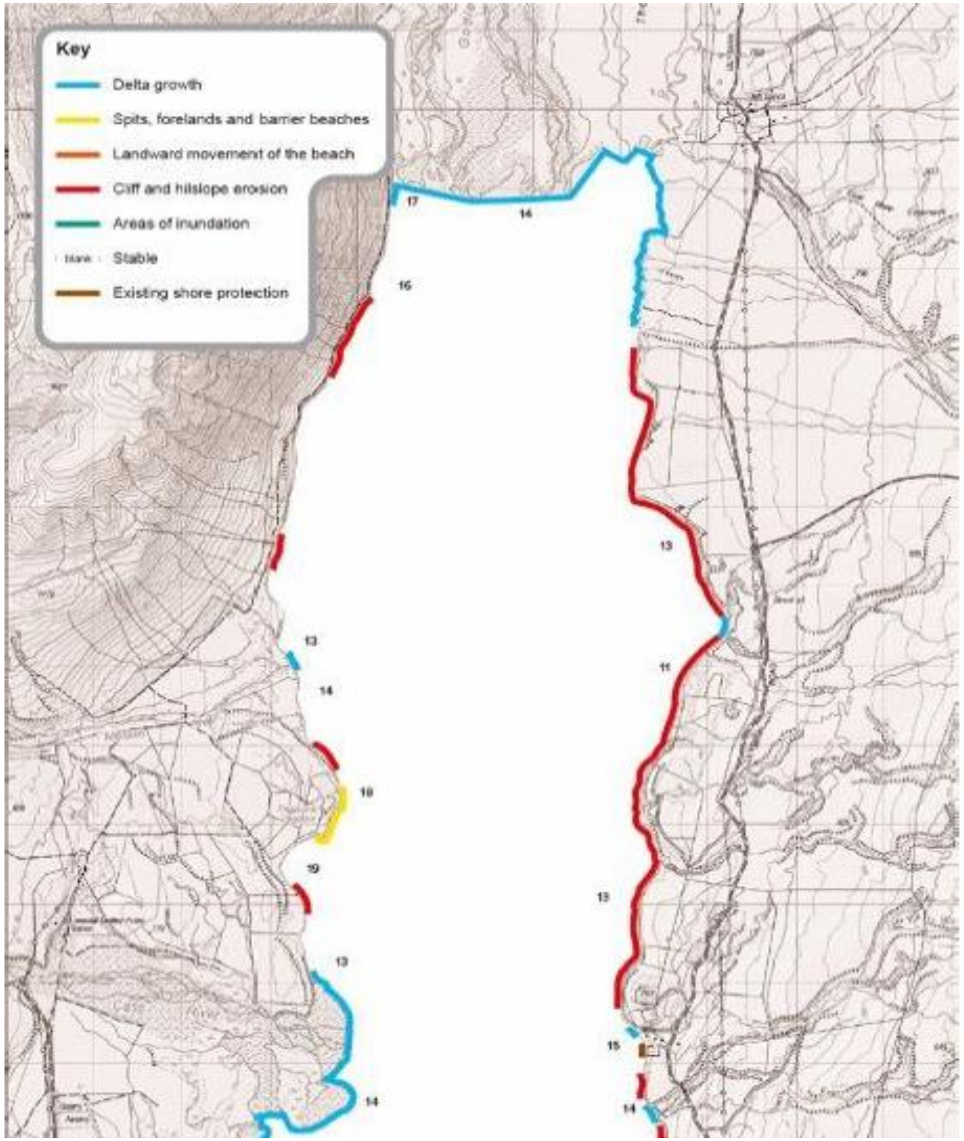

Figure 10: Potential Changes in Lake Shore Morphology (Northern Section)

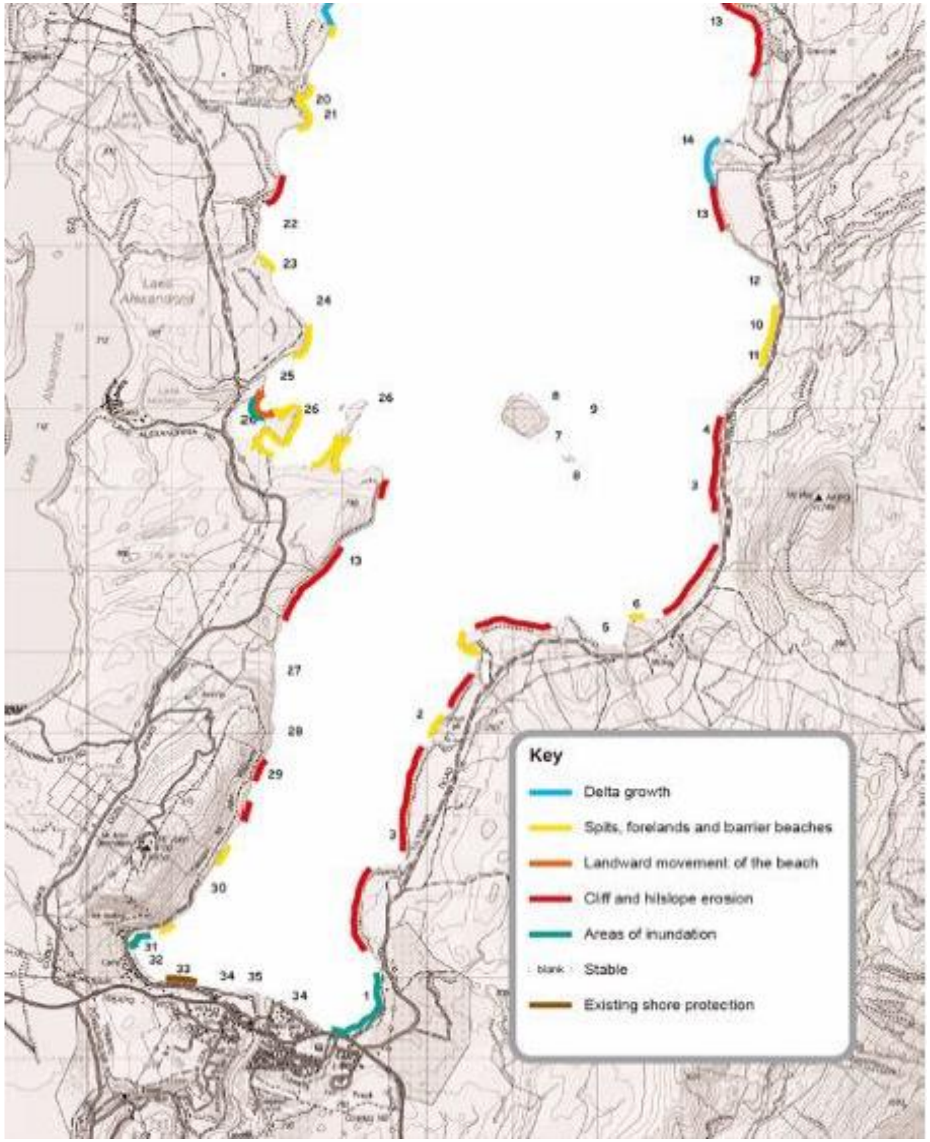

Figure 11: Potential Changes in Lake Shore Morphology (Southern Section)

2.5 TEKAPO CANAL

2.5.1 Natural Character

The Tekapo Canal is entirely man-made for the purpose of conveying water associated with the operation of the Tekapo PS. In that regard, Boffa Miskell Landscape, 2023 considers that the natural character of the canal is very low. That said, the Tekapo Canal now forms an integral part of the existing environment and contributes to the environment people experience when travelling in the area.

2.5.2 Hydrological Effects

As detailed in the Hydrology and Hydrogeology Assessment by PDP 2023, the hydrological operation of the Tekapo PS will remain unchanged. As such, the hydrological and hydrogeological effects of the Tekapo PS in respect of the Tekapo Canal will remain unchanged.

2.5.3 Freshwater Ecology and Water Quality Effects

Overall, based on their assessments Cawthron 2023 conclude that the Tekapo Canal provides a productive environment for macroinvertebrates and salmonid fish supporting a popular fishery, and the ongoing operation of the Tekapo PS will not affect the canal's ecology and fishery.

2.6 TAKAPŌ RIVER

2.6.1 Natural Character Effects

As detailed in Boffa Miskell Landscape, 2023, the degree and modification of the flow regime within a river channel is one factor that is considered to contribute to peoples experience of the naturalness of river environments, as well as how this affects other aspects of natural character including its abiotic and biotic attributes. As the Takapō River often has no / minor groundwater levels of flow for the first 7 km, due to upstream water diversion by the Tekapo PS, this highly modified natural flow regime has resulted in a visible reduction in natural character of the Takapō River along this particular reach of the river. Beyond the Fork Stream confluence to its mouth at Lake Benmore, the Takapō River maintains a small, but permanent flow, lifting the levels of natural character to a moderate degree. It is noted that the Tekapo PS has an effect on the flow for the whole river.

The natural character of the Takapō River will remain at its existing level, as Genesis is not proposing any changes to the diversions associated with the Tekapo PS. This means that there will be an absence of flows at times in the river for the first 7 km and a lower flow for the remaining parts of the river. While this represents a major modification compared to the natural flow regime, Boffa Miskell Landscape, 2023 considers that there will be no additional adverse effects compared of the ongoing operation of the Tekapo PS due to the already highly modified current flow regime.

Boffa Miskell Landscape, 2023 concludes that a consistent minimum flow would enhance natural character (and landscape and amenity values) of the Takapō River, most notably in its upper reaches between the Takapō control gates and Fork Stream.

However, the extent of the minimum flow that would be required in order to provide any material enhancement of natural character is difficult to identify and, as discussed earlier in this assessment, would have significant implications for the level of electricity generation possible from the WPS.

2.6.2 Hydrological Effects

As detailed in the Hydrology and Hydrogeology Assessment by PDP 2023, Genesis is not proposing modifications to the hydrological operation of the Tekapo PS. As such, the hydrological and hydrogeological effects of the Tekapo PS will remain unchanged from those currently forming part of the existing environment.

2.6.3 Freshwater Ecology and Water Quality Effects

As detailed in Cawthron 2023 and Water Ways 2023, the construction of the infrastructure associated with the Tekapo PS and the diversion of water from Takapō through the Tekapo Canal has resulted in significant changes to the Takapō River, which can be summarised as follows:

1. Change in riverine habitat in the Takapō River with the reduced flows altering habitat availability leading to changes in the fish community and/or abundance;
2. Impedance of fish passage from the Takapō River to Takapō;

3. Reduction in habitat quality in the Takapō River due to lack of flushing flows;

4. Very limited surface flows in the Takapō River above the Fork Stream confluence;

5. High water clarity associated with the diversion of glacial flour from Takapō;

6. A stable flow regime conducive to high production of periphyton and macroinvertebrates and successful salmonid spawning; and

7. Physical habitat (depths, velocities and substrate) downstream of the Grays River confluence that are highly suitable for trout food production and trout spawning.

In addition, there is the potential for the Tekapo PS to have positive effects, including:

1. The flow reduction in the Takapō River provides more suitable habitat for native fish species that prefer low water velocities and shallow water habitats. This includes the bully and galaxiid species present in the Takapō River;

2. The flow reduction in the Takapō River upstream of the Mary Burn and Grays River confluences may limit the presence of large salmonids and correspondingly provide more suitable habitat for native fish species; and

3. A reduction in flood disturbance thereby a reduction in flood related mortality.

CRC also actively manages the Takapō River as part of flood protection works involving the use of machinery to grade the riverbed and in some locations exotic species such as willow have been planted to stabilise the river. Such activities alter the habitat available for specialist braided river birds.

The Takapō River was invaded by didymo in 2007, which has further altered the river. Didymo commonly reaches nuisance levels in natural lake-fed rivers. The stable flow regimes, immobile substrate, and low sediment supply of such rivers allow didymo to accrue with little bed disturbance and sandblasting. Consequently, Cawthron 2023 considers that didymo would likely flourish in the Takapō River, even if it were flowing naturally in the absence of the Tekapo PS.

Notwithstanding this, the Takapō River has good water quality and a stable flow regime that supports a productive ecosystem (abundant periphyton and invertebrates), habitat for six species of native fish, habitat for brown trout, rainbow trout and sockeye salmon, that in turn support a relatively popular trout fishery. The overall effects of the existing operation of the Tekapo PS on the Takapō River are challenging to assess given the invasion of didymo—the stable flowing clear water habitat enhances macroinvertebrate and trout production while also promoting didymo which simultaneously reduces them. The generally positive effects of the Tekapo PS scheme on the salmonid fishery in the Takapō River have been reduced by the introduction of didymo. However, the river still supports important values and continuing operation of the Tekapo PS will not change the existing values.

Cawthron 2023 concludes that the Tekapo PS has minor adverse effects, as well as minor positive effects, on water quality and aquatic ecology within the Takapō River.

In respect of native fish, Water Ways 2023 sets out that, overall, the Takapō River supports the expected range of native fish, given the context of effects within the Waitaki catchment that influences the distribution and abundance of the native fish. In addition, common bully and kōaro are both more abundant in the catchment than they are expected to have been in the catchment in its pre-development state.

In terms of direct negative effects on native fish, the flow reduction in the Takapō River created by the Tekapo PS has reduced the available habitat for some species, e.g., longfin eel, but other factors rather than habitat are limiting their populations. For the threatened native galaxiids the present-day distribution indicates that the pre-development Takapō River was unlikely to have supported populations of these fish and scheme is unlikely to have any effect on their abundance.

2.7 LAKE PŪKAKI

2.7.1 Freshwater Ecology and Water Quality Effects

Cawthron 2023 provides a brief assessment of the water quality and ecology impact of the Tekapo PS on Lake Pūkaki, stating that the quality of water that is discharged from the Tekapo Canal into Lake Pūkaki is generally excellent and therefore adverse effects of the Tekapo PS on the ecology of Lake Pūkaki are less than minor.

2.8 LAKE BENMORE

Cawthron 2023 sets out an assessment of the effects of the Tekapo PS on Lake Benmore, being a receiving environment for flow releases from the scheme along the Takapō River (which discharges into Lake Benmore). The assessment sets out that flow releases part the Lake George Scott Weir are occasionally of a size such that didymo and other periphyton mats can be scoured from the Takapō River.

The deposition and decomposition of these transported periphyton mats in the hypolimnion of the Haldon Arm of Lake Benmore represents a potential risk to bottom water oxygen concentrations within the lake. However, Cawthron undertook a mass balance assessment using worst case scenario estimates of biomass and decomposition rate, demonstrating that this potential risk is less than minor in nature. This assessment, coupled with the Cawthron assessment of monitored water quality parameters, indicates that the Tekapo PS has no adverse effects on Lake Benmore.

2.9 FISH PASSAGE

Water Ways 2023 provides an assessment of the effects of the Tekapo PS on fish passage, which is summarised, as follows:

1. Migratory fish are largely absent from the Takapō River, which is due to the barriers further downstream on the Waitaki River blocking fish passage for migrant species capable of long inland migrations. This lack of migratory fish is not an effect of the Tekapo PS. However, the Tekapo PS will prevent fish passage from the Takapō River to Takapō and back downstream. If longfin eel transfers occur to Takapō and upstream areas, downstream passage or transfer for adult migrant eels would need to be provided;

2. The pre-existing stock of longfin eels in the Takapō River catchment is unknown. However, local residents recall large eels being common or abundant 30-40 years ago in the Takapō River tributaries such as the Grays River. It is unlikely the eels were abundant in the Takapō River if it had an open braided gravel riverbed as this does not provide good cover

for large longfin eels unless there are logjams, macrophyte beds and stable side braids to reside in;

3. Kōaro resident in Takapō can conduct their natural migration to and from the lake and its upstream tributaries. However, larval kōaro in the Takapō River migrate downstream to Lake Benmore. Lake Benmore has provided new rearing habitat for the pelagic kōaro larvae and the adult population is expected to be increasing in the Tekapo catchment downstream of Takapō; and

4. Landlocked populations of common bully are present in all the upper Waitaki Lakes including Takapō. The populations are abundant and the distributions of adult common bullies in the lower reaches of lake tributaries is also normal. The presence of large numbers of common bully in the Tekapo Canal also indicate the bully has benefited from the construction of the canal.

In respect of fish passage at the Tekapo Canal culverts:

a. The Mary Burn, Irishman's Creek and Fork Stream are the major streams that flow under the Tekapo Canal. All three streams flow through culverts and these have the potential to be fish passage barriers;

b. The Mary Burn culvert has records of upland bully and Canterbury galaxias upstream of the culvert in recent years. The culvert is likely to prevent salmonid passage which would protecting native fish communities upstream of the Tekapo Canal;

c. At Irishman's Creek there is no evidence that the culvert is a fish passage barrier with fish survey data upstream of the culvert showing all species are passing through the culvert; and

d. Fork Stream culvert has a downstream concrete apron with an approximately 1 m fall that will impede fish passage. A small fish ladder was constructed to assist trout passage over the concrete apron; however, a trout barrier was subsequently installed to protect threatened galaxiids. Kōaro and elvers can still ascend the 1 m fall as these small fish can both climb the vertical face of the concrete apron and also still use the fish ladder as a small flow suitable for their passage still flows down the fish ladder. Other native fish such as upland bully and Canterbury galaxias will struggle to gain upstream fish passage at this culvert. However, neither species needs to migrate upstream and there are resident populations of both species upstream of the culvert. The present restriction on salmonid passage by this culvert is beneficial to native fish in the upper reaches of Fork Stream as it may be limiting salmonid abundance and reducing predation. Therefore, the present limitation of fish passage at Fork Stream is most likely either neutral or a benefit to native fish in Fork Stream.

2.10 GROUNDWATER EFFECTS

As detailed in the Hydrology and Hydrogeology Assessment by PDP, the hydrological operation of the Tekapo PS will remain unchanged. As such, no changes in the groundwater level fluctuations currently experienced will occur as a result of the ongoing operation of the Tekapo PS and the effects of the Tekapo PS on groundwater will remain unchanged.

2.11 TERRESTRIAL ECOLOGY EFFECTS

2.11.1 Terrestrial Invertebrates

Entecol 2023 undertook an assessment of the impact of the Tekapo PS on braided river invertebrates. In doing so, Entecol identifies that Tekapo A was commissioned 70 years ago and the Tekapo Canal and Tekapo B more than 40 years ago, so controlled water flows have been in place for several decades. Invertebrates typically have much shorter generation times than vertebrates, and invertebrate communities respond to perturbations quite rapidly, so the most significant changes in invertebrate communities due to the effects of reduced flows will already have occurred.

The impacts of both predators and weeds are exacerbated by the modification to flow regimes in the Takapō River as a result of the Tekapo PS, however Entecol notes that both weeds and predators would still pose a threat to terrestrial invertebrates in the Takapō River even if the Tekapo PS was not operating. However, the reduced frequency and severity of flooding allows increased opportunity for weed growth and vegetation stability over the affected reach of the Takapō River, and this has potential to affect the community structure of those habitats over the long-term, unless managed.

In contrast to this, and as noted for several species (in particular grasshoppers and weta), the reduced severity of natural flood events can also have a potentially positive effect for some of the species that benefit from a more stable habitat.

Taking the potential for both negative and positive effects into account and given the known distribution of the species of conservation interest in the wider Mackenzie Basin, Entecol 2023 concludes that that the ongoing operation of the Tekapo PS is largely neutral, to minor adverse, in terms of its impact on the terrestrial invertebrate values of braided river habitats.

2.11.2 Herpetofauna

RMA Ecology 2023 sets out that adverse effects may potentially occur due to the ongoing operation of the Tekapo PS in relation to river flows. Mortality of Southern Alps gecko may result if releases of flows into the upper Takapō River result in swiftly rising waters that inundate lizards that have moved into vacant river bed habitat. This contrasts with the lake margin areas, where periodic inundation would be a more gradual process, and would allow animals to retreat to higher ground.

Southern Alps gecko and McCann's skink are listed as 'Not Threatened' in the DoC threat classification. The population of both species are locally very large. Any potential loss of Southern Alps gecko and McCann's skink through operations of the Tekapo PS, would constitute a very small portion of the overall populations in the local area.

The level of potential effects in terms of loss of ecology values is assessed as 'Very low'. This 'Very low' level of ecological effect is equivalent to 'no more than minor' when considered in the context of potential effects on the environment under the RMA. Where the level of effects is anticipated to be 'Very low', the EIANZ guidelines recommend that normal design, construction and operational care should be exercised to minimise adverse effects.

Project River Recovery is a key programme that has resulted in beneficial outcomes for native lizards, through its focus on weed control and nesting bird protection across very large areas of the upper Waitaki Basin. RMA Ecology Ltd considers that the likely benefits of the work undertaken by Project River Recovery for controlling lizard predators over a large scale, and the potential conservation benefits on threatened as well as less rare lizard species in those areas, is likely to provide a conservation benefit that greatly exceeds the no more than minor level of adverse effects that may be caused by the re-consenting of the Tekapo PS scheme on native lizards.

2.11.3 Avifauna

Boffa Miskell was engaged to undertake an assessment of effects on avifauna associated with the Tekapo PS. To provide an assessment of environmental effects of the Tekapo PS on avifauna, information was gathered on the ecological values (habitat and species) present at the Tekapo PS sites and within the wider area through a combined desktop and field approach. The assessment also considers the positive effects that Project River Recovery has had on avifauna in the catchments upstream of the Tekapo PS.

The Boffa Miskell avifauna report (Boffa Miskell Avifauna, 2023) concludes:

1. The inter-relationship of a number of ecosystem factors potentially affecting freshwater birds as a result of the Tekapo PS are complex and extremely difficult to separate. There are other variables, not associated with the Tekapo PS, both within and beyond the Tekapo catchment that have the potential to impact on the freshwater birds that are present;

2. The current freshwater species richness in the Takapō 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;

3. In terms of the specialist river-bird 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 Takapō River since 1991 (that being the time from which data has been collected for Project River Recovery);

4. While no data is available regarding river bird populations prior to the construction of the Tekapo PS, it is likely that the loss of braided river habitat in the Takapō River associated with the commissioning of Tekapo A (1950) and Tekapo B (1977) power stations would have resulted in a decline in the specialist river bird 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;

5. Further analysis of the specialist river birds showed a general increase in abundance above the combined WPS (including the Tekapo PS) most likely due to the Project River Recovery measures and decrease below. Notably, significant increases in abundance of NZ pied oystercatcher and banded dotterel recorded in catchments above the combined WPS where Project River Recovery management is occurring, are contrary to the national population trends;

6. Conversely, a decreasing trend in abundance of wrybill was reported in five catchments, including three above the combined WPS. These decreasing trends in abundance are contrary to the national population trend recently reported for this species. The detection of instances of significant decreases in species abundance above the Tekapo PS indicate that additional pressures beyond the power scheme are threatening several populations. Based on Boffa Miskell's avifauna 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; and

7. Finally, the assessment recommends additional measures to be 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 Tekapo PS indicate that additional pressures beyond the combined WPS are threatening several populations, particularly in the Ahuriri. As such, conservation measures should be investigated with DoC for the Ahuriri catchment. As detailed earlier in this AEE, Genesis is proposing the continuation of and increased funding for an indigenous biodiversity enhancement programme to work towards improving the condition, resilience, native biodiversity, ecological processes and other values of the braided rivers and associated environment including the wetlands within the Waitaki Catchment.

2.11.4 Vegetation

The Ecological Solutions 2023 report provides an assessment of the existing ecological context within which the Tekapo PS operates and how the continued operation of the scheme affects the ecology values currently present, which is summarised below.

Since the Tekapo A Power Station was commissioned in 1951 and Tekapo B in 1977, the vegetation communities around the Tekapo PS have developed under a regime of managed water levels in Takapō and managed flows in the Takapō River. In combination with other external pressures (e.g., farming, flood protection works, planting by the former Catchment Board and more recently the regional council, pest browsing pressure and invasive species colonisation) this has resulted in generally low-quality lake edge vegetation, low quality braided river vegetation and typically moderate quality wetland vegetation. The vegetation recorded reflects the management regime and is not expected to be affected to any more than a low level by continued operation under the same control levels. In summary, the overall magnitude of local (ecological district) effects on the three specific vegetation types identified is set out in Table 5.

Table 5: Vegetation Effects

Habitat	Ecological Value	Level of effect	Overall magnitude of effect
Wetlands	High – Very high	Negligible	Low – Very low
Braided River vegetation in the Takapō River	Low – Moderate	Negligible	Very low
Lake edge vegetation	Low – High	Negligible	Very low

Lakeshore vegetation

The lake edge vegetation varies in quality from low (sparse, predominantly exotic e.g., exotic herbs growing between cobble and boulders) to moderate (includes more native species, representative and demonstrates ecological gradients e.g., matagouri shrubland or some turf vegetation). The majority of the lake edge comprises vegetation of low ecological quality and low to moderate ecological value.

At present the lake level variations are such that the extent of cobble and gravels is maintained and areas suitable for the development of turf vegetation are limited. Where turf vegetation does occur, there is limited opportunity for natural zonation to woodier indigenous vegetation typical of natural lake edges to occur because of other adjoining land uses. Development of matagouri shrubland is limited to the upper margins (above the boulder and cobble zones and above the highest water level. Some of the river flats at the head of the lake and various areas around the shoreline such as at Lake McGregor and near Tekapo township have developed turf vegetation of moderate or better ecological quality since commissioning of the Tekapo PS, but their ecological value is limited by the high proportion of exotic species.

Given the same operating parameters the low to high value habitats described above are expected to persist in much the same proportions and at the same locations to where they currently occur.

Wetland vegetation

The average wetland condition is indicative of comparatively good quality wetlands with a low degree of modification and low – medium external modification pressures. The wetlands are typically of high – very high ecological value.

Amongst other ecological drivers, the distribution and occurrence of wetlands in the landscape varies with the size, depth and connectivity of the wetland(s) to other hydrological systems. Overall, a reduction in water input usually results in a decrease in floristic diversity and an increase in exotic dryland vegetation, whereas an increase in water input can increase the size of the wetted area, increase the extent and depth of open water and bring about an increase in the abundance and diversity of aquatic vegetation.

There is no historic vegetation data for any of the wetlands in the vicinity of the Tekapo PS against which current vegetation can be compared, however any wetlands which are hydraulically connected to Takapō or other parts of the Tekapo PS (such as the canal) have developed or persisted over time under the hydrological regime imposed by the scheme.

On the basis that Genesis propose no change to the current operating regime, the risk of ecological change in these wetlands would be low except perhaps in infrequent events when the lake levels either exceed the maximum operating levels (due to natural rainfall or snow melt) or fall below the minimum operating levels (because of drought conditions) for a substantial amount of time. Other natural water inputs such as rainfall and snow melt are expected to alter with climate change, but those effects would be mitigated to some degree by the existing operating constraints of the scheme which would assist in maintaining ecological values. Groundwater movements are not expected to alter, and no effects are expected from that source.

Braided river vegetation

The modified flow regime in the Takapō River resulting from the operation of the Tekapo PS appears to have favoured the spread of exotic species and vegetation of the Takapō River, with the river habitat now comprising mostly exotic species. The [Briar rose] / (*Muehlenbeckia axillaris*) herb – stonefield community comprises the majority of the vegetation in the Takapō River today where reduced flows have created smaller, less isolated shingle bars and islands, with larger areas of the riverbed now stabilised by vegetation, particularly weed species. This has been exacerbated by historic planting of species such as crack willow (*Salix fragilis*) by the former Catchment Board and the CRC. More recently willow clearance has been undertaken in an effort to restore natural patterns and flood protection works to stabilise the river. involving the use of machinery to grade the riverbed and planting alter the habitat available for specialist braided river birds.

Plant species adapted to the unstable braided river environment have been adversely affected by the reduction in suitable habitat, particularly in the upper Takapō River, but the lack of seed sources in the upper river has also likely adversely affected the lower river as well.

Given that Genesis proposes no change to the flow regime in the Takapō River, and that the vegetation surrounding the Takapō River has remained similar since at least 1991, Ecological Solutions considers that no changes to the vegetation are expected from continued operation of the Tekapo PS.

Lake edge habitats

The lake edge habitats range from steep boulder banks above the water line with few to no native plant species to flat turf communities with a range of native monocots, dicot herbs, rushes and sedges. These communities have developed since the Tekapo A Power Station was commissioned in 1951 and given no change in operating parameters is proposed, these communities are expected to persist in their current form.

Effects on species of conservation interest

Only one species which is regarded as "threatened (nationally vulnerable)" (*Carmichaelia corrugata*, dwarf common broom) was detected during the surveys undertaken by Ecological Solutions, along with nine species which are regarded as "at risk (declining)" The majority of these species, including the dwarf common broom, were seen in short tussock grassland habitat near the Tekapo Canal with the remainder in other habitats, none of which would be affected by the continued operation of the Tekapo PS. Matagouri is more widespread around the area including near the lake edge and would not be affected since there are no plans to alter the lake management regime.

Given their ongoing persistence under the current operating regime, for any species which are most at threat due to habitat removal or mammals, adverse effects on the species of conservation concern due to continued operation of the Tekapo PS are not expected. For species of disturbed sites, the continued operation is not expected to allow the type of infrequent disturbance events (particularly floods) which would lead to new habitats becoming available, particularly within the Takapō River. The majority of such species have already gone from the vicinity of the Tekapo PS because of the water management regime over the past 70 years, and those which remain are the species which can tolerate the operating regime. None of the threatened or at risk species detected near the scheme were located in such close proximity to the scheme infrastructure that they would be affected by changing lake levels.

Project River Recovery

The PRR approach in relation to vegetation has been as follows:

a. With respect to wetlands, to develop new habitat, or to enhance degraded habitat, in an attempt to increase the amount of good quality wetland habitat in the vicinity of the WPS; and

b. With respect to braided rivers, to control and remove weeds, particularly within the more pristine upper catchments (above the hydroelectricity lakes).

The Ecological Solutions report notes that PRR continues to accord high priority to preventing weed invasions of the catchments above the hydro lakes, including spending considerable time and resources on targeted weed control in eight riverbeds (Godley, Macauley, Cass, Tasman, Ōhau, Ahuriri, Twizel and Pūkaki), four streams (Coal, Mistake, Fraser and Fork), three wetlands (Ruataniwha, Fraser Stream and Waterwheel) and three lake shore sites (Ōhau, Poaka and Ruataniwha), as well as contributing to landowner weed control in the upper Takapō River, the Dobson River and upper Ahuriri River and undertaking substantial pest control efforts, species monitoring and wetland management.

With respect to the mitigation of the indigenous vegetation effects of the WPS since the water rights were granted in 1991, Project River Recovery has focussed on removal of weeds from headwater catchments, surveillance of weeds and creation or enhancement of wetland habitats. Project River Recovery has made a substantial contribution to maintaining indigenous vegetation in the Waitaki catchment, particularly with respect to weed control. Ecological Solutions consider that Project River Recovery is effective at achieving its goals for braided river recovery and wetland enhancement.

2.12 LANDSCAPE AND VISUAL AMENITY EFFECTS

2.12.1 Landscape and Visual Amenity

The Tekapo PS and canals are an existing part of the landscape character of Takapō. Furthermore, the MDP specifically provides for hydro-electricity generation by scheduling, as a permitted activity, works associated with the maintenance, operation, upgrading and refurbishment of the existing electricity generation facilities within the Rural Zone. While the consents being sought relate to the taking, diverting, damming and discharges associated with the Tekapo PS, Genesis is not proposing to further modify the landscape (i.e., via changing the operational parameters associated with the scheme) or introduce any new structures into the landscape as part of these consent applications. The Tekapo PS will therefore not cause additional effects on the biophysical, perceptual or associative landscape attributes of the associated waterbodies and landscape context. The natural elements, patterns and processes of the river and lakes will not be further modified, other than what the current operation of the power scheme permits.

Based on this, there will be no additional landscape effects of the scheme compared to the status quo.

This proposal will not change the existing views, landscape amenity values, water clarity or general vistas associated with the area. Based on this, there will be no additional visual effects of the scheme compared to the status quo.

2.13 FLOOD MANAGEMENT

The current Tekapo flood rules prescribe a minimum discharge from lake Tekapo as a function of the lake level above MCL; as the lake level increases further above MCL the minimum discharge requirement increases. Provision for establishing modified flood rules are included in the consent conditions proposed by Genesis.

The changes to the flood rules do not have any implications in terms of the WAP provisions for existing activities (i.e., changes to the flood rules will not change the activity status for these applications) but will provide an effective management tool for achieving the limits specified in the WAP during peak inflow events. In particular, the modified rules will be designed to provide for safe passage of the Probable Maximum Flood[24] ("**PMF**") via Gate 16 and the Lake George Scott Control Weir during significant flood events.

2.14 RECREATION EFFECTS

Rob Greenaway & Associates 2023 has identified the recreation and tourism values of Takapō, the Takapō River and the Tekapo Canal, identified trends in recreation and tourism patterns since 1990 and provides an assessment of the degree to which the operation of the Tekapo PS has influenced this. In addition, the report addresses the likely future trends in participation out to 2060. In summary:

1. There is limited quantitative trend data available to ascertain the long terms trends in recreation participation within the study area. The key resource used in the assessment is the national angler surveys undertaken by the New Zealand Fish and Game Council;
2. The national angler surveys indicate that there has been a decline in angling activity on the Takapō River that is coincident with the arrival of

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[24] An estimate of a hypothetical flood (peak flow, volume and hydrograph shape) that is considered to be the most severe "reasonably possible" at a particular location and time of year (New Zealand Dam Safety Guidelines, 2015). The current PMF estimate methodology used in NZ is highly conservative.

didymo in 2007 while over the same time period there has been a significant increase in angling activity on the Tekapo Canal and on Takapō;

3. Commercial accommodation monitoring in the Mackenzie District indicates a steady growth in tourism;

4. The operation of the Tekapo PS controls kayaking and jet boating opportunities on the Takapō River via the release of recreation flows. The frequency of these flows is being discussed with the Tekapo White Water Trust. Activities associated with the operation of the Tekapo PS can impact the opportunities for recreation in and around the Takapō River;

5. The assessment found that interviewees reported an increase in the frequency and duration of low lake levels in Takapō (resulting from the operation of the Tekapo PS) over the past three to five years, although similar statements were made in similar research in 2004 (when Meridian Energy operated the scheme). Low lake levels are considered to have adverse effects on recreation and tourism due to a reduction in scenic values, a loss of water space for recreation, dust effects, exposure to navigational hazards and increased difficulty in launching boats;

6. Lake level records show that Genesis has operated Takapō on average 0.295m lower from 2011-2020 than did Meridian Energy from 2000-2010 (although the average lake levels from November to June are very similar), and Meridian operated the lake at lower average levels than ECNZ did prior to 2000; and

7. Growth projections out to 2050 suggest that there will be a potential doubling in outdoor recreation participation by residents and a tripling in participation by visitors over a 30-year period. The assessment considers that this substantial increase will result in significant pressure on recreation facilities and there will be an additional need for recreation infrastructure, management and regulation.

The Rob Greenaway & Associates assessment concludes that, overall, the Tekapo PS has provided significant recreational opportunities for angling, and the operation of Takapō for hydro generation maintains its traditional recreational and scenic values. Walking and cycling opportunities have developed around generation infrastructure and now provide significant activity opportunities for visitors and residents.

2.15 CONCLUSION

This section has been informed by comprehensive technical assessments commissioned by Genesis to assess the potential environmental effects associated with the continued operation of the Tekapo PS.

Overall, and based on the technical assessments that have been prepared, it is considered that the continued operation of the Tekapo PS will appropriately avoid, remedy or mitigate potential adverse effects on the environment. The assessments also demonstrate the positive effect that Project River Recovery has had on terrestrial invertebrates, lizards, water birds and vegetation.

Where more than minor ongoing adverse effects on a significant value have been identified mitigation measures have been assessed. Measures are detailed in the following section for avoiding, remedying or mitigating adverse effects of the ongoing operation of the Tekapo PS, which are also reflected in the proposed resource consent conditions proposed by Genesis.

3. CONCLUSION

Genesis owns and operates the Tekapo PS, which has an installed generation capacity of 190 MW and as part of the Combined WPS, provides up to 65% of New Zealand's hydro-electricity storage. The Tekapo PS is an important contributor to electricity generation from a renewable energy source and to the local and national economy. It is proposed that the operation of the scheme will align with the existing operational parameters and environmental conditions.

The Tekapo PS operates in accordance with a suite of resource consents granted by the CRC under the RMA, some of which expire in April 2025. Genesis therefore needs to apply for new resource consents to allow the continued lawful operation of the Tekapo PS. The applications for new resource consents are being lodged with the CRC more than 6 months prior to the expiry of the existing resource consents and therefore Genesis is able to continue to operate the Tekapo PS in accordance with the expired consents pursuant to section 124 of the RMA until the new applications to replace those consents have been determined.

To replace the expiring resource consents authorising the Tekapo PS, Genesis is seeking the following resource consents:

1. **Water Permit** - To dam, take, divert and use water associated with the operation of the Tekapo PS; and

2. **Discharge Permit –** To discharge water and associated contaminants associated with the operation of the Tekapo PS.

The resource consent applications being lodged with the CRC in relation to the activities associated with the ongoing operation Tekapo PS are to be assessed as controlled activities. Under the RMA, these consents must be granted; however, the matters to which control is reserved enable conditions of consent to be included to address a broad range of environmental effects of the scheme.

The actual and potential effects associated with the activities that are the subject of the resource consents sought by Genesis have been considered in accordance with section 104(1)(a) of the RMA. Overall, it is concluded that with the agreements with Ngā Rūnaka, DoC and other parties, and the proposed conditions any more than minor adverse effects generated by the proposal will be appropriately avoided, mitigated or compensated for. The assessments conclude that with the measures proposed by Genesis (in particular, the continuation of and increased funding for an indigenous biodiversity enhancement programme to work towards improving the condition, resilience, native biodiversity, ecological processes and other values of the braided rivers and associated environment within the Waitaki Catchment), the continued operation of the Tekapo PS can be undertaken in a manner that will sustain the current environmental values of the waterbodies influenced by the scheme.

Overall, it is considered that the continued operation of the Tekapo PS with the conditions proposed, is consistent with the purpose of the RMA.