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Toitū Te Hakapupu – Pleasant River Catchment Restoration Project

Context analysis to inform catchment management plan

Date: August 2023

COMMUNITY & CLIMATE

BIODIVERSITY & RESTORATION

FRESHWATER, FOOD, FARMS & FOREST

ENERGY, CARBON & WASTE

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Report number: 230807_05013_4A

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Document Version History

Version	Purpose	Prepared by	Reviewer	Review date
1	Draft for Client	Solis Norton, Sally Dicey, Ray Mohan	Rhys Millar, Sally Dicey	31 March 2023
2	Draft for Client V2	Solis Norton, Sally Dicey, Ray Mohan, Rhys Millar	Sally Dicey, Rhys Millar	7 August 2023
3	Final	Solis Norton, Sally Dicey, Ray Mohan, Rhys Millar	Sally Dicey, Rhys Millar	18 August 2023

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1 Introduction

This report has been prepared as part of the Toitū Te Hakapupu Pleasant River Catchment Restoration Project (referred to as the Toitū Te Hakapupu project), a Jobs for Nature project funded by the Ministry for the Environment. The project began in January 2023 and will conclude in December 2025. The project is being delivered by the Otago Regional Council (ORC) with technical assistance from Ahikā Consulting.

This report provides an overview of the current natural and regulatory context that will inform the development of the Hakapupu/Pleasant Catchment Management Plan (CMP). This report is based on a desktop review of the natural and physical characteristics of the catchment, land uses within the catchment and the regulatory context affecting management of land uses. Mana whenua and community values are considered, along with the results of consultation that may inform catchment management.

This document is a working document that will be updated as the project progresses. More detailed local information and perspectives will be gathered by working closely with mana whenua, the local community and other stakeholders.

2 Te Hakapupu catchment

The Hakapupu/Pleasant catchment (referred to hereafter as the Hakapupu catchment) is 13,000 hectares (130 square kilometres) in area and situated about 50 km north of Dunedin as shown in Figure 1.

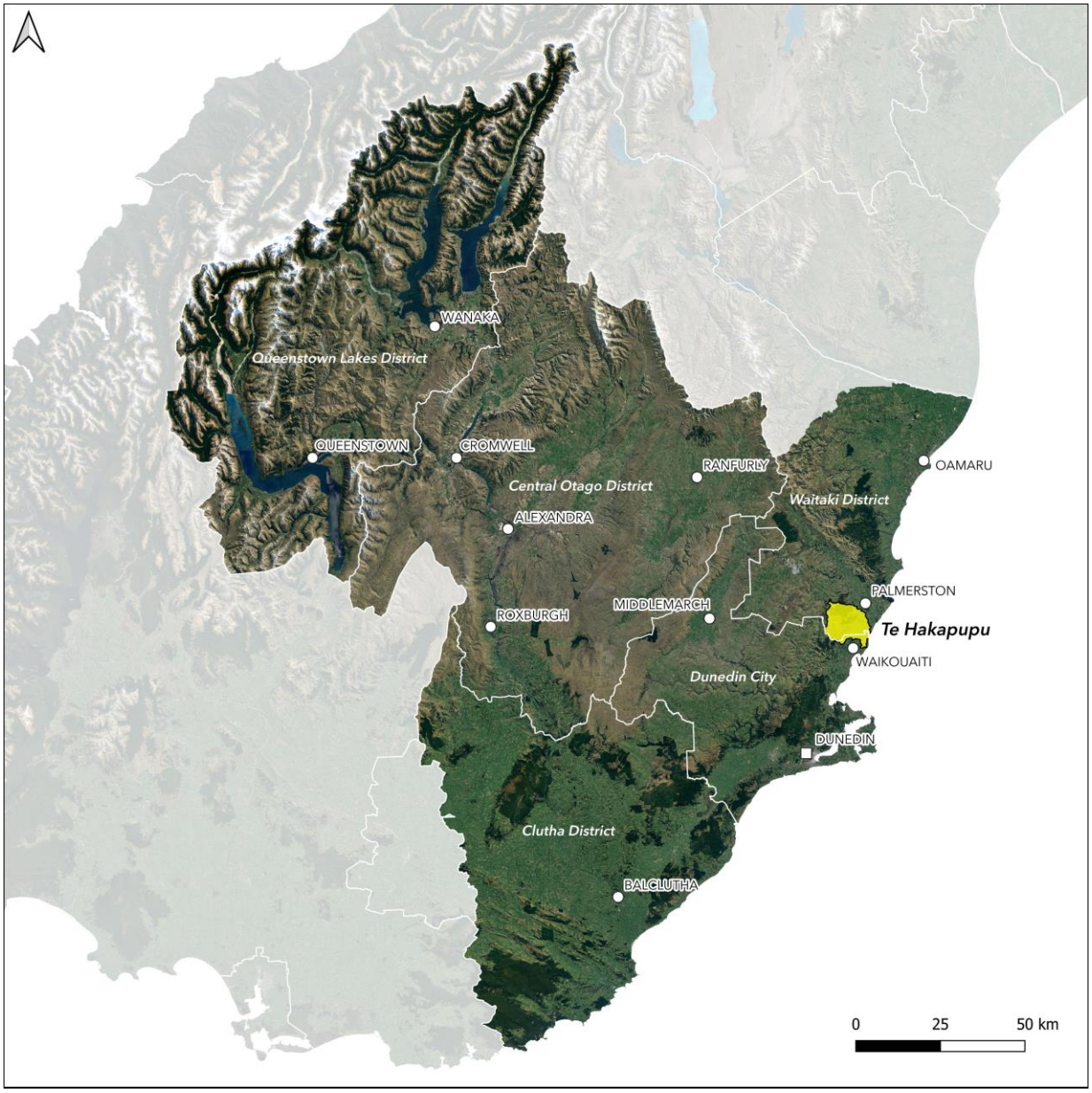

Figure 1. Location of the Hakapupu/Pleasant catchment within the Otago Region.

The catchment is located immediately to the north of the Waikouaiti River Catchment in East Otago (Figure 2). The catchment is one of several located within the Otago Regional Council's North Otago Freshwater Management Unit.

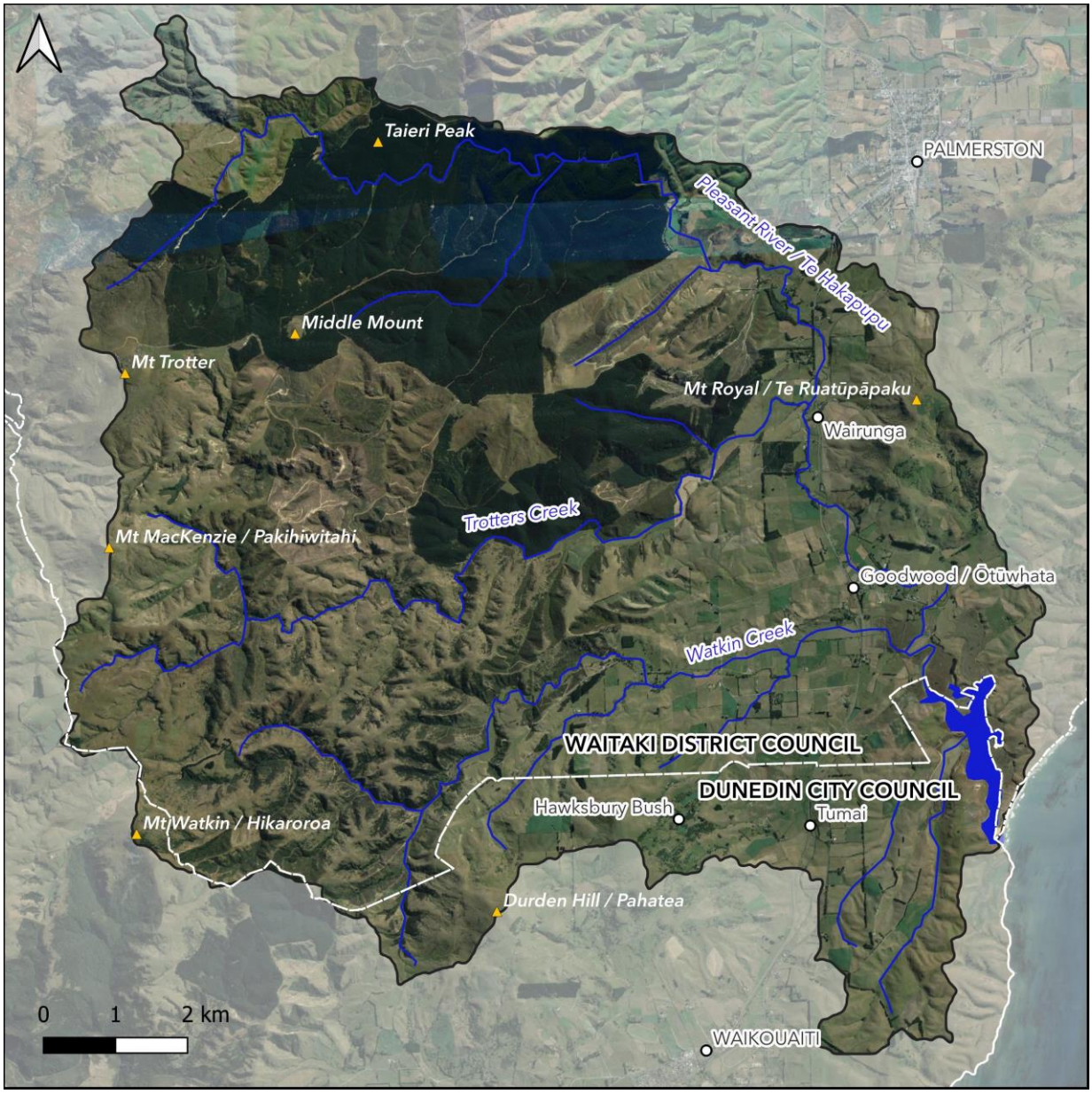

Figure 2. The Hakapupu catchment in East Otago

3 Mana whenua

Ngāi Tahu are the principal iwi of the South Island, but are comprised of 18 Papatipu Rūnaka, with Te Hakapupu situated within the takiwā of Kāti Huirapa ki Puketeraki (Kāti Huirapa). This means that Kāti Huirapa Rūnaka ki Puketeraki holds mana whenua status in the East Otago and kaitiakitaka over Te Hakapupu.The Tōitu Te Hakapupu Project is working to understand the values, concerns and aspirations of Kāti Huirapa members in relation to the catchment.

Kāti Huirapa is active in the environmental management space. Their mahi includes Komiti Kaupapa Taiao (focused on environmental issues), the East Otago Taiapure Management Committee, and their native plant nursery.

Their mahi also includes assessment of the ecological and cultural health of sites in the Hakapupu catchment. This is carried out through the He Pātaka Wai Ora project, which draws on the Cultural Health Index (Gail & Laurel, 2006). This project was initially established to make recommendations on the restoration and connections to the Waikouaiti River (van Halderen et al., 2016) which lies in the catchment to the south of Te Hakapupu. The approach used in He Pātaka Wai Ora in the Hakapupu catchment is intended to be used by mana whenua to connect with and deepen their understanding of their awa and empower them to enact kaitiakitaka over these taoka.

The values of Kāti Huirapa are addressed in section 6 below.

4 Socio-economic context

Land use within the Hakapupu catchment is predominantly rural in nature and dominated by forestry and pastoral farming. The catchment is sparsely populated, with the resident population estimated to be about 200 people (based on the 2018 census).

There are no towns or industry in the catchment. Waikouaiti (population 1,240) lies to the south-east and Palmerston (population 795) is located to the northeast. These towns act as the local service centres for this catchment.

The catchment lies within both the Waitaki and Dunedin City Districts but is primarily located within the Waitaki District (Figure 2).

The catchment straddles multiple statistical units and these contain substantial out-of-catchment areas (Figure 3), which makes a detailed desktop socio-economic analysis more challenging. The orange squares in Figure 3 contain estimated resident population from the 2018 census. This is a new data set with no estimates from earlier censuses. However, the statistical unit falling over most of the Hakapupu catchment (shown as the light-yellow polygon

in Figure 3) indicates an increasing population in the area, as the population in this unit went from 159 in 2006 to 180 in 2013 to 189 in 2018.

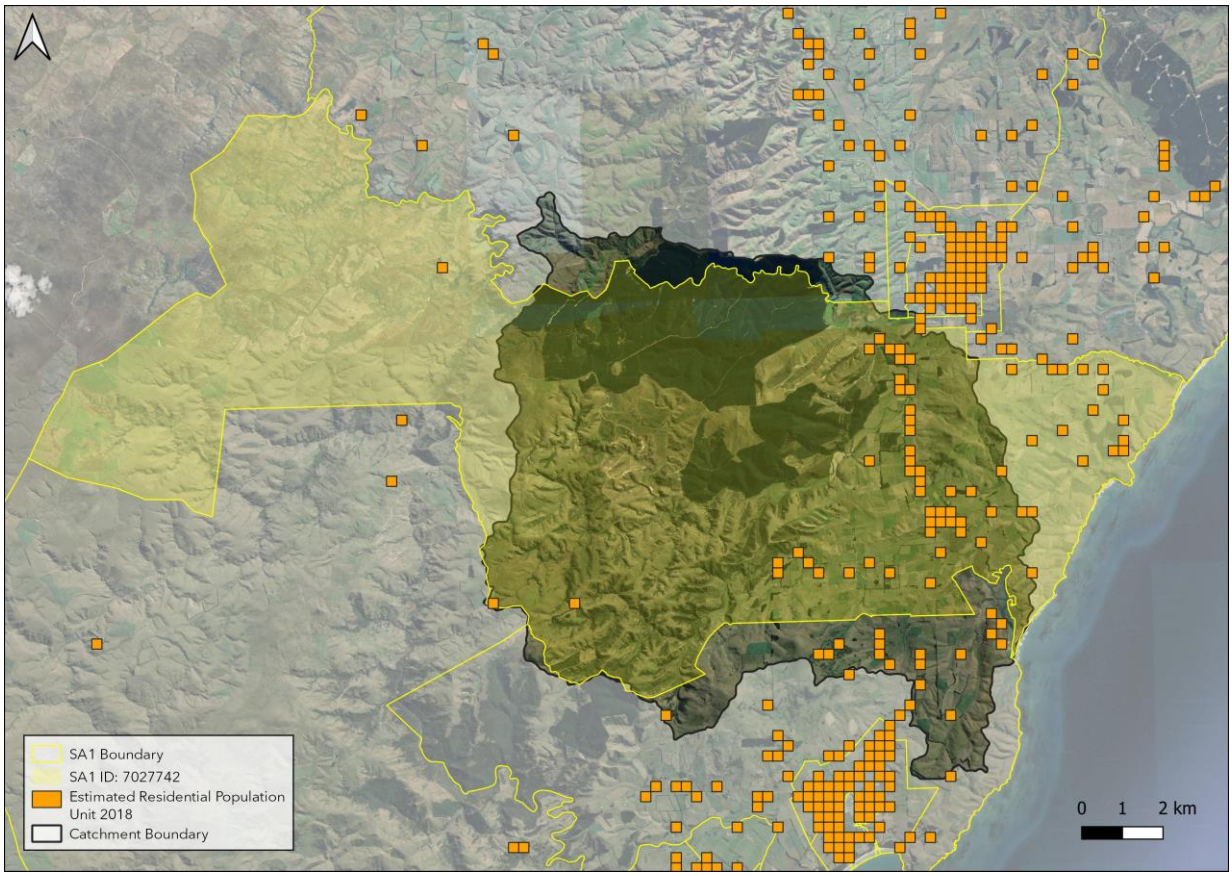

Figure 3. Boundary of statistical units in relation to The Hakapupu catchment boundary

Of the approximately 166 properties in the catchment, 84 are less than 20 ha in area, many of which appear to be lifestyle blocks. Approximately 8-9 properties are in plantation forestry. Remaining properties are mostly pastoral farming and some of these (approximately 13) also have areas of forestry within them.

5 Natural and physical characteristics of the catchment

This section provides an overview of the natural and physical characteristics of this catchment.

5.1 Topography and landscape

The catchment is approximately 13,000 hectares, ranging from sea level to the tops of the headwaters at about 600m in elevation. The floodplains of the catchment are characteristically

flat (<7º), with a few rolling to easy hill areas present. However, upstream areas of the catchment are dominated by easy hill (16-25º) and steep (>26º) topography (Figure 4).

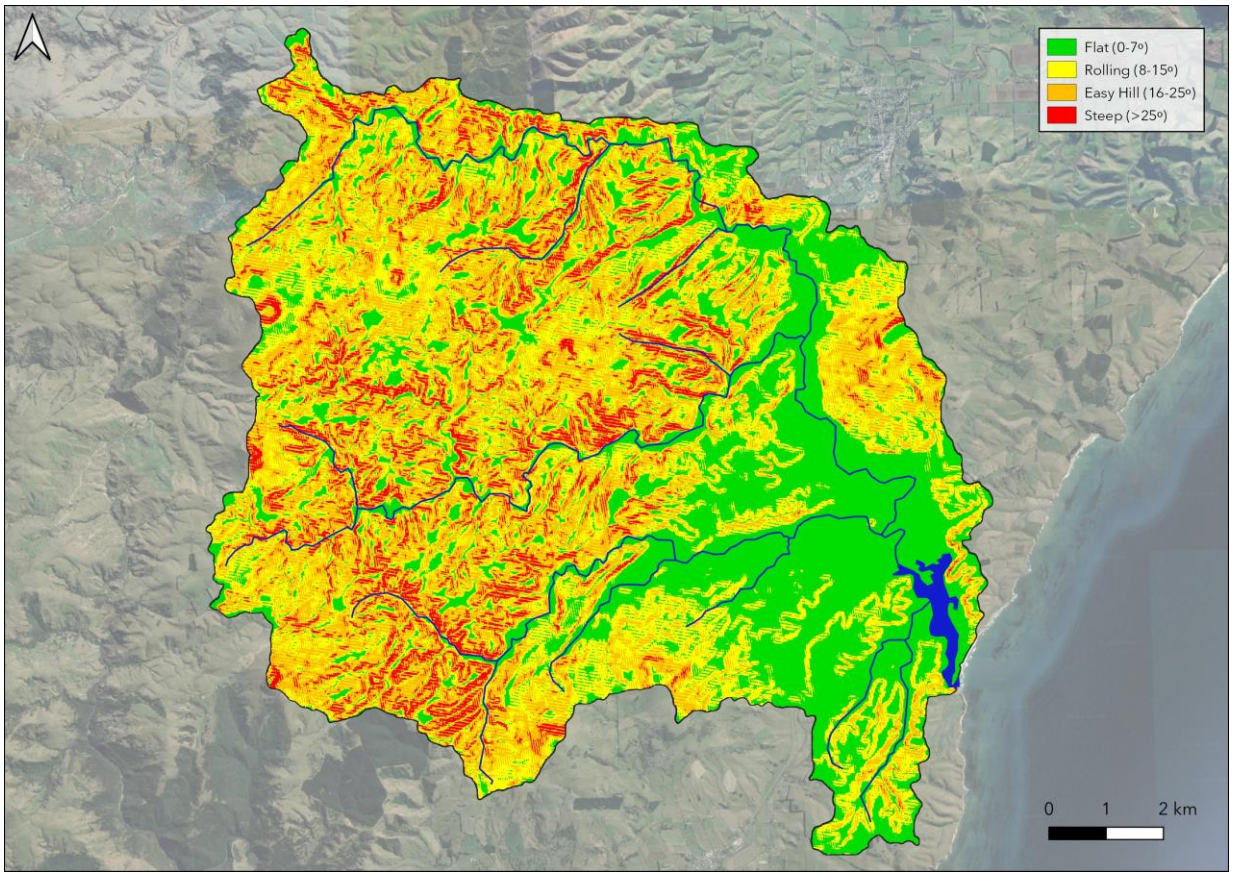

Figure 4. Distribution of slope categories within the Hakapupu catchment.

The Hakapupu / Pleasant River begins in the hills to the north west of the catchment, and flows along the northern boundary of the catchment in an easterly direction for the first half of its length, before turning to the south as it enters the flatter part of the catchment and heads toward the estuary. Two main tributaries, Watkin Creek, Trotters (Owhakaoho) Creek, join the Hakapupu (Figure 2). Watkin Creek and Trotters creek generally run from west to east and are located in the southern third of the catchment.

The estuary complex located on the eastern side of the catchment covers 0.6% of the catchment area and is described in more detail below in Section 5.7.

A geological aspect of the catchment is its six volcanic peaks; Mount Watkin (Hikaroroa), Mount McKenzie (Pakihiwitahi), Mount Trotter, Mount Royal (Te Ruatūpāku), Middle Mount, and Mount Pleasant which are 400-600m in elevation. All are identified as significant natural features in the Waitaki District Plan (Figure 5) with ‘production forestry to be avoided’ (Policy 16.8.3.6; Site Development Standards 4.4.7.4a), although forestry is permitted in the underlying rural general zone). Several of these peaks do have ‘production forestry’ on them –

potentially as lawfully established existing use activities, or via resource consent (further work is required to establish this). Appendix A contains further information on District Plan provisions relating to the catchment.

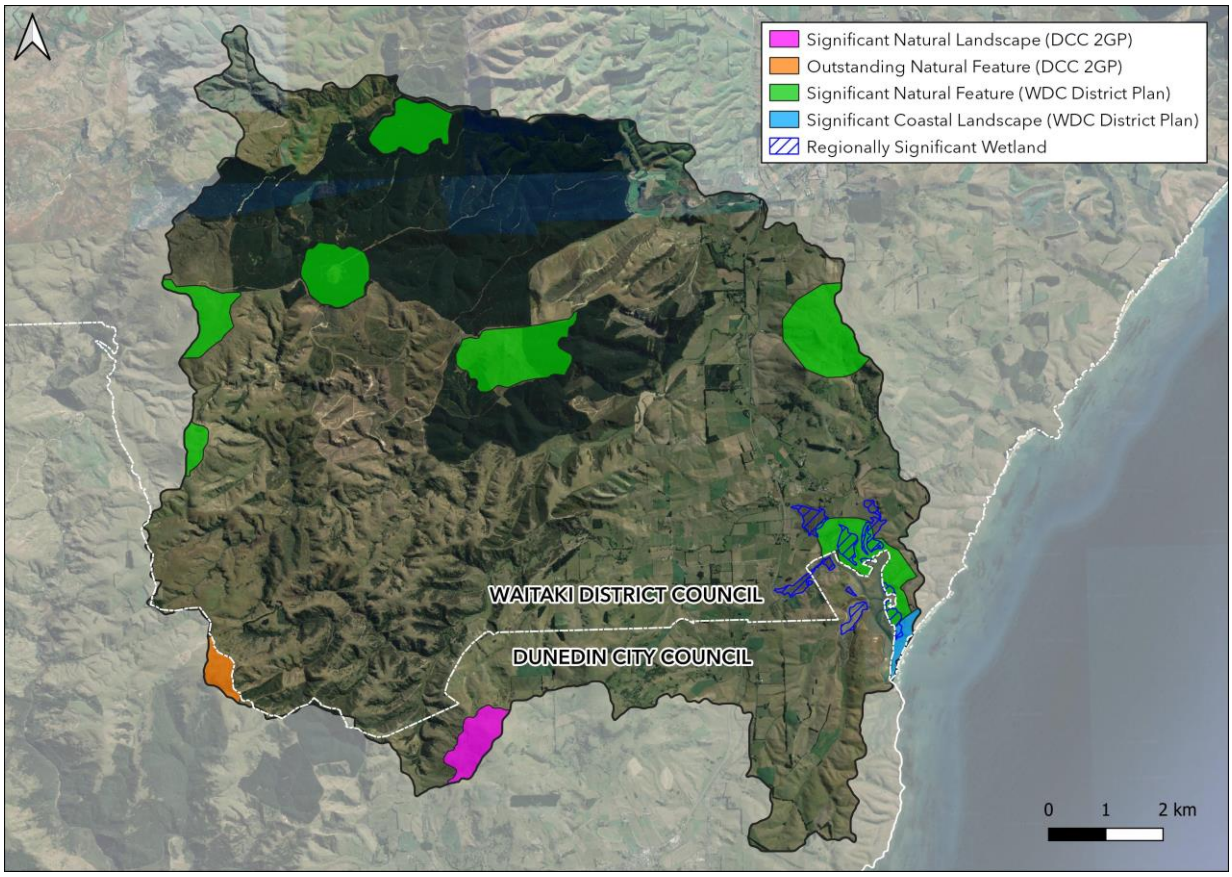

Figure 5. Features of the Hakapupu catchment designated significant or outstanding in the Waitaki District Plan and Dunedin City Council Second Generation District Plan

The lower reaches of the catchment within several kilometres of the estuary are generally flat and pasture covered. Much of the area around the estuary are wetlands or would have once been wetlands. The coastline to the north of the mouth of the Pleasant River/Estuary is identified as a Significant Coastal Landscape in Waitaki District Plan and an area to the south is identified as being within the Coastal Character overlay zone in the Dunedin District Plan.

State Highway 1 passes through the catchment in a north-south direction toward its eastern side and the main south railway line runs adjacent to it. Other roading is typical of a sparsely populated rural area with both sealed and gravel roads that stem from the main highway.

5.2 Climate

Climatic characteristics of the Hakapupu catchment are typical of Eastern Otago. Temperatures generally range from 18 to 24 degrees in summer afternoons and from -2 to 3 degrees on winter nights.

Annual rainfall is low, around 600-650mm and the catchment can become dry by New Zealand standards during the summer. Even though the monthly distribution of rainfall is several percent higher during summer months (Figure 6) the higher evapotranspiration rates over this time can result in drought conditions.

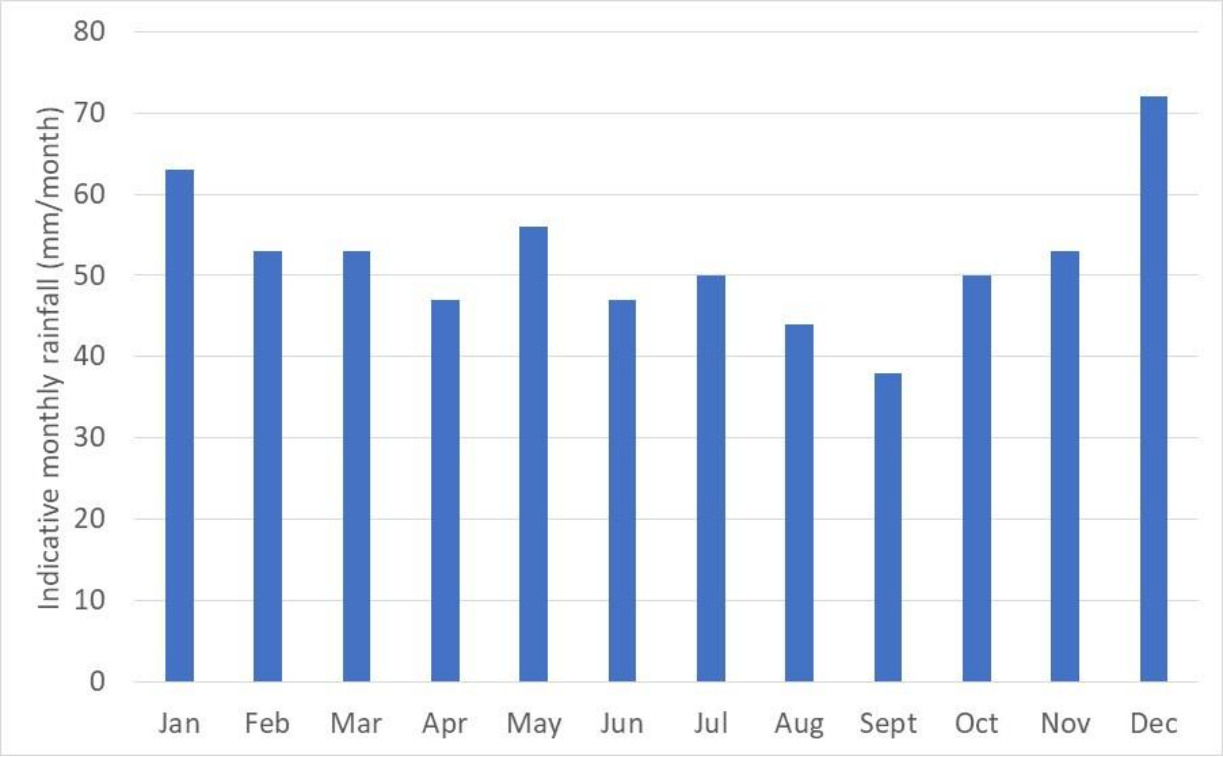

Figure 6. Indicative monthly rainfall in the Hakapupu catchment based on 29 years of data from 1981 to 2010 (adapted from NIWA, 2015).

Flow rates in the catchment's waterways can be very low during summer, as illustrated in Figure 7below. Low instream flows can result in several stressors on freshwater communities including from potentially increased temperatures and lower dissolved oxygen levels. These factors affect the health and presence of aquatic plants and organisms. They can also affect movement of fish along the waterway when surface flow ceases altogether, or if the resulting anoxic conditions in parts of the watercourse are uninhabitable to them. Low flows may increase the concentration of nutrients within waterways.

Figure 7 Example of low flow rate in the catchment in spring (November 2022).

The East Otago area can experience sudden heavy rainfall events. The events typically occur over a 12-to-72-hour period when a depression is centred to the east of the South Island. For example, significant flooding occurred in 2022 when 120-140mm of rain fell within 24 hours. The resulting deposition of sediment and other flood born material, as well as damage to roading and farm infrastructure and farmland itself was repaired over the following year but the memory of it remains with the community.

5.2.1 Climate change predictions and risks

The National Institute of Water & Atmospheric Research Ltd (NIWA) analysed projected climate changes for the Otago Region (Macara et al, 2019). This report addresses expected changes for various climate variables out to 2100, drawing heavily on climate model simulations from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. In addition, the report hydrological impacts of climate change were assessed.

Future climate change projections are considered under different emission scenarios, called Representative Concentration Pathways (RCPs) by the IPCC. RCPs project different climate futures based on future greenhouse gas concentrations, determined by economic, political and social developments during the 21st century. Projections for the future climate in Otago are presented for RCP4.5 and RCP8.5 in the report. These scenarios are as follows:

- RCP4.5 - Stabilisation scenario – a mid-range scenarios where greenhouse gas concentrations stabilise by 2100.
- RCP8.5 - Business as usual scenario - a 'business as usual' scenario with greenhouse gas emissions continuing at current rates.

Predictions in the report are provided at the regional scale (including via maps) and for towns throughout Otago, including Waikouaiti. Maps in the report show that predictions for Waikouaiti are reasonably representative for the Hakapupu catchment.

Predictions for Waikouaiti under the RCP4.5 and RCP8.5 emission scenarios indicate that temperatures will increase, as will the number of extreme hot days, while frost days will decrease. By 2040 the number of dry days per year decreases near Waikouaiti by 1-2 fewer dry days per year. By 2090 decreases in annual dry days of 2-6 days are projected for the area. The lower and upper values of these ranges are based on Emissions Scenarios RCP4.5 and RCP8.5 respectively.

Extreme, rare rainfall events are projected to become more severe. These events may cause significant damage to land, buildings, and infrastructure. Short duration rainfall events have the largest relative increases compared with longer duration rainfall events. Floods are also expected to become larger everywhere in Otago, including the Hakapupu catchment.

Significant rainfall events can also lead to landslides and soil erosion in steeper areas, and creates risks to farming and forestry businesses, as well as to the built environment (Tonkin & Taylor Ltd, 2021). Extreme weather events pose the highest risk to freshwater communities, with extreme flood events resulting in losses in almost all ecosystem services provided by rivers and significant loss of freshwater communities. Bank-side erosion removes spawning habitats for native fish and invertebrates (Tonkin & Taylor Ltd, 2021).

Coastal wetlands such as Te Hakapupu Pleasant River Estuary Wetland Complex are anticipated to be primarily exposed to increased salinity stress from rising sea levels, and from increased severity of flooding and extreme weather events. Inland wetlands will be impacted by changing rainfall patterns, higher temperatures and flooding, which are likely to increase stress on many wetland species (Tonkin & Taylor Ltd, 2021).

Changes in rainfall and higher temperatures are likely to create a risk to plant and animal species from pests (including both exotic plants and animal pests) and disease. These impacts have corresponding impacts on land-uses and human health and welfare, as well as the human values.

5.3 Geology

Common geological forms (as shown in Figure 8) in the catchment are schist (38%), sandstone (28%) and siltstone (22%). Siltstone is of particular risk of erosion. As a sedimentary rock it is formed mainly of silt sized particles and is softer than many other parent rock materials. It is mostly present on the lower sloped western and southern parts of the catchment but also underlies some of the steeper parts of the catchment in the southern and western areas which are under forestry and low producing grassland respectively.

Sandstone is a common rock type in Otago and can weather and erode quickly, particularly when exposed to freeze-thaw cycles or high rainfall. In areas where sandstone is abundant such as the headwaters of the catchment, erosion can be a significant issue, leading to sediment transport and loss of topsoil.

Similarly, schist can be prone to mass earth movements, weathering and erosion over a longer period (Balance, 2009).

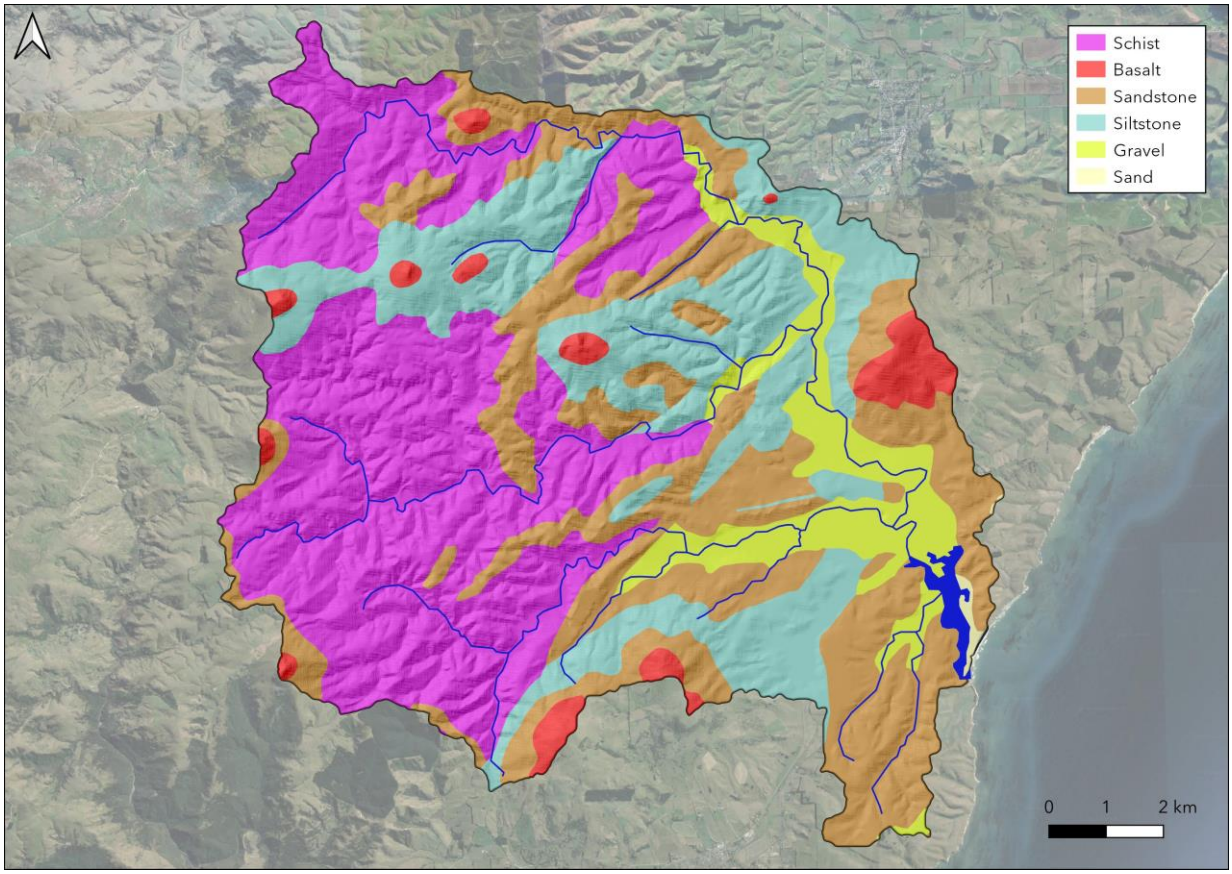

Figure 8. Geology of the Hakapupu catchment (source: GNS Science, Geological Map of New Zealand)

There is evidence in the Hakapupu catchment of slip and gully erosion occurring in areas that have been harvested and not replanted (refer to Figure 9), as well as stream bank erosion along the low-lying waterways through grazed farmland. There is also historical evidence (scars) of rill erosion in sloping paddocks previously cultivated.

Figure 9. Examples of mass movement erosion on steep land where forestry has been harvested in the preceding decade and not replanted.

Erosion susceptibility in the catchment based on the Ministry for Primary Industries (MPI) Plantation Forestry Erosion Susceptibility Classification is shown in Figure 10.

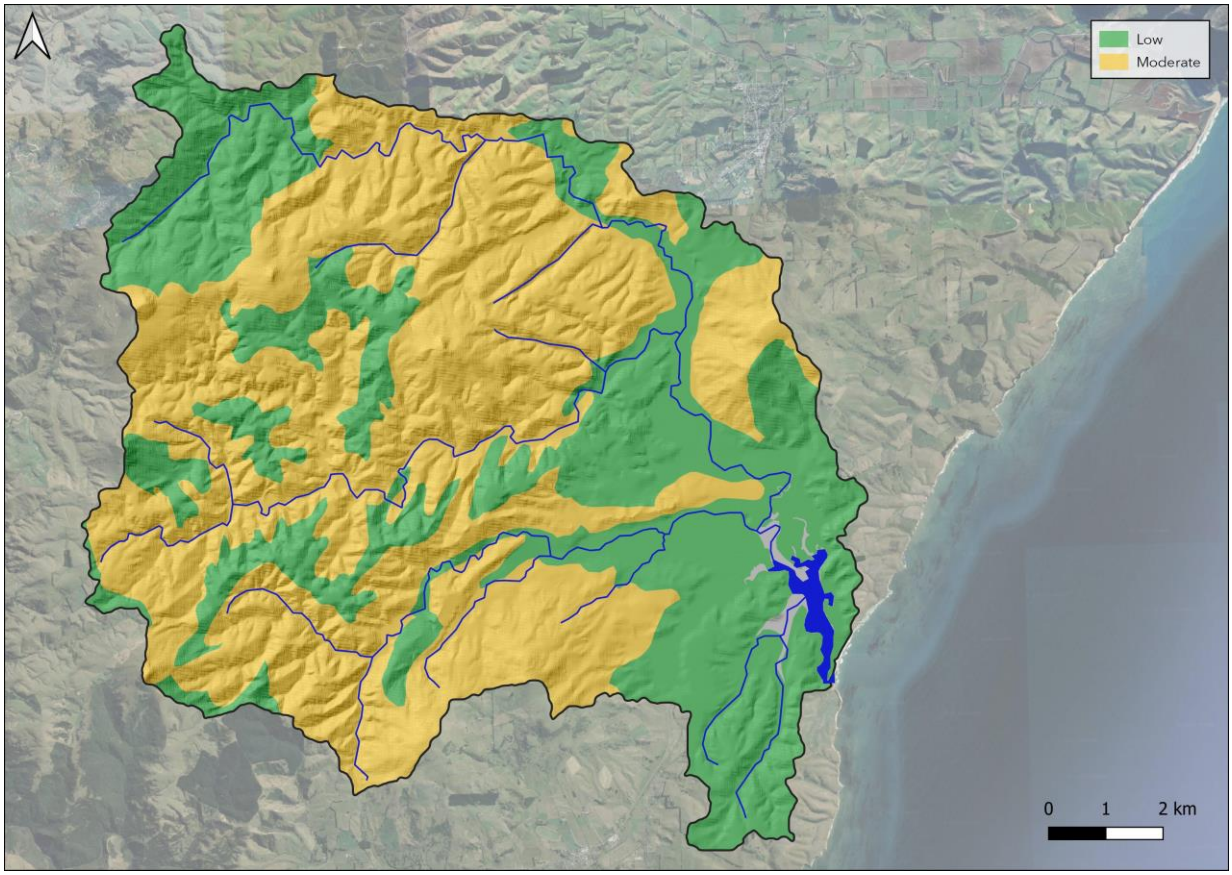

Figure 10. Erosion susceptibility in the Hakapupu catchment (source: MPI Plantation Forestry Erosion Susceptibility Classification)

5.4 Soil types

Soils within the catchment are shown in Figure 11. Pallic and brown soils predominate, these typically have moderate to good natural fertility characteristics. The pallic type soils are most common and located mainly through a north to south band of the eastern part of the catchment. This type of soil typically has high levels of organic matter and low nutrient content with low cation exchange capacity. The low cation exchange capacity indicates that the soil's particles do not hold nutrients well. Soils with this quality require larger volumes and more frequent applications of synthetic fertiliser to meet the objective of optimum nutrient levels for agricultural production. Pallic type soils tends to have a lower profile available water (PAW) value and be poorly drained, prone to waterlogging and compaction.

The brown soils are next most common and mainly in the western part and in a band that follows the Pleasant River along the middle half of its length. They tend to be deeper with higher organic matter content and better water holding capacity, and so are better suited to crop production.

In the lowest parts of the catchment within a kilometre or two of the estuary melanic and saline gley soils are present. These tend to be low in natural fertility with a low cation exchange capacity and PAW and are also prone to waterlogging.

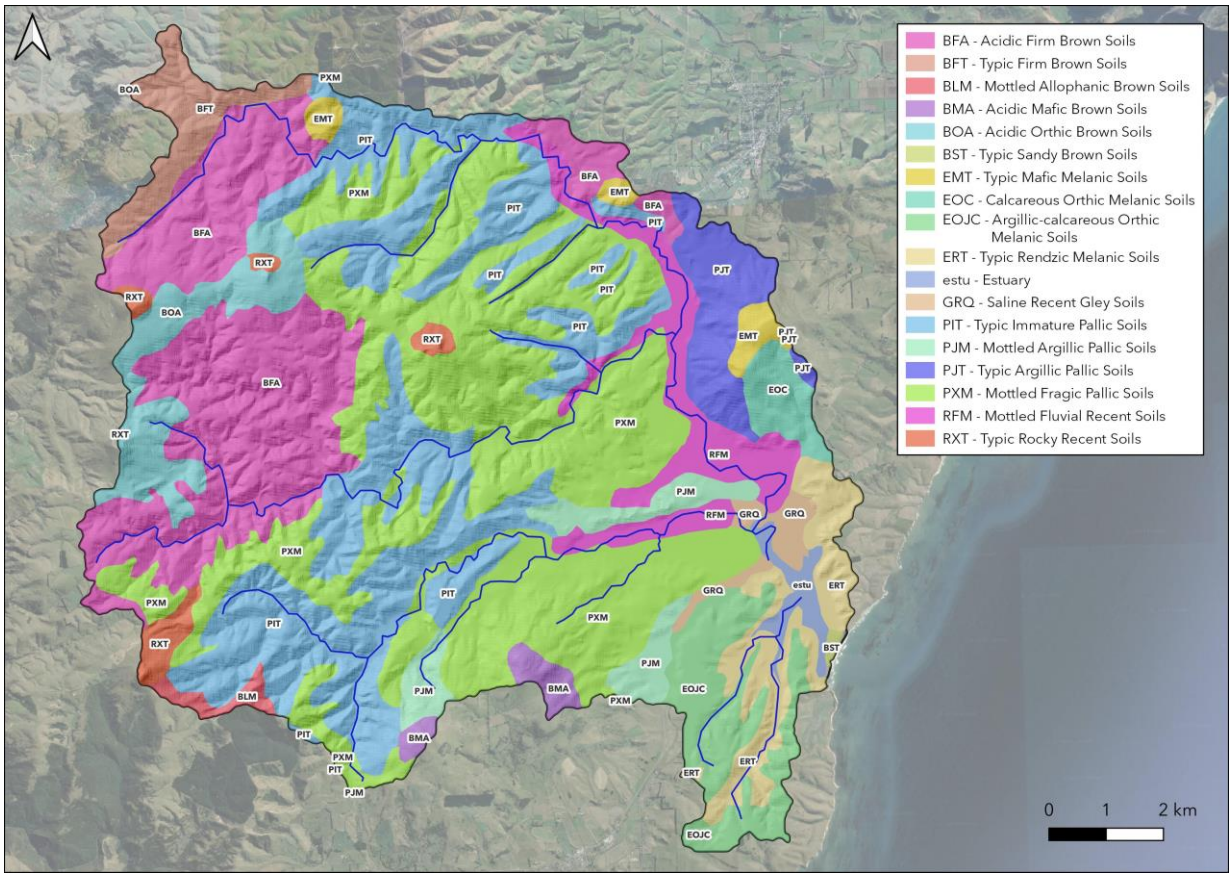

Figure 11. Soil distribution of the Hakapupu catchment (source: Land Cover Database, 2018).

5.5 Land use capability

New Zealand's Land Use Capability System (LUC) is based on the New Zealand Land Resource Inventory (NZLRI) which is an assessment of physical factors required for long-term land use and management (Collins et al, 2014). The Land Use Capability system categorises land into eight classes according to its long-term capability to sustain one or more productive uses based on physical limitations and site-specific management needs. Productive capacity depends on physical qualities of the land, soil and environment.

Some of the limitations considered in the LUC include the: susceptibility to erosion, steepness of slope, climate, susceptibility to flooding, liability to wetness or drought, salinity, and depth, texture, structure and nutrient supply of the soil.[1]

The majority of the catchment is in Land Use Capability (LUC) Class 4 and 6 (Figure 12) with smaller areas of Class 2 and 3 land also present.

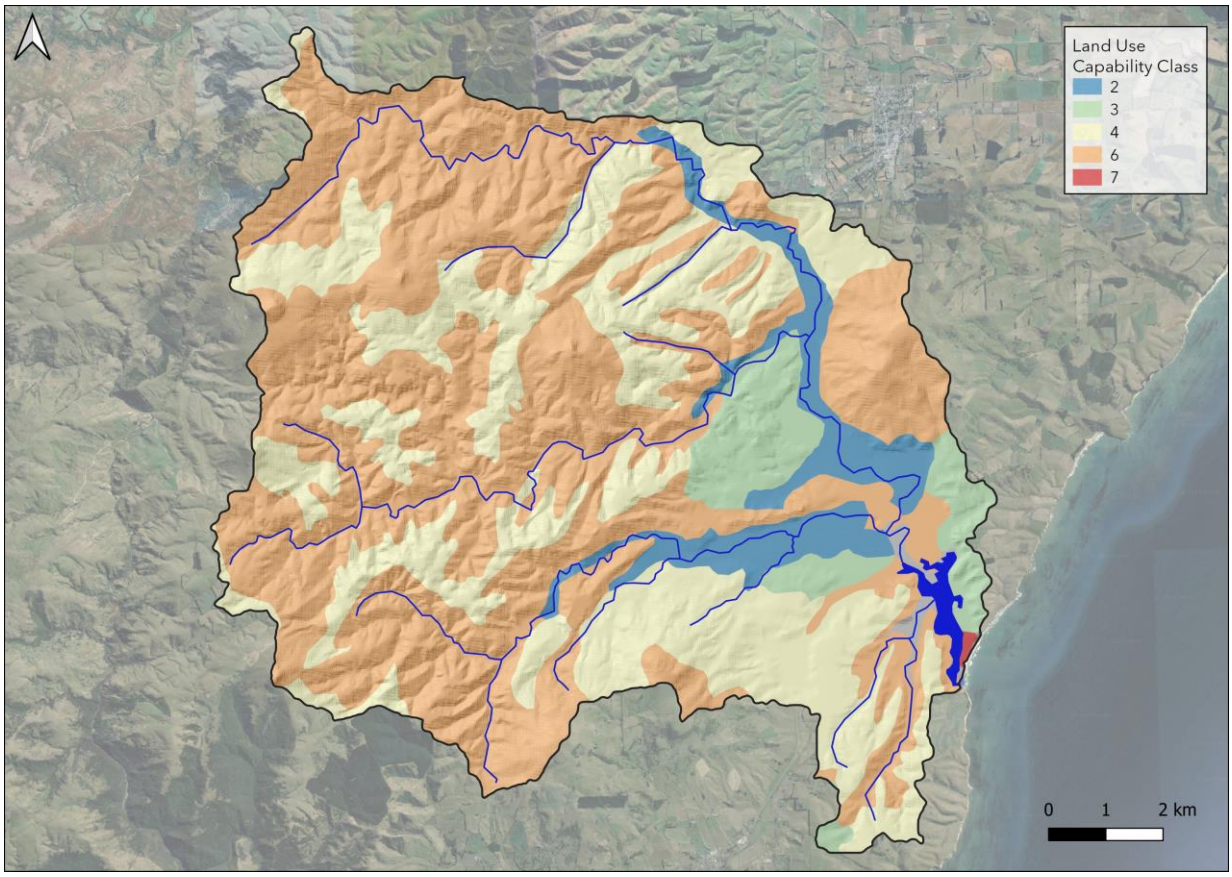

Figure 12. Land Use Capability classification for the Hakapupu catchment

Descriptions for the main classes present in the catchment include:

- Class 2 - Arable. Regarded as high-quality land with few biophysical limitations, suitable for a variety of use including higher requirements activities such as mixed

[1] https://www.landcareresearch.co.nz/https://ourenvironment.scinfo.org.nz/maps-and-tools/app/Land%20Capability/lri_luc_main

cropping, viticulture, fruit production, and also common land use of pastoral systems and forests.

- Class 3 - Arable. Moderate limitations, restricting crop types and intensity of cultivation, however with suitability for complex Class 2 land uses such as cropping and viticulture.
- Class 4 - Arable. Significant limitations for arable use or cultivation, very limited crop types, suitable for occasional cropping, pastoralism, tree crops and forestry. Some Class 4 is also suitable for viticulture and berry fruit.
- Class 6 - Non-arable. Slight to moderate limitations to pastural use, suitable for pasture, tree crops and forestry and in some cases vineyards. Erosion is generally the dominant limitation.[2]

Within the catchment, the majority of land classified under Class 4 and Class 6 is under forestry – while permanent vegetative cover is often seen as the optimum land use type for steeper classes (i.e. permanent pasture or forests), the forestry cover acts as a strong mitigator for erosion on those land classes. Harvesting on steep terrain is challenging and usually results in erosion driven sediment movement. Therefore, appropriate management of forestry activities is critical to ensuring that erosion and sediment loss on Class 4 and 6 land is minimised. The flat to rolling landscapes within the catchment are within the Class 2 and 3 land use classification, with the majority of the land cover being pasture-based systems well within the recommended capabilities framework.

5.6 Land cover and biodiversity

The potential extent of the original ecosystems of the Hakapupu catchment that might have existed prior to human arrival is shown in Figure 13 below. Potential ecosystem mapping utilises the locations and species composition of surviving remnants of ecosystems together with climate and land data to reconstruct New Zealand's potential vegetation pattern (Leathwick et al, 2012). This provides an indication of what vegetative cover may have been present in the catchment before human arrival and subsequent land clearances.

[2] https://www.landcareresearch.co.nz/https://ourenvironment.scinfo.org.nz/maps-and-tools/app/Land%20Capability/lri_luc_main

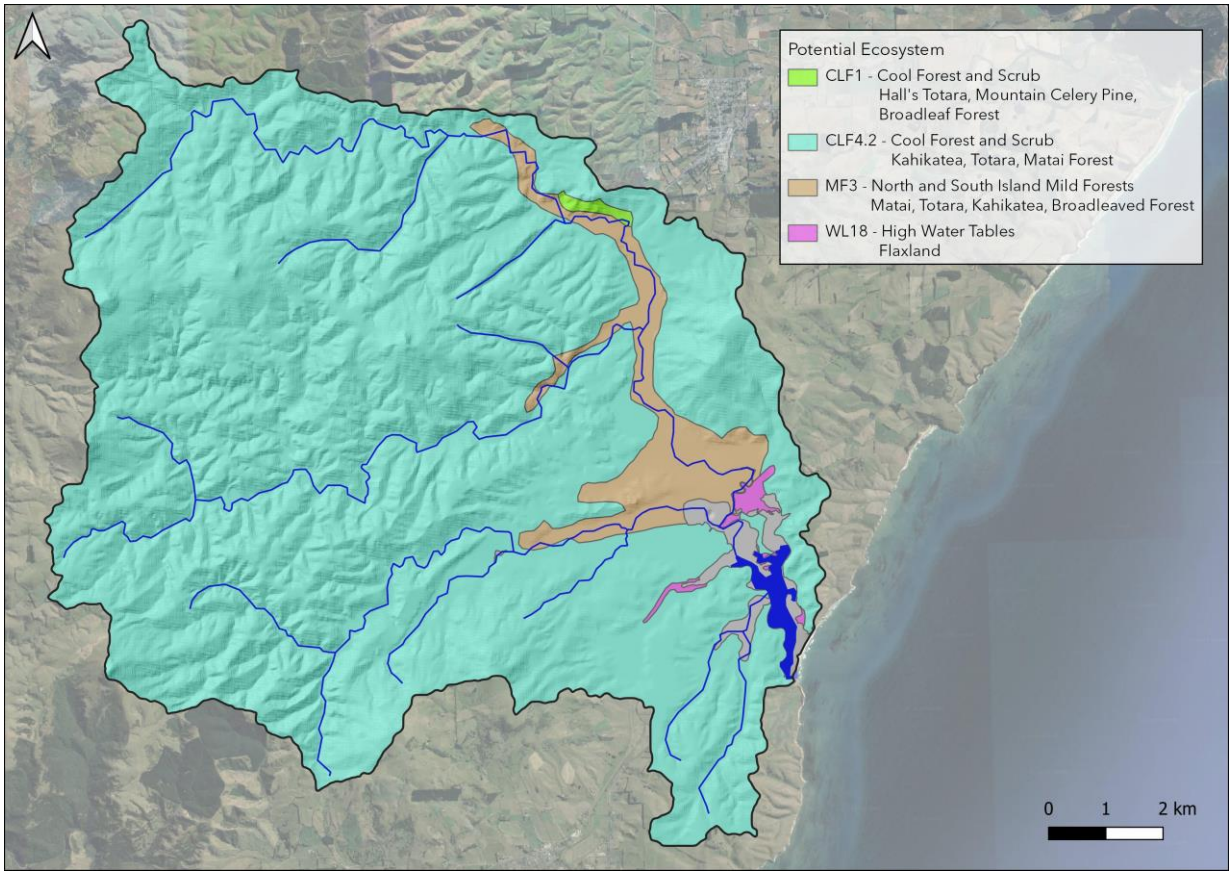

Figure 13. Potential ecosystems within the Hakapupu catchment (source: Otago Regional Council and https://lris.scinfo.org.nz/layer/48289-potential-vegetation-of-new-zealand/).

Landcover today within the catchment is shown in Figure 14 below. Plantation forestry covers 49.4% of the catchment, mostly in the steeper upper reaches. Most of the remainder is in pasture for farming of which 34.7% is improved exotic species and 10.2% is unimproved. Indigenous forest areas, kanuka and manuka, matagouri and grey shrub collectively cover 1% of the catchment. Herbaceous saline vegetation covers 0.9% of the catchment.

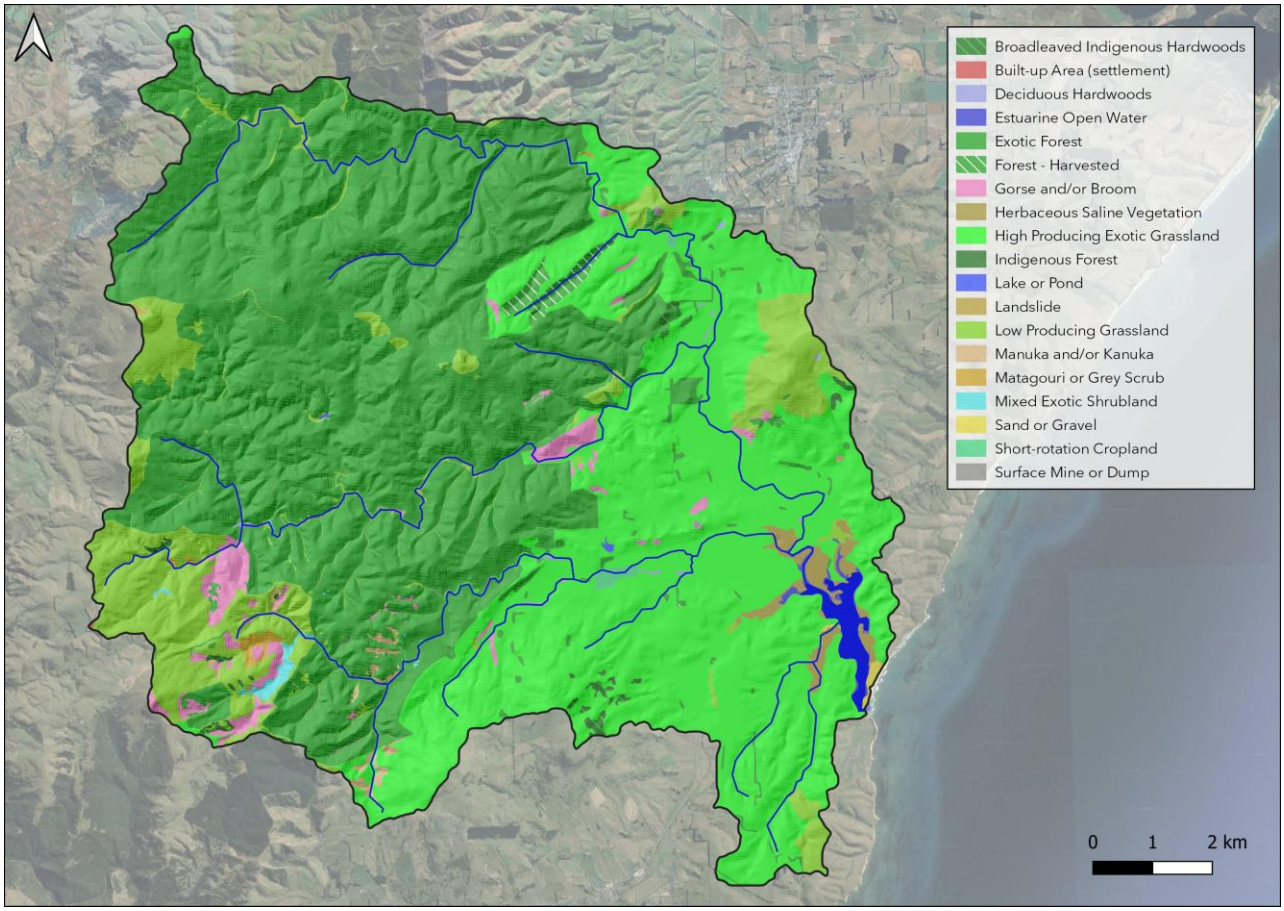

Figure 14. Land cover across the Hakapupu catchment (Source: Land Cover Database 2018)

Remnants of indigenous forest or native scrub such as manuka or kanuka are mostly clustered in the area surrounding the estuary or sprinkled through the steeper parts of the south-eastern corner of the catchment, while the herbaceous saline vegetation is associated with the Hakapupu - Pleasant River Estuary Wetland Complex. This is a key natural value in the catchment and described in more detail below.

Biodiversity features in the Hakapupu catchment have been identified from a range of sources and are shown in Figure 15. They provide an indication of the presence of native fish spawning sites, areas of indigenous vegetation, wetlands and rare plants and animals in the area.

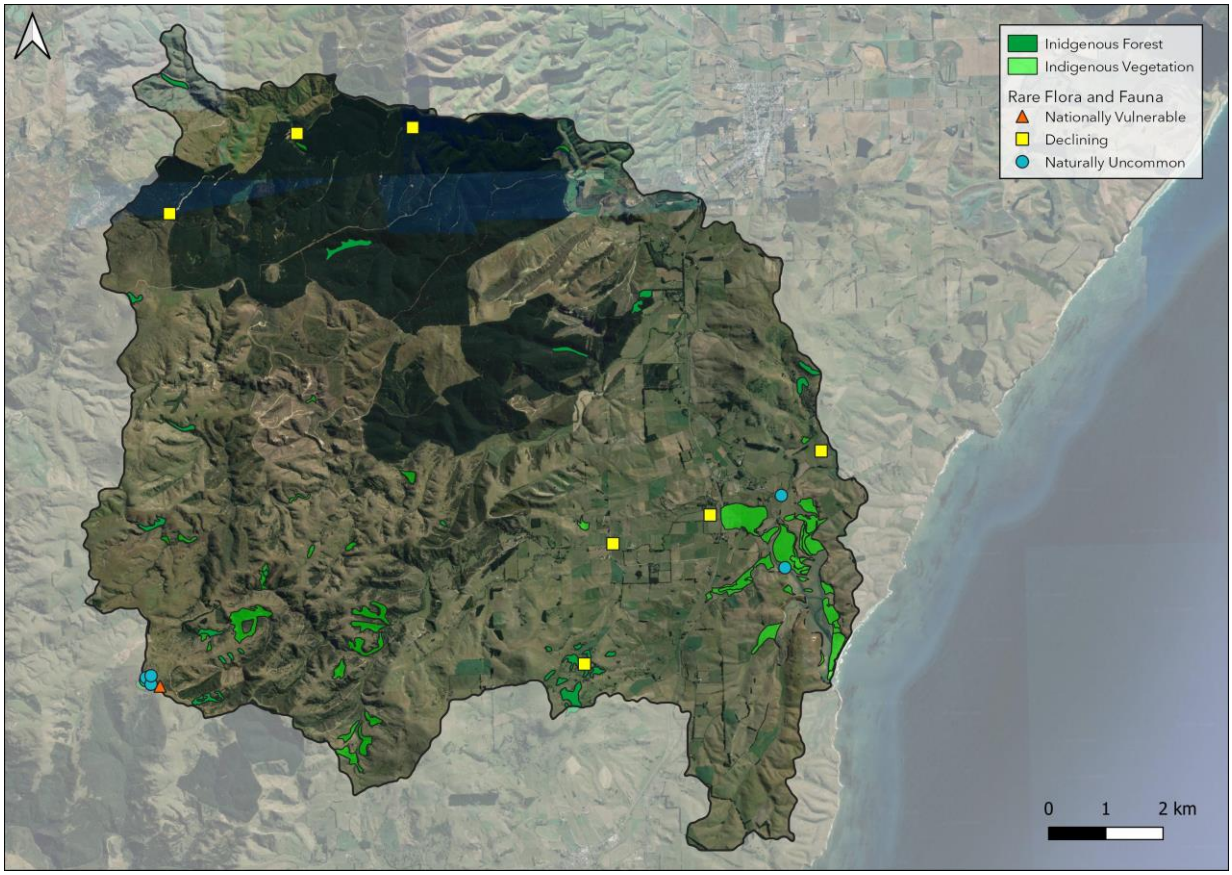

Figure 15. Indigenous species identified within the catchment. Sources: 'Indigenous Forest', 'Indigenous Vegetation' from the Otago Regional Council; rare species data from Endangered Species Foundation, sourced from Bioweb, eBird, NIWA Freshwater Fish Database and Landcare CHR Herbarium

Indigenous freshwater species present in the catchment include *Anguilla dieffenbachia*, tuna (New Zealand longfinned eel, at risk, declining), *galaxias maculatus* īnaka (īnanga) (at risk, declining), *Gobiomorphus gobiodes* giant bully (at risk, naturally uncommon). One vulnerable species of bird noted is the royal spoonbill (*Platalea regia*, nationally vulnerable).

Indigenous plant species present include *Brachyglottis sciadophila* climbing groundsel (declining), *carmichaelia petriei* (at risk, declining), *gingidia grisea* (naturally uncommon), *Melicytus flexuosus* (nationally vulnerable).

In addition to the sources noted above, information is also being collected by monitoring of fish and macroinvertebrate species along with habitat and water quality as part of the Toitū Te Hakapupu project. eDNA analysis of fish species in the three main tributaries in the catchment and the estuary indicated the presence of ten species of freshwater fish and seven estuarine/marine species. Of these freshwater species, bluegill bully, īnaka and tuna (New Zealand longfinned eel) are considered threatened (at risk – declining), and four are considered mahika kai species (banded kokopu, īnaka, tuna - New Zealand longfin eel and

short-finned eel). Of the estuarine fish species detected, four are considered mahika kai species; kahawai, sand flounder, skate and yellow eyed mullet.

Hawkesbury Bush is the single QEII covenant in the catchment, it covers a ten hectare area of native forest remnant near the southern boundary of the catchment.

Restoration work and conservation planting on private land including that undertaken as part of the Tumai subdivision in the southeastern part of the catchment adjacent to the estuary is contributing to the natural values of the catchment. Similarly, the work done as part of the Toitū Te Hakapupu project, including working with landowners to establish 100,000 plants and 60 kilometres of fencing for freshwater enhancement will contribute to natural values in the area.

5.7 Wetlands and Estuary

Assessments of historic wetland areas in the catchment indicate that there were approximately 198 ha of wetland, including marsh, seepage and swamp areas around the estuary compared to 5 ha currently (Leathwick et al., 2010). This assessment does not identify historic wetlands in other parts of the catchment (except on the upper slopes of Mt Pleasant and hill country near Mt Watkins, which may or may not be valid, given the topography of those areas).

Under the National Policy Statement for Freshwater Management 2020, regional councils are required to map freshwater wetlands down to a 0.05 hectares, or smaller if they are of a type that is naturally less than 0.05 hectares and supports threatened species. This mapping may identify more wetlands in the catchment that those captured in the Freshwater Ecosystems of New Zealand (Leathwick et al., 2010).

The wetland and estuary are known as the Te Hakapupu Pleasant River Estuary Wetland Complex – this is predominantly an estuarine system of about 84 hectares in size. It is the largest wetland in the North Otago Freshwater Management Unit (FMU). Estuarine wetlands such as this are one of the Naturally Uncommon Ecosystems in New Zealand, meaning historically rare, however it is also classified as ‘vulnerable’ (ecosystem red-list criteria, International Union for Conservation of Nature) due to historic and ongoing loss in extent and decline in its ecological integrity (Holdaway et al., 2012).

The complex consists mostly of salt marsh, mud flat and sandspit, supporting flora that is adapted to saline condition such as glasswort *Sarcocornia quinqueflora*, Puccinellia spp., rekoreko *Selliera radicans*, sea primrose *Samolus repens* var.*repens*, and saltmarsh

ribbonwood *Plagianthus divaricatus*.[3] None of these species is considered threatened (De Lange et al., 2018).

The complex has been identified as permanently open to the sea. Research in the ten years prior to the Toitū Te Hakapupu Project suggest that it is similar in its level of health and amount of biodiversity to other estuarine systems along the East Otago coast (Foote, 2016; Wolebu, 2019).

The complex is an important habitat for birds of which some species have significant conservation status (Robertson et al., 2021). These include but are not limited to bar-tailed godwits *Limosa lapponica* (At Risk – Declining), South Island Pied Oystercatcher *Haematopus finschi* (At Risk – Declining), variable oystercatcher *Haematopus unicolor* (At Risk – Recovering), pied stilt *Himantopus himantopus leucocephalus* (Not Threatened), banded dotterel *Charadrius bicinctus bicinctus* (At Risk – Declining), white-faced heron *Egretta novaehollandiae* (Not Threatened), black-billed gull *Larus bulleri* (At Risk – Declining), and white-fronted tern *Sterna striata* (At-Risk - Declining). Some of these are recorded as breeding within the complex. The area is important for estuarine terrestrial invertebrates.[4]

The complex is identified as a Regionally Significant Wetland in the Otago Regional Council Regional Plan and as Significant Natural Feature and an Area of Significant Nature Conservation Value and a Geopreservation Site under the Waitaki District Plan on the true left of the estuary (within the Waitaki District). Some of the area on the true right side of the complex is identified as an Area of Significant Biodiversity Value in the Dunedin City Council District Plan.

Two recent scientific studies have included the Hakapupu estuary (Foote, 2016 and Wolebu, 2019). Collectively, they suggest that the estuary has a similar level of health to other estuarine systems along the East Otago Coast. A high diversity and biomass of macroinvertebrate infauna was recorded relative to three other estuarine systems along the East Otago Coast (Foote, 2016). The types and numbers of fish species recorded were similar to those recorded for other estuaries in Otago (Wolebu, 2019). The trends in salinity and elevated nitrates were also similar to other estuaries on the Otago coast (Foote, 2016).

The Otago Regional Council is also conducting State of the Environment monitoring in the Hakapupu estuary.

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[3] https://www.orc.govt.nz/managing-our-environment/water/wetlands-and-estuaries/waitaki-district/pleasant-river-estuary-wetland-complex

[4] https://www.orc.govt.nz/managing-our-environment/water/wetlands-and-estuaries/waitaki-district/pleasant-river-estuary-wetland-complex

Survey work carried out as part of this monitoring was conducted in the estuary in November 2021. This assessed the dominant substrate and vegetation features present in the estuary, including seagrass, salt marsh and macroalgae (Roberts et al, 2022), as well as fine scale monitoring of estuarine biota and sediment quality (Forrest et al, 2022). Overall, the estuary was found to be in 'fair' to 'poor' condition with highly eutrophic side arms expressing excess algal growth on soft, muddy sediments with low sediment oxygen. The compromised ecological quality of the estuary was likely to reflect high freshwater inputs from a developed catchment, extensive estuary reclamation, and restricted flushing of side arms (Roberts et al, 2022).

Fine scale monitoring sites had a moderate to high sediment mud content and showed mild to moderate symptoms of enrichment in key environmental quality indicators. This was considered to be consistent with catchment run-off, in part reflecting catchment land uses dominated by pasture and exotic forestry (Forrest et al, 2022).

Prolific growths of opportunistic macroalgae and filamentous algae were present in the side arms, mid estuary, and ponds within herbfields. Nuisance blooms of algae can be caused by excessive levels of nutrients and suitable growing conditions and can adversely effect on estuary health (e.g. by smothering seagrass, trapping fine sediments, increasing organic loading, and causing low oxygen conditions) (Roberts et al, 2022).

Seagrass, a key feature in estuaries, was not recorded in the estuary This potentially reflects the large-scale estuary modification and/or other conditions that would limit seagrass growth, in particular, a strong freshwater influence (low salinity), high sediment deposition, macroalgal growth in the likely areas seagrass would grow (i.e. side arms), and wave fetch and substrate mobility in the mid to lower estuary that could prevent establishment (Roberts et al, 2022).

In addition, this study noted that reclamation, drainage and structures that impede salt marsh growth are common in the estuary, including causeways, flapgates, shoreline hardening for rail infrastructure. These modifications have significantly altered estuary hydrology and disrupted the natural connectivity between the land and the sea, compromising overall ecological health.

The most significant issues identified in in the estuary were large scale estuary reclamation (~20% loss), altered hydrology and ongoing drainage and grazing of salt marsh habitat, and excessive growths of opportunistic macroalgae and filamentous algal species. Along with elevated catchment nutrient and sediment loads, the estuary's assimilative capacity has been greatly reduced resulting in large areas of eutrophic conditions (i.e. excess algal growth coupled with poor sediment oxygen and muddy sediments), particularly in the side arms (Roberts et al, 2022)

Eutrophication susceptibility modelling is being undertaken by NIWA. This modelling estimates the estuary's susceptibility to nutrient loading and produces a susceptibility rating based on

the ecological quality rating, which is a measure related to macroalgal cover. NIWA is also currently undertaking a study to identify sources of fine sediments in the Hakapupu and its estuary.

The results of these studies will be valuable in further informing management approaches within the catchment.

5.8 River water quality

The Otago Regional Council has a State of the Environment river monitoring site on the Pleasant River, located at Patterson Road. This site, which was established in 2018, records water temperature, dissolved oxygen, conductivity, turbidity, total suspended solids, nutrients (TN, TP, DRP, NNN, NH4), pH and *E. coli*. Samples are collected monthly.

Data is not yet available on the LAWA website (https://www.lawa.org.nz/explore-data/otago-region/river-quality/), however, data from this monitoring site is available in the ORC's state-of-the-environment report under the section "North Otago FMU" (Ozanne 2021).

The record of observations wasn't long enough for trend analyses to be done, but the report assessed the state of various attributes of river water quality in relation to national guidelines (https://environment.govt.nz/acts-and-regulations/freshwater-implementation-guidance/rivers-and-streams). The results (Figure 16) show that the river breaches the national bottom line for some of the *E. coli* guidelines for ecosystem health and also for contact recreation (swimming). Periphyton levels inferred from nutrient relationships indicate only fair water quality. All other attributes (ammonium, dissolved reactive phosphorus, nitrate, and suspended fine sediment) reflect good and excellent water quality. However this appears to be inconsistent with monitoring undertaken within the estuary which indicates elevated of sediment and nutrient loads (as described in Section 5.7).

Figure 16. Assessment of ecological state of rivers in the North Otago FMU, including the Hakapupu, from the Otago Regional Council's state-of-the-environment report (Ozanne 2021). Circles indicate that the assessment is based on a short time series and is, therefore, tentative. As a guide to interpreting the results, A = excellent, B = good, C = fair, D = unacceptable. The national bottom line is the threshold between the C and D bands. Source (Ozanne 2021).

In addition to the State of the Environment monitoring by ORC described above, further monitoring work is being carried out as part of the Toitū Te Hakapupu project. These are: telemetered water quality monitoring; annual water quality monitoring; environmental DNA (eDNA); fish passage characteristics and also ecological baseline monitoring. At this early stage, after the first summer/autumn season of data collection several points of interest have emerged. However, for the most part this first season has provided initial data that sets a baseline for future comparison but is too sparse to draw conclusions from.

One point of interest was a marked difference in sediment levels between the ten sites included in the ecological baseline monitoring (these sites are shown in Figure 17).

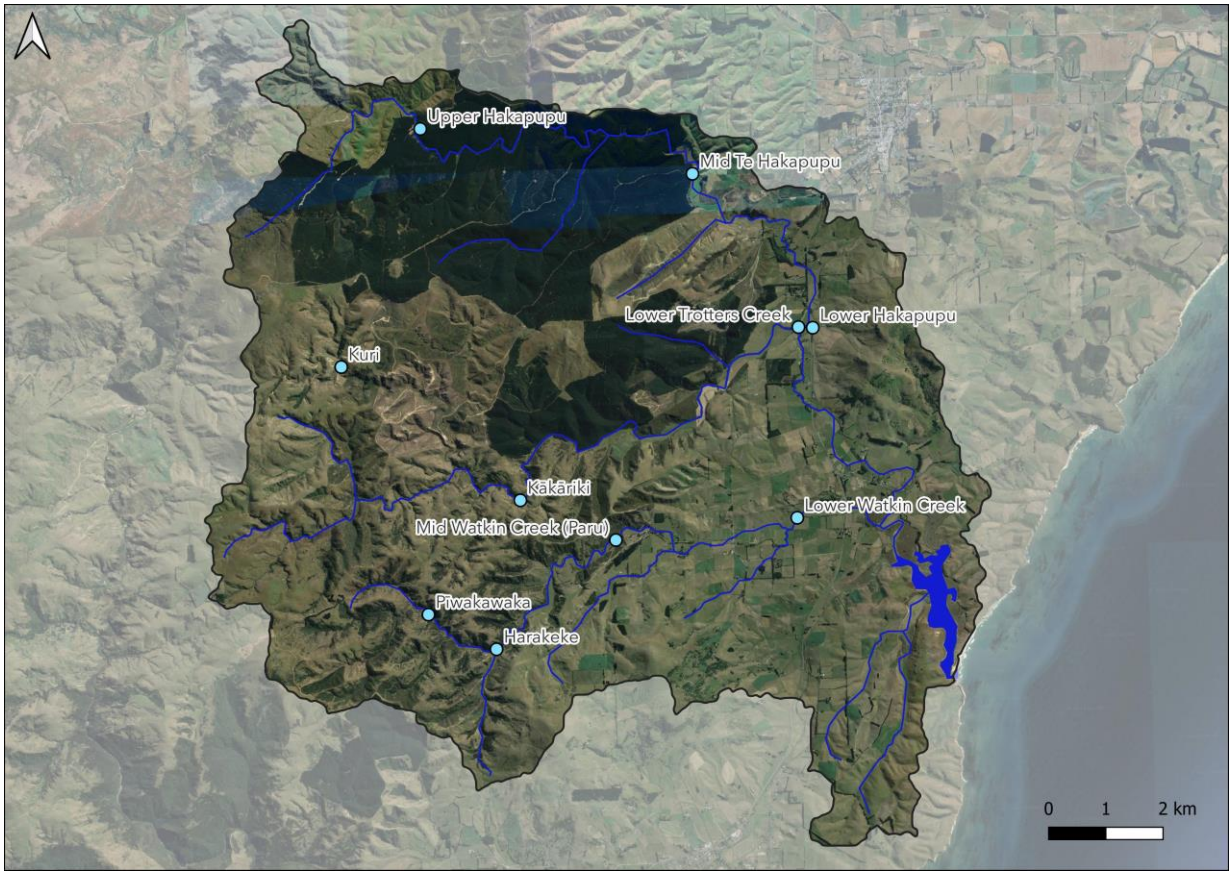

Figure 17. The ten water testing sites surveyed in the summer/autumn of 2023 in the Hakapupu catchment as part of the Toitū Te Hakpupu project.

Re-suspendable sediment levels (measured as using the Quorer method as part of the ecological baseline monitoring) at the mid Watkin site “Paru” were approximately three times higher than any other site (Figure 18). A similar result was observed when this site was tested in the year preceding the project by Kāti Huirapa and Ngai Tāhu Forestry.

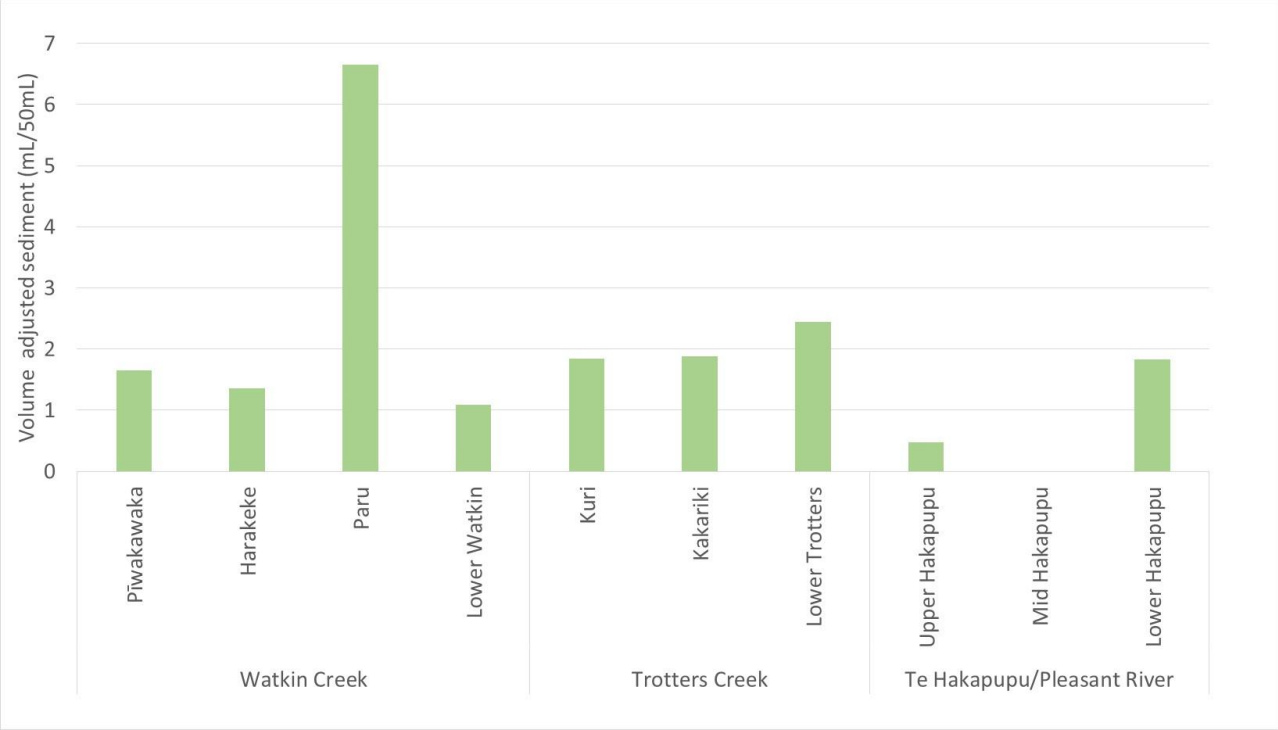

Figure 19. Volume adjusted re-suspendable sediment levels measured at ten sites in the Hakapupu catchment in the autumn of 2023. The Mid Hakapupu sample could not be analysed.

Secondly, measures of waterway ecological health tend to be ‘fair’ to ‘poor’. The habitat scores at the ten sites mentioned above were mostly in the ‘fair’ category. Six were ‘fair’, two were ‘poor’ and two were ‘good’. None were excellent. Similarly, the TICI index (Taxon Independent Community Index), which is a measure of ecological health derived from eDNA data, was ‘poor’ for four sites and ‘average’ for the fifth at locations lower in the catchment shown in Figure 20.

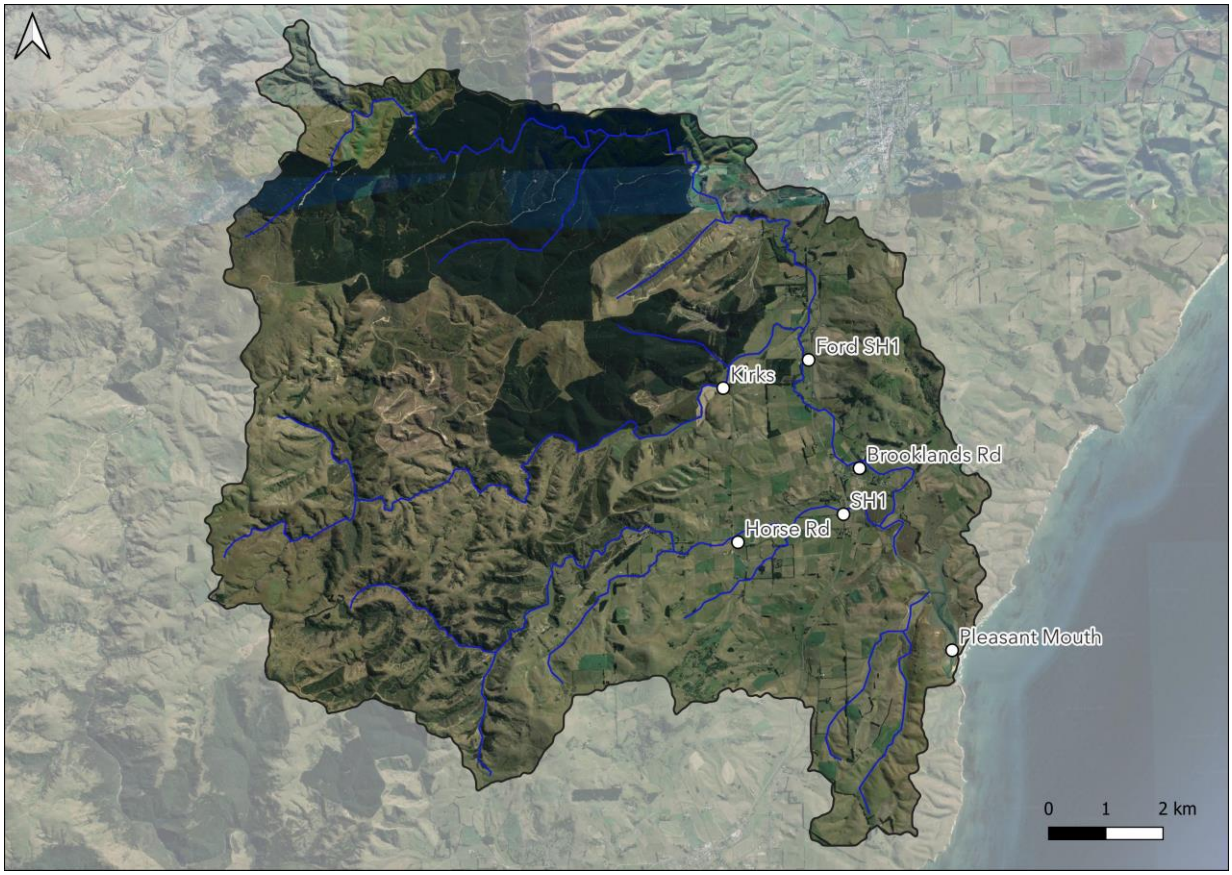

Figure 20. The five fresh water testing sites surveyed in the summer/autumn of 2023 and the estuarine site at the mouth of the Hakapupu – Pleasant river as part of the Toitū Te Hakpupu project.

Watkin Creek, despite having the unusually high sediment result at its Paru, site had the higher ecological health results both by habitat score and TICI index.

The third point is that eDNA sampling at six sites (results described in more detail in section 5.6) revealed three species of freshwater fish that are considered threatened and four species of estuarine/marine fish that are considered mahika kai.

Large variations in water clarity can be observed along tributaries within the catchment during periods of reduced flow. This may be caused by anoxic groundwater entering waterways at specific sites in the mid-catchment region. Longitudinal water quality monitoring undertaken as part of the Toitū Te Hakapupu project will investigate whether contaminants enter the tributaries with this groundwater.

5.9 Pest species

The catchment has moderate to low populations of common pest animals such as feral goats (*Capra hircus*), deer (*Cervus elephus*), pigs (*Sus scrofa*), and rabbits (*Oryctolagus cuniculus*)

based on anecdotal evidence, however no formal quantification is available. Anecdotal evidence also suggests deer numbers are increasing, especially over the last three years. Enhancement efforts including riparian and biodiversity plantings are more likely to be successful when the pressure on them from these species is low or is managed effectively.

The most prominent pest plants in the catchment include gorse (*Ulex europeaus*) and broom (*Cytisus scoparius*) which are in the sustained control programme set out in the ORC Regional Pest Management Plan (refer to Appendix A, section 10 for further detail). Spartina (*Spartina* spp) is present in the estuary and wetland complex, and is managed within the ORC's progressive containment programme for pest species. Colonies of spartina form dense grassy clumps. Within the estuarine area, vast meadows of Spartina can form causing a build-up of sediment. This can increase the risk of flooding and also alter the habitat for wading bird species and other estuarine flora and fauna (ORC Regional Pest Management Plan, 2019).

Willows (*Salix* spp) and alders (*Alnus glutinosa*) are also considered pests by some in the local community, on the basis that these trees are perceived to disrupt the flow characteristics of the waterways under high flow conditions, exacerbating flooding.[5]

Regenerating conifers such as *Pinus radiata* are evident in some areas that have been logged in the last five years.

Other pest plant species present but less prominent in the catchment that are also categorised as pests by the Otago Regional Council include nodding thistle (*Carduus nutans*), perennial nettle (*Urtica dioica*), old man's beard (*Clematis vitalba*), sycamore (*Acer pseudoplatanus*) and ragwort (*Senecio jacobaea*).

6 Kāti Huirapa ki Puketeraki values and perspectives

As noted in section 3, Kāti Huirapa are assessing the ecological and cultural health of sites in the Hakapupu catchment through their He Pātaka Wai Ora project. The approach used in He Pātaka Wai Ora is intended to be used by mana whenua to connect with and deepen their understanding of their awa and empower them to enact kaitiakitaka over these taoka.

To support the cultural health monitoring, Kāti Huirapa have prepared a Te Hakapupu cultural health monitoring plan (Rata-Te Raki, 2023). Values identified for monitoring include mahika

[5] Feedback recieved at community hui on 24 May 2023 at the East Otago Events Centre in Waikouaiti as part of Toitū Te Hakapupu Project

kai, mauri, mātauraka Māori and the kaitiakitaka of Kāti Huirapa who have a kaitiaki relationship with the Hakapupu.

These values are elaborated on further as follows:

- **Mahika Kai** – the availability and use of mahika kai supports and sustains connections to wāhi tupuna, and the retention and transfer of mātauraka across the generations. Populations of mahika kai species must be present and abundant across all life stages and must be plentiful enough for long term sustainable harvest. Safe access to the waterway must be available, kai and kaimoana must be safe to gather, safe to harvest and safe for human consumption. Management and harvesting practices must be able to be carried out in accordance with tikaka.
- **Mauri** - Mauri is a life-giving force that flows from our living world and down through whakapapa, connecting and binding together all aspects of our world. Kāi Tahu believe that people, flora, fauna and natural phenomena such as forest, waters, mist, wind and rocks possess a mauri or life force. Waterbodies and estuaries with an intact and strong mauri sustain healthy ecosystems and support mahika kai and other cultural values.
- **Mātauraka Māori** - Mātauraka Māori is a term that describes the body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity and cultural practices. It embraces individual, local and collective knowledge, Māori values, cultural expressions, perspectives and observations, being traditional, historical and contemporary.

  While this term is used in the context of cultural monitoring, the retention and passing on of Mātauraka Māori is only possible if resources such as mahika kai are still available.

- **Kaitiakitaka** – this is the cultural practice of guardianship or stewardship. For Māori, kinship between people and the natural world creates an obligation to care for te taiao, maintain it for future generations and act as an agent for environmental protection and decision-making, on behalf of tūpuna and mokopuna. The whakapapa connection with the natural environment imposes a kaitiakitaka obligation on mana whenua to protect wai and all the life it supports, in accordance with customs, knowledge, and mātauraka developed over many generations.

The first component of the cultural health monitoring framework assesses the significance of the site to mana whenua and asks whether the sites are traditional or contemporary sites. It also assesses whether mana whenua would return to the site in future. The second component assesses mahika kai values at a site. Inclusion of this component recognises that the mauri of a waterway is influenced by characteristics including indigenous flora and fauna and mahika kai yields.

The results of the cultural health monitoring will be invaluable in supporting a broader understanding of the values held by Kāti Huirapa in relation to this catchment and how they have been impacted by the use of resources in the catchment. This in turn will support identification of potential sites or actions which might be prioritised for protection or enhancement in order to recognise these values.

As this work is still underway by Kāti Huirapa, this report also relies on information in the Kāi Tahu ki Otago Natural Resource Management Plan (2005) as a placeholder.

The Kāi Tahu ki Otago Natural Resource Management Plan (2005) states that many of the smaller catchments that rise in the coastal lowlands of East Otago have cultural significance. These areas all have important sites - this is a testament to the occupation and use of these areas by Kāi Tahi ki Otago. The catchments were all part of seasonal trails, sources of mahika kai and resource gathering as well as places for hapu and whānau bonding.

Many place names along the East Otago Coast originate from the waka Āraiteuru. The names of the waves which wrecked the waka, plus the names of the many passengers of the waka are represented in the names of the reefs, hills, and mountains of East Otago.

The Hakapupu estuary is recognised as an important source of habitat for birds, kōhaka (nursery/spawning area) for juvenile fish such as pātiki (flounder) and īnaka (whitebait), while wetlands in the area were valued for tuna (eel).

Issues noted for East Coast catchments of potential relevance to Te Hakapupu include:

- Nutrient enrichment from sewage discharges and nutrient runoff
- Sediment deposition in lower catchments affecting shellfish and filling in channels as a result of upper catchment land development
- Lack of riparian margins free from stock gracing impacting īnaka spawning sites.
- Historic drainage and reclamation of estuary margins
- Wāhi tapu are numerous throughout the East Otago catchments. Extensive wetlands once existed, especially in the lower East Otago Catchments and estuarine areas which were largely covered with harakeke and other wetland species. Before farming practices shaped the land most streams were not confined to deep channels on flat land and tended to fan out across the land in multiple shallow channels and swamps.

Mahika kai and biodiversity issues identified in the plan include:

- Ecosystem dynamics and estuarine hydrology
- The impacts of grazing and sedimentation on īnaka spawning sites
- Loss of freshwater fish kōhaka areas

- Loss of wetlands
- Lack of fencing of remnant bush areas

Policies in response aim to promote the retention of indigenous freshwater fisheries and to promote the identification and protection of areas that support exclusively indigenous freshwater fisheries.

There are 22 listed archaeological sites within the catchment, many of which are mana whenua sites (Figure 21). Most of these sites are coastal and particularly clustered around the estuary which is testament to the historical importance of this area (https://archsite.eaglegis.co.nz/NZAAPublic) to mana whenua.

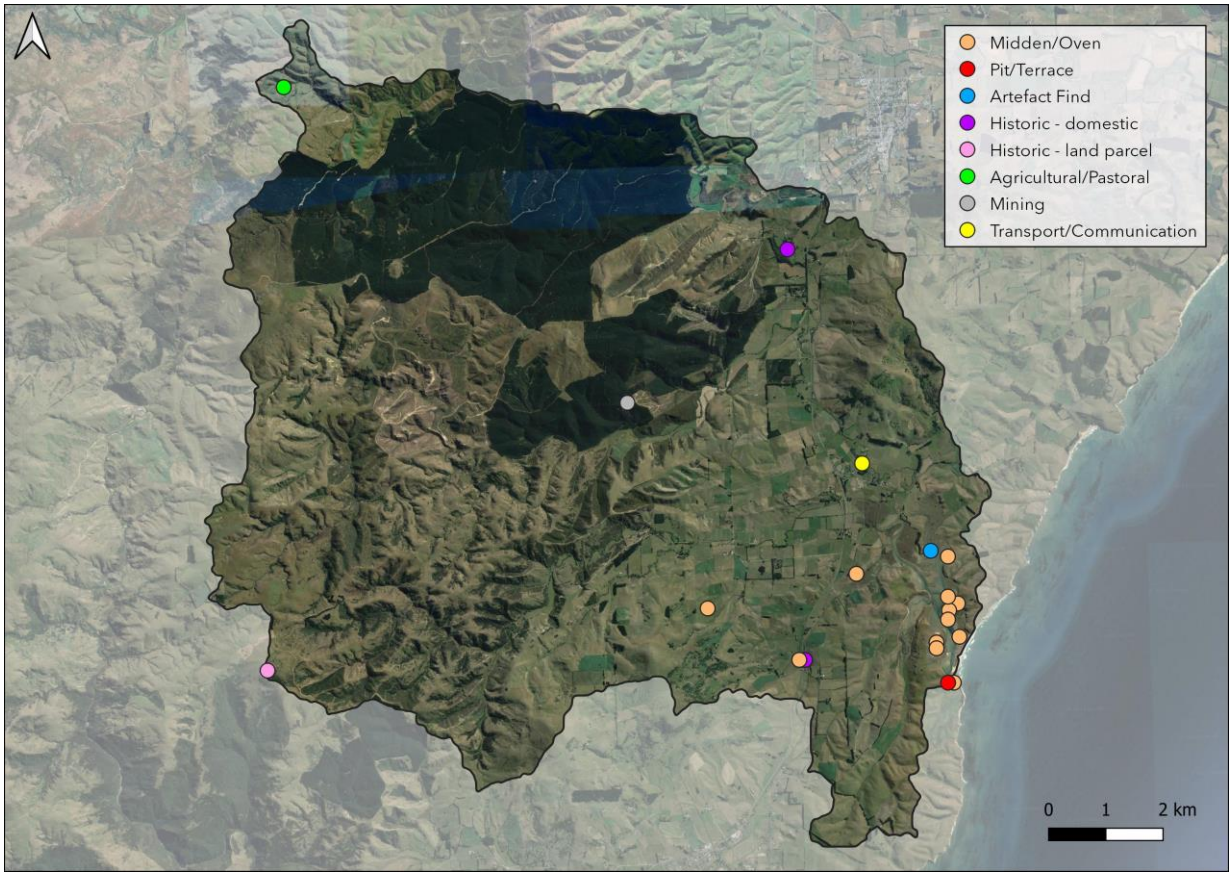

Figure 21. Archaeological sites recorded in the Hakapupu catchment (source: New Zealand Archaeological Association).

7 Community values and perspectives

7.1 Toitū Te Hakapupu Project community workshops

A community workshop for the Toitū Te Hakapupu Project was held in late May 2023 to support the development of a catchment management plan for the catchment, with a particular focus on the values present, issues in the catchment, and the community's aspirations for the catchment.

The hui was attended by 27 people, 20 of which were from the catchment's local community. This amounts to 10-15% of the residents in this lightly populated rural catchment.

Several themes arose from the workshop, with a summary of these provided below.

1. What is special/great about the Te Hakapupu/Pleasant catchment? - Important / special values? Special places?

Biodiversity throughout the catchment, and particularly the estuary, is important as is a good clean environment, including tuna (eels), īnaka, and birdlife. Historical and recreational values linked to the estuary were also valued. More broadly across the catchment the community valued the geology and its aesthetics, the four peaks for example, as well as the freedom from major infrastructure, its rural character and affordability.

2 & 3. What issues or challenges are facing this catchment and what is important for its management?

Among the issues, water quality was important; it's look and smell. Related to this were the issues of appropriate setbacks from waterways for farming and the restoration of waterside and wetland habitat.

Forestry was also identified by the participants as a significant issue. Concern was expressed about its continued expansion and the difficulty engaging off-shore forest ownership in relation to local issues. This was considered to result in risks such as people leaving the area, reduced water flows and the heavy traffic on narrow roads which is both dangerous and damaging. In addition, dust from the trucks and the pollen, increased risk of fire, and the forests as a reservoir for pests were noted as forestry related issues.

The lack of access to waterways and the estuary for fishing and recreation and to significant geological sites was also identified as an important issue. Participants felt that better communication and connection amongst the people in the area might help with this. This lack of access had negative impacts on mana whenua, as it restricted them from sites of cultural significance, limited their ability to undertake cultural practices (as did degraded freshwater values) and to either retain or regain knowledge and traditions.

In relation to the identified need for improved connection with and between the community, bio-cultural restoration was also discussed. Bio-cultural restoration relates to the link between environmental health, human health and wellbeing, and the connection between people. It was pointed out that efforts to improve water quality should also integrate these other social factors to bring the community along on the restoration journey in order for it to be a success.

Lack of knowledge, both historical and for good management of the land and the water was an important overarching theme.

4. What do you want the catchment to be like for future generations?

Objectives for the future included leaving this area in a better place for coming generations, to ensure it is beautiful and flourishing. There was also a desire to pass on knowledge, tikanga and practices that let future generations continue the journey. Other goals were to enjoy healthy restored wetlands and waterways for mahika kia and swimming, with farming as a land use suitably set back from these resources and forestry in better balance with community expectations.

7.2 Land and Water Regional Plan consultation by ORC

The ORC is developing a new Land and Water Regional Plan and has undertaken public consultation to support this process. Consultation was undertaken at the FMU level by ORC in community meetings in March and December 2022. The aim of these meetings was to support the development of the Land and Water Regional Plan for the North Otago FMU. The Te Hakapupu catchment lies at the southern end of this FMU.

Feedback from these meetings is described below in relation to environmental outcomes for the FMU and possible actions for managing water quality.

Environmental outcomes for the North Otago FMU (as outlined by the ORC during this consultation in accordance with the priorities set out in National Policy Statement for Freshwater Management 2020, discussed in further detail in Appendix A, section 3) focussed on several tiers of priority. At the top were: ecosystem health, threatened species, natural form and character of waterways and wetlands. The second priority identified was drinking water supply. The third was human contact, fishing, animal drinking water, cultivation and production of food, beverages and fibre, commercial and industrial use and finally hydroelectric power generation.

Individual feedback varied widely but supported the prioritisation. Comments on potential environmental outcomes ranged from concern about the management of pesticides and heavy metals to perceptions the environment is healthier in this FMU than 20-30 years ago. Concern was expressed that minimum baselines for waterway quality would be set relative to the already degraded state of those waterways, resulting in it being harder to elevate quality higher.

The challenge was observed of creating thriving ecosystems in a time frame and at an expense that does not unreasonably impact the local community.

Other comments noted the challenge of quantifying and enhancing threatened species, the need to manage the impacts of short periods of intense rainfall, and realistically setting productivity and industry expectations regarding the reliability of instream flows in dryland areas.

7.2.1 Possible actions for managing water quality

Feedback on consultation for the North Otago FMU highlighted several main themes regarding possible actions for managing water quality:

- Land use change from farming to forestry received substantial feedback. The overall tone was in support of this switch when conditions such as slope, erodibility, and farm productivity were met. However indigenous rather than plantation forest was preferred and the importance of best practice for forest harvest methods was recognised, set backs from waterways, and the planting of sensitive areas.
- Opinion was that existing regulation already addresses farming and forestry practices' impact on water.
- There was broad support for most actions proposed to mitigate adverse impacts on water, especially establishing and enhancing constructed wetlands.
- In contrast, there was diverse perspectives on actions proposed to manage farming, notably very little support for the use of winter barns, ensuring stock spend shorter periods (4 or 10 hours) on winter crop, or using nutrients on farm.
- There was very little support for the promotion of regenerative agriculture for the purpose of improving water quality.

The information derived from these meetings is a valuable FMU scale perspective on environmental outcomes, and actions that might be taken to achieve these outcomes. However, as compared to the broader area within the North Otago FMU, the Hakapupu catchment has a higher percentage of land cover as forestry and a lower intensity of agricultural production, including no irrigation.

8 Land use within the catchment

The Hakapupu catchment is likely to have been covered in forest a thousand years ago, as indicated by the potential ecosystems mapping (Figure 13). The forest has been cleared as Māori and Europeans settled and their populations and resource use increased. Today remnants of native forest cover a tiny fraction (0.1%) of the catchment. This is common in many other parts of New Zealand.

Over the last 150 years agriculture has been the main land use in the catchment. The intensity of the catchment's farm systems has not increased to the extent evident in the wider region over this period. The low rainfall, limited access to water from beyond the catchment for irrigation, and the soil types are probably mostly responsible for this. However, agriculture has still influenced water quality and related conservation values through vegetation clearance, drainage of wetlands and the channelisation of water ways to support farm management. It has also increased the amount of sediment entering waterways primarily through sheet and mass movement erosion, but also through stock access to waterways.

In addition, the increased availability of nutrients, including synthetic compound fertilisers have helped increase on farm productivity, however over-use/ poorly timed applications may increase the risk of nutrients such as phosphorus, entering waterways as run-off or via drainage and impacting water quality.

More recently plantation forestry of predominantly *Pinus radiata* has become the predominant land use (50.8%) within the catchment, taking over what was previously farmland (Figure 22). Farming now makes up 43.9% of the catchment. Conservation estate represents just 0.2% or 30 hectares. Tourism and recreational use also occupy just 0.2%. Residential use and industrial use both take up less than 0.1% of the catchment area.

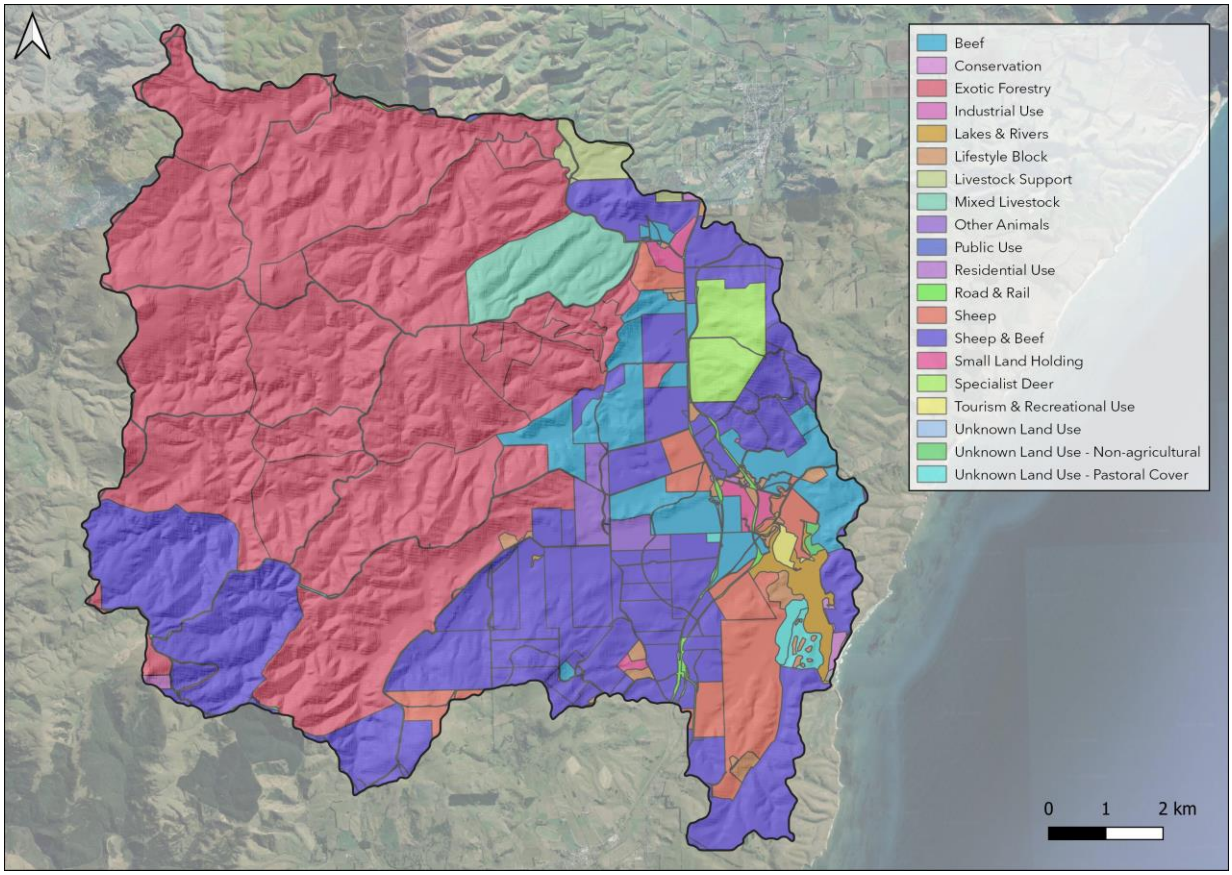

Figure 22. Land use type in the Hakapupu catchment (Source: ORC and community input at a community workshops held on February 2023 as part of Toitū Te Hakapupu project).

A more detailed analysis of forestry and farming, as the dominant land-uses within the catchment, is carried out below.

8.1 Forestry

Plantation forestry brings both benefits and risks to water quality. The benefits occur throughout the growing phase of the trees, but risks are associated with the harvest and replanting period, termed the 'window of vulnerability' (Phillips et al., 2015).

Forest estate in the catchment is located mainly in the steeper areas to the east of the catchment. There are 23 individual owners of which twelve have forestry as part of their farming business. Four owners have over 1,000 hectares planted, five have 100 – 300 hectares and the remaining 14 owners have less than 100 hectares planted.

At present four main forestry companies manage the vast majority of the planted area: PF Olsen; Wenita; Ngai Tāhu Forestry; and Calder Stewart.

Forestry's expansion has occurred through the conversion of farmland and mainly through the conversion of large areas rather than increases in smaller blocks of farm-forestry. A much

smaller amount of expansion has occurred through farm businesses establishing plantation forestry on their land.

Plantation forestry can provide environmental benefits, with canopy cover and root systems reducing sediment loss. Mature *Pinus radiata* forests can reduce sediment loss ten-fold relative to pasture and can store 8.5t of carbon per hectare per year (Basher 2013). It also helps reduce flood peaks. While this depends on the proportion of the catchment that is planted, forestry can reduce the peaks of small floods (up to a size that is expected annually) by 30-90% and by 20-50% in larger events but does little to stem peak flows during extreme floods (Basher, 2013).

Forestry also presents risks to water quality which are heightened by the scale of this land use in this catchment. The most significant risk, erosion leading to sediment loss, occurs during harvest and replanting.

8.1.1 Water quality risks related to forest harvest

Harvesting on steep terrain is challenging and usually results in erosion driven sediment movement. Erosion susceptibility has two components: predisposing factors and the preparatory/mitigation factors. The predisposing factors are notably slope and lithology (the general physical characteristics of the underlying rock types) which determine the inherent susceptibility of a land unit to erode (Satchell, 2018).

Preparatory factors influence the likelihood of land to erode. For example roading and skid site earthworks interrupt natural drainage patterns and undercut and/or create an unstable surface on slopes that were previously stable. The removal of the forest canopy using clear fell harvesting is also a preparatory factor that increases erosion and subsequent sediment contamination of water. Mitigation factors include the reinstatement of a forest canopy by tree planting or forest regeneration (Satchell, 2018).

8.1.2 Water quality risks related to earthworks and roading

The development of new road infrastructure typically has the greatest impact on erosion within a working forest. It will often create two main adverse effects:

1. Accelerated erosion arising from the increased soil exposure and instability.
2. Excessive sediment discharge into waterways through erosion of water control structure, fill-slope failures, and soil disturbance.

Fransen et al. (2000) summarised the key contributions of roads to erosion, as well as the sediment yields from plantations on steep and erodible sites in the Marlborough Sounds and Nelson. They found that:

- Surface erosion from roads at harvest times may increase sediment yield five-fold when compared with pre-harvest ungraded and lightly used roads. Logging truck traffic during rainfall events can markedly increase sedimentation from road surfaces.
- Surface sediment yield rates from permanent forest roads were generally an order of magnitude lower than estimated background catchment sediment yields. Sediment yields from harvest tracks may generate much higher proportions of catchment sediment yield.
- Infrequent, road-related mass movements (slips) are major sources of sediment within forests and they have the greatest potential to negatively affect streams. Road-related mass-movement erosion rates are up to three orders of magnitude greater than surface erosion rates.
- Mass-movement erosion rates decline with road age but may increase to earlier levels when the roads are upgraded for harvesting activities or when they are subject to intense storm events—such as those that caused major road-related mass movements in the Motueka Catchment in 1990 (Fahey and Coker, 1993).

8.1.3 Reestablishment of canopy cover

Forest cover mitigates soil erosion because: (1) the forest's root network reinforces the soil; (2) the interception and evaporation of rainfall by the forest canopy generally lowers the soil water balances; and (3) a permanent or semi-permanent forest that is not disturbed by cultivation, fire or grazing builds the soil through litterfall, nutrient cycling, and aggregate stability (Baille, 2015).

For New Zealand radiata pine plantations, there are 4-7 years from the time of harvest until the replanted crop establishes a full canopy. During this time plantation sites are more susceptible to erosion. This period is referred to as "the window of vulnerability".

While the importance of rapid canopy re-establishment is recognised in New Zealand plantation forestry, companies are reluctant to limit the size of clear-felling areas for economic and operational reasons. Nonetheless, research cited in Sidle and Ochiai (2006) and elsewhere suggests that limiting harvest area and/or partial harvesting are effective ways to reduce erosion. Excluding sensitive areas from commercial planting and harvesting is also effective. Because of the potential impact of sediment on water quality, these kinds of limitations are particularly pertinent to the project area.

Localised, storm-induced erosion events can mobilise woody residue during or after the harvesting of plantation forest. These events will mobilise sediment and can trigger soil slumps or erosion.

Woody debris resulting from harvest can both help in the retention of waterborne sediment but also become a risk when present in large volumes and on steeper slopes. Debris flows, which

are landslide generated sediment mixed with wood debris, can be much more damaging than water alone if confined to a channel.

Once vegetation is removed via harvesting, the overall erosion risk increases. Retaining a vegetation cover is the best way of limiting erosion and sedimentation risk to water quality. As such, management of the 'window of vulnerability' where the soil is exposed in the 4-8 years following planting before the canopy is established is important.

8.1.4 Impact of forestry on catchment hydrology

Plantation forestry can affect the hydrology of a catchment. Trees may transpire 50-200mm more water than grass and afforestation can influence a catchment's water balance depending on its scale and other local characteristics (Mourot et al., 2021). Applied tests of this relationship in New Zealand have had mixed results. The Mangahahuru stream catchment in Northland, when forest cover increased in the catchment by 30% (and with an 8% decrease in mean annual rainfall), showed a mean annual stream flow decrease of 44% over the 2013-18 compared to 2001-2007. But in the Oraka catchment in Waikato no clear effects of increased forest cover were seen, likely due to the larger size of the catchment, the smaller percentage of forest cover, and longer time lags (Mourot et al., 2021) .

The effects of afforestation on peak flows is considerable, particularly on small flood events (Davie & Fahey 2005). At Berwick, about 40km south of the Hakapupu catchment a reduction in annual peak flows due to afforestation of around a third was reported (Smith 1987). At Purukohukohu in Northland this reduction was 50% (Rowe 2003). A similar reduction was evident for floods with an average return period of 50 years (Duncan, 1995).

The impact of forestry on low flows is not as clear. The indication, based on four New Zealand data sets (Davie & Fahey 2004) is that low flows were affected less by afforestation, but the actual percentage change depended on which low-flow measure was used (there are many) and on the particular catchment.

8.1.5 Management of forest harvesting

One of the fundamental attributes of a good harvest plan that meets best practice guidance on earthworks and harvest planning, effective infrastructure construction methods, erosion and sediment control methods and structures, and the harvest plan and extraction methods is the one that is site specific, not generic (Gilmore, 2023).

A harvest plan should deploy available planning tools such as LiDAR, and be developed with reasonable understanding of the site, and has had a thorough field evaluation to confirm feasibility.

A harvest plan should provide for the full cycle of 'plan, do, check, act', enabling the plan to be regularly updated and adaptive to a range of situations through the duration of harvesting and post-harvest.

8.1.6 Riparian buffer

Wider riparian buffers will reduce the 'risk' of erosion and sediment input to the receiving environment. Riparian buffers alone, however, may not prevent the erosion. To increase the effectiveness for sediment control is to maximise ground cover, improve road runoff dispersal, increase resistance to probable surface flow paths and selectively increase buffer width in high-risk areas (e.g. steeper, larger).

It is therefore recommended that riparian buffers are left intact during the harvest operation. Where native vegetation is regenerating, it should be left intact and preferably promoted by other management intervention such as directional or machine-assisted harvesting.

8.1.7 Annual harvestable area

The identification of the harvestable area over multiple years is informed by the following aspects;

- Harvestable area excludes riparian buffer zone as described above, and;
- Harvestable area accounts for erosion risk assessment. Once vegetation is removed via harvesting, the overall erosion risk becomes high due to its susceptibility to erosion. In general, mechanised harvest operations compact soils, increasing bulk density and decreasing porosity and hydraulic conductivity (Basher et al., 2015; Brown et al., 2012; Millar et al., 2017). This change in soil property, especially on steeper slopes, can increase overland flow and therefore soil erosion potential. Erosion risk may be elevated for the first several years of the planting until their canopies develop and rainfall can be intercepted. This so-called window of vulnerability associated with harvested land (4-6 years) (Amishev et al., 2013; Bloomberg et al., 2019), needs to be managed to minimise the risk of erosion.

Alternatives to clear-fell harvesting techniques are available. Smaller scale and staggered 'coupe' harvesting are practical ways to minimise the likelihood and scale of soil erosion at harvest sites. While forestry companies are reluctant to limit the size of clear-felling areas for economic and operational reasons, small scale clear-fell harvesting should not be technically any more difficult than unrestricted clear-fell harvesting as a typical hauler setting in steep country is approximately 20 ha (Bloomberg et al., 2019; Tonkin & Taylor Ltd, 2022).

Limited studies provide evidence to suggest that the cost of erosion (realised through soil loss, lost production, damage, sediment effects) generally outweighs the cost of

prevention/mitigation (Jones et al., 2008; World Resource Institute, 2020). Typically, the lost production due to soil loss is accounted as predominant 'value' lost. There are, however, a range of other ecosystem services that will be lost through erosion, such as water retention, decomposition of waste, carbon accumulation, nitrogen and methane regulations (Dominati & MacKay, 2013). If these services are accounted for in the cost of erosion, the cost of prevention/mitigation is likely to be even greater.

8.2 Farming

The vast majority of farmland in the catchment (approximately 40% of the catchment area) is used for sheep and cattle production, with a small amount of deer farming and one classed as 'other animals'. There are around 70 properties each with a total area larger than 20 hectares, of which 12 have areas of farm-forestry within them. There are no arable farms.

Of the farmland, 77% is classified as high producing exotic grassland and most of the remainder is low producing grassland. Low producing grassland is characterised by species such as brown-top, sweet vernal, and fescue, coupled with native short tussocks in some places. In comparison, the high producing grassland contains species such as ryegrass/clover mixes, as well as lucerne. The ability of higher yield pasture species to thrive is influenced by higher soil fertility and adequate moisture.

8.2.1 Water use and management

There is just one consented water take and little water storage in the catchment, with Otago Regional Council maps (ORC) showing just four dam permits (https://maps.orc.govt.nz/OtagoMaps/).

This reflects the low volumes of water moving through the catchment. To increase water storage landowners would need to rely on high flow water takes. This means that larger storage would be required (at greater cost but used only intermittently) to buffer water use through dry periods and that a guaranteed volume of water to support farm production cannot be relied upon.

There are environmental benefits associated with the lack of widespread irrigation in the catchment. These include avoidance of effects on instream values, less disruption of natural groundwater levels and surface level flows, also less use of fertiliser which is linked to higher stocking rates both of which have their own impacts on water quality, aquatic organisms and habitat.

The distribution of high producing exotic and low producing pasture, coupled with the generally dry conditions in the catchment, would suggest an average stocking rate across the

catchment's farmland of 9 revised stock units per hectare[6]. The lack of irrigation in the catchment also influences pasture and crop productivity, which then impacts on stock carrying capacity.

Assuming the total stock units on farmland in the catchment are divided into 33% as cattle (six stock units per hectare) and as 67% sheep (one stock unit per hectare), stock water consumption in the catchment is estimated to be 85,000 – 200,000 litres per day, depending on seasonal requirements[7].

The Waitaki District Council Water Mains Network delivers water via the Stoneburn scheme through the Hakapupu catchment to Goodwood, as shown in Figure 23. The scheme takes water from out of this catchment, from the north branch of the Waikouaiti River.

The Stoneburn scheme is classed as rural agricultural supply because it is mainly for livestock, but it does service the small settlement of Goodwood. There are 77 points of supply throughout the catchment that range from 1000 – 2000 litres per day to 10,000 – 19,800 litres per day. Total allocation to the catchment is in the range of 130,000 – 240,000 litres per day.

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[7] Aqualinc (2004) assumptions - 6 RSU per head of cattle at 28 l/h/d, 1 RSU per head sheep at 2 l/h/day.

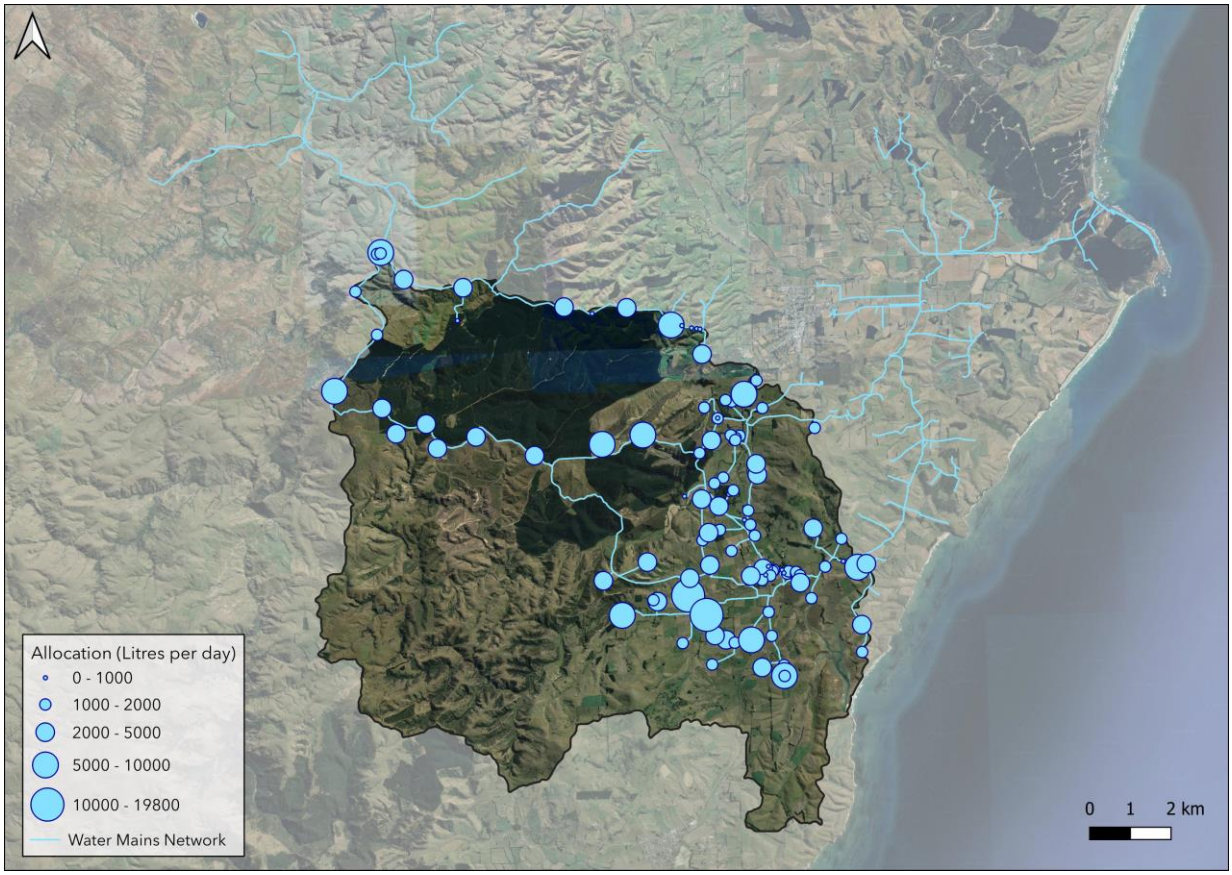

Figure 23. Waitaki District Council Water Mains Network in the Hakapupu catchment

Stock drinking water not supplied from this scheme is likely to be to be supplied with an on farm reticulated system, drawing from adjacent waterways or stock may be accessing waterways or small earth dams directly. Stock exclusion regulations will impact the ability of stock (except sheep) from accessing waterways directly, which may result in affected landowners having to seek alternative methods of supplying their stock with drinking water.

Waterways have been re-formed in many places historically to improve farm management. This typically results in a straighter, deeper waterway channel, which will increase flow velocity and thus erosion potential.

8.2.2 Cropping and intensive winter grazing

Agricultural land use such as cropping and intensive winter grazing increases the risk of erosion and subsequent mobilisation of the resulting sediment into adjacent waterways. This risk is particularly heightened when these practices occur on steeper slopes and in combination with the natural factors related to soils, weather and proximity to waterways (Climate-ADAPT, 2020; Nasirzadehdizaji & Akyuz, 2022).

Compaction and disturbance from heavy machinery such as tractors, particularly during the winter can also result in increased erosion risks.

Arable cropping in the Hakapupu catchment does not occur but intensive winter grazing on forage crop is common (Figure 24). The forage crops are typically brassicas such as swedes, rape, or kale.

Figure 24. Example of intensive winter grazing of crops in Otago showing bare soil (Source: Solis Norton).

The risk of erosion is reduced by careful selection and use of methods for preparing crop paddocks, conducting cultivation, and grazing the crop. Techniques such as minimum tillage and direct drilling of crop seed are beneficial. Feed planning and paddock management during grazing of the crop, such as having alternative areas to stand stock off during wet periods, also play a key role in managing the overall erosion risk.

An alternative to crops for winter grazing is currently being explored by some farmers in the region. It uses round bales of baleage distributed on pasture at around fifty metre intervals, approximating a grid network. The bales are fed sequentially, causing stock to move around the area gradually during the winter period. While not common practice yet, this initiative shows that farmers recognise the risk of winter grazing and are pursuing other options.

Similarly, the placement of troughs and practices around supplementary feeding, (e.g., baleage) also influence erosion risk. Stock movements and behaviour such as ‘camping’ around these areas can result in damage to pasture cover, resulting in exposed soil over time. Following grazing on forage crops, back fencing can help reduce pugging damage and minimise the risk of overland flow.

Intensive winter grazing is a commonly used and important method of bridging winter feed shortages so it has a strong influence on overall farm productivity. The use of crops to bridge feed deficits in farming will become more important if climate change predictions of more intense rainfall and droughts prove correct. Heavy or prolonged rainfall can have a very large impact on the amount of sediment lost through this practice, so effective management is essential. Guidelines to assist farmers in this regard are well established and are likely to become further embedded into farming practices with the introduction of winter grazing consents under the National Environmental Standards for Freshwater (see Section 9.2 below).

As a driver of farming's impact on water quality, intensive winter grazing is an ideal practice to focus on. There are numerous tools and guides to inform best practice, many mitigations are low cost as they focus on management, plus mitigations occur at the point of sediment mobilisation which is the generally the best place to act.

Intensive winter grazing is uncommon in lifestyle block properties which are seldom dependent just on animal production for profitability.

There are three active consents in the Hakapupu catchment for winter grazing in the 2023 winter season. However, it was noted that compliance satellite imagery and aerial assessments indicated that there was likely more widespread use of this practice than is actually consented for (ORC Acting Manager Consents, personal communication, 4 August 2023).

8.2.3 Fertiliser use

Farming systems in the Hakapupu catchment are of medium to low intensity which indicates fertiliser application rates will be lower than in more productive/high intensity regions. In these systems nitrogen is often used on the comparatively small part of the farm used to grow winter crops to boost growth but seldom used to boost pasture growth. Phosphorus is often applied in a structured maintenance schedule that is supported by soil testing and dependent to some extent on the profitability of the farm from year to year. The application of other elements, including lime, is more variable between farms (EM Consulting, 2022).

In some cases, and even at lower application rates significant amounts of these nutrients can still enter water ways. Rainfall soon after their application can mobilise them into the water flow. Rainfall after a prolonged dry period can flush a pulse of accumulated nutrient into the soil water which can then drain to water courses.

The measures of nitrate, ammonia, and dissolved reactive phosphate are all in the A band (excellent) based on State of the Environment water testing results from the Hakapupu at the Patterson Road ford (Figure 16). This broadly indicates that fertiliser application upstream from that location uses good practice and that the nutrient balance is appropriate in that the volumes applied do not greatly exceed the volumes converted into farm produce.

8.3 Lifestyle Blocks

The analysis of land use in the catchment (Figure 22) indicates that there are between 36-39 properties classified as lifestyle blocks or small holdings within the catchment (less than 20 ha), totalling approximately 130 ha and making up only 1% of catchment area. This figure is likely to be indicative only, given other properties fall within this area range but are classified differently e.g. as sheep and beef properties.

Lifestyle blocks vary greatly in terms of the types of livestock reared and presence of crops due to their smaller scale. These small operations may not always fall under the same regulatory requirements as larger farms, particularly in relation to regulations relating to freshwater management.

However, the management of lifestyle blocks may still impact environmental factors such as water quality. Lifestyle blocks often have limited productive areas which may result in stock being confined to smaller grazing areas without sufficient space for rotational grazing. Without proper rotation, continuous grazing in small areas can lead to overgrazing and the removal of vegetation cover, leaving the soil vulnerable to erosion, as well as soil compaction.

9 Key legislative tools

Legislation, regulations and planning instruments can be a driver for changes in land use and environmental management practices or may restrict what landowners can do with their land. This section provides an overview of the regulatory context anticipated to directly affect land use and environmental management in the Hakapupu catchment, and the development of the catchment management plan. A more detailed description of the legislative context affecting management of the environment in this catchment is provided in Appendix A.

9.1 National Policy Statement for Freshwater Management 2020

The National Policy Statement for Freshwater Management 2020 (NPSFM) directs local authority management of freshwater under the Resource Management Act 1991.

Te Mana o te Wai is the fundamental concept underpinning the NPSFM. This is defined as:

> *"a concept that refers to the fundamental importance of water and recognises that protecting the health of freshwater protects the health and well-being of the wider environment. It protects the mauri of the wai. Te Mana o te Wai is about restoring and preserving the balance between the water, the wider environment, and the community." (clause 1.3)*

The NPSFM sets out a hierarchy of obligations, so that natural and physical resources are managed in a way that prioritises:

- First, the health and well-being of water bodies and freshwater ecosystems
- Second, the health needs of people
- Third, the ability for people and communities to provide for social, economic and cultural well-being, now and in the future.

Councils are also required to manage freshwater through freshwater management units (FMUs). FMUs can be all or any part of a water body or water bodies, and their related catchments that regional council determines is appropriate for freshwater management.

9.2 National Environmental Standards for Freshwater

The National Environmental Standards for Freshwater (NESFW) sets out requirements for activities that pose risks to freshwater and freshwater ecosystems. This includes feedlots and stockholding areas, intensive winter grazing, works in or within 100 metres of wetlands, structures in rivers/streams, agricultural intensification (increases in the area of a farm used for dairy or dairy support, or increases in irrigation area).

The regulations affect all properties with

- Five hectares or more of horticultural land use,
- Twenty hectares or more of pastoral or arable land use, or
- Twenty hectares or more of a combination of any two or more of the land uses.

Requirements relating to specific activities are set out below:

Land use intensification - resource consent is required for land use intensification. This includes conversion of land to dairy farming, conversion of plantation forestry to pastoral use, and increases in irrigation area for dairy farming by more than ten hectares.

Intensive winter grazing - Farms will require a consent to carry out intensive winter grazing where intensive winter grazing is greater than 50 ha or 10% of the farm, or on a slope greater than ten degrees. In addition, stock must not be within five metres of a waterway and forage crops and intensive winter grazing must not be within a critical source area. Consents must be in place by 1 May 2023.

Nitrogen cap - The NESFW applies a cap to the amount of nitrogen fertiliser than can be applied of 190 kg N/yr on any hectare of pastoral land (land grazed by livestock).

Activities in, or within ten metres of a natural inland wetland - Vegetation clearance, earthworks and the taking, damming or use of water within, or within ten metres of a natural

inland wetland are only permitted if they relate to specified activities such as restoration work or scientific research, otherwise consent will be required.

9.3 Resource Management (National Environmental Standards for Plantation Forestry) Regulations 2017

The National Environmental Standards for Plantation Forestry (NESPF) aims to maintain or improve the environmental outcomes associated with plantation forestry activities, and to increase certainty and efficiency in the management of plantation forestry activities.

The NESPF requires resource consent for activities where the environmental risk is higher and requires more site-specific oversight, or where permitted activity conditions cannot be complied with, and sets out conditions to be complied with.

Conditions on plantation forestry activities include:

- setback requirements e.g. fire metres setback from waterways with a channel width of less than three metres, and wetlands larger than 0.25 hectares, ten metre setback in a range of situations including significant natural areas and rivers with a channel width greater than three metres
- implementation of erosion and sediment control measures
- requirements to prepare, and comply with, management plans for earthworks, forestry quarrying and harvesting to enable site specific environmental risks to be identified and managed up-front

The NESPF contains tools that enable location specific assessment of risk:

- the Erosion Susceptibility Classification – classifies all land according to erosion risk, with consent requirements for specified forestry activities in high or very high-risk categories (Figure 10).
- Wilding Tree Risk Calculator – this includes factors such as type of species, prevailing wind, and downwind land use.
- Fish Spawning Indicator - used to manage the timing of activities that involve disturbance of the bed of a river or a lake, or a wetland in fish spawning locations.

Afforestation and forestry activities (such as river crossings, earthworks, harvesting) in the catchment that occurred since this NPS-PF has come into effect are required to comply with it. For existing forestry areas (that pre-date the NPS-PF), some rules will only be given effect to at the time of the second or subsequent rotations e.g. setbacks and tree species.

9.4 Resource Management (Stock Exclusion) Regulations 2020

The Resource Management (Stock Exclusion) Regulations 2020 (referred to as the "stock exclusion regulations") require stock to be excluded from waterways by certain dates. All stock (beef cattle, dairy cattle, dairy support cattle, deer or pigs) are required to be excluded from wetlands by 1 July 2025 at the latest, but from Regionally Significant Wetlands by 1 July 2023. This will apply to Te Hakapupu Pleasant River Estuary Wetland Complex, where it is identified as a regional significant wetland in the operative ORC Regional Plan: Water.

Beef cattle and deer are to be excluded from waterways by a minimum of three metres in a range of situations including:

- from all lakes and rivers by on low slope land,
- regardless of slope where adjoining land is used for intensive grazing or grazing on pasture irrigated within the previous 12 months.

Dairy cattle, dairy support cattle and pigs are to be excluded from waterways by a minimum of three metres regardless of slope.

Where all or part of a lake or river is already permanent fenced or has riparian vegetation that effectively excluded stock by 3 September 2020 they do not need to meet the 3 m setback.

These regulations will impact landowners in the Hakapupu catchment, with cattle observed to have access to waterways in a number of locations throughout the catchment.

As noted above (refer to Section 5) the identification of wetlands is being undertaken over a number of years by the ORC (as required under the NPSFM), and the number of identified wetlands in the catchment is anticipated to increase.

9.5 Part 9A of the Resource Management Act 1991 and Resource Management (Freshwater Farm Plans) Regulations 2023

Part 9A of the Resource Management Act require farms to have a freshwater farm plan to assist with managing and reducing the impact of farming on the freshwater environment. They are required where the farm is:

- 20 hectares or more in arable or pastoral use
- 5 hectares or more in horticultural use
- 20 hectares or more of combined use.

The regulations set out the requirements for these farm plans, including the identification of risks to freshwater, and actions to mitigate these risks. These plans are been phased in across the country, with rollout in parts of Otago likely from early 2024, potentially starting with

the North Otago FMU (ORC Council Meeting - 28 June 2023 Agenda Item 8.1. Freshwater Farm Plans).

These plans are anticipated to further support water quality protection and enhancement efforts occurring in the catchment, including through actions focused on improved management of critical source areas and plans to manage and restore wetlands.

10 Summary - management issues

As with many other rural catchments in New Zealand, historic clearance and development of land, along with current land management practices has resulted in significant biodiversity and wetland loss, and associated impacts on water quality effects. Based on the assessment of catchment characteristics and current land use within the catchment, a number of key issues have emerged. An initial discussion of these key issues is provided below. Further work on addressing these issues will be progressed as the catchment management plan is developed, and further monitoring work is undertaken.

While issues are addressed separately below, it is critical to note that they are inherently interlinked, and that they must responded to holistically, taking a ki utu ki tai approach.

10.1 Sediment and erosion risk

The geology of the catchment – with the presence of siltstone, sandstone and also schist – means that a large proportion of the catchment is vulnerable to erosion, as outlined in Section 5. This vulnerability has been further exacerbated by historic land clearance and land use practices. Erosion and sedimentation is not only an issue for water quality, but results in a loss of soil nutrients and can cause a decline in soil fertility.

As noted in Section 8.1, plantation forestry can reduce sediment loss through its canopy cover and root systems, whilst also reducing peak flood flows – which in turn can also help reduce sediment loss in downstream areas outside of the forestry estate. However, the harvesting and replanting period, and associated earthworks and roading creates a risk of erosion leading to sediment loss.

The historic clearance of land for farming combined with the geology of the area and alteration of waterways to suit farm management has resulted in an increased risk of erosion. This in combination with farming practices such as intensive winter grazing increases the risk of erosion at a localised scale (Climate-ADAPT, 2020; Nasirzadehdizaji & Akyuz, 2022).

Erosion and sediment loss due to winter grazing on forage crops is an important consideration. This farming practice is often a key driver of productivity for the types of farms common in the Hakapupu catchment. But this practice is also a key source of erosion. Best

practice for intensive winter grazing is well established and there is a multitude of guidance documents to assist with it. Even so, under winter conditions and heavy rainfall erosion due to this practice is a challenge to prevent.

Several regulatory requirements aimed at protecting and enhancing freshwater quality have recently come into effect or will soon come into effect. With regard to sedimentation, stock exclusion and consents for winter grazing are likely to see improvements in riparian management and intensive winter grazing, as well as the management of critical source areas.

10.2 Water quality

While water quality monitoring indicates that nitrogen and phosphorous levels are good at the State of the Environment monitoring site at Paterson Road, estuary monitoring indicates that elevated nutrient loads have entered the estuary. Monitoring at the Paterson Road site also indicated breaches to the national bottom line for some of the *E. coli* guidelines for ecosystem health and also for contact recreation (swimming). Monitoring undertaken as part of the Toitū Te Hakapupu project so far suggests that water quality varies throughout the catchment. Most of the sites sampled to measure waterway ecological health rank as 'fair' or 'poor'.

While State of the Environment monitoring indicated that suspended fine sediment levels were 'excellent', this may not be an accurate reflection of sediment loads in waterways. This monitoring occurs when flows are not elevated. Sediment mobilisation from soils to waterways usually occurs during overland flow events, which are related to high precipitation events and floods. Elevated sediment and nutrient levels were identified in State of the Environment monitoring for the estuary in 2021, with mud levels indicating that the macrofauna community is unbalanced and dominated by a small number of tolerant species.

Water quality in some parts of the catchment may be influenced by anoxic ground water seeps. The impact of these seeps would be exacerbated by low flow conditions. Further study as part of the project will investigate this issue and its implications for the health of aquatic organisms.

As with the management of sediment described in the section immediately above, regulatory requirements aimed at protecting and enhancing freshwater quality have recently, or will soon, come into effect. Consents for intensive winter grazing, stock exclusion from waterways and wetlands and freshwater farm plans (including actions for the management of critical source areas, and the management and restoration of wetlands) will all contribute to reducing the effects of farming activities on waterways. Further actions identified for water quality enhancements can build on these regulatory requirements.

10.3 Water quantity

Waterways within the catchment have low instream flows. Abstraction of water (from waterways or groundwater) is not considered to be an issue of significance in this catchment, given the lack of water takes and irrigation within the catchment. The low flows within the catchment may however have an impact on freshwater values. There is high degree of uncertainty about the potential impact of plantation forestry on low flows within the catchment.

Heavy rainfall events and floods can have a significant impact on erosion and sedimentation, through mobilisation of sediment by sheet flow or mass movement. Sediments can be deposited in receiving environments instream, out of channel in flood plains, in the estuary and beyond into the coastal marine area.

The historical clearance of native vegetation surrounding wetlands, as well as on flat land bordering the waterways throughout farmland can exacerbate flood risk. Native riparian plantings can act as a buffer against increased flows during critical, high rainfall events.

Exotic species such as willows have been used to mitigate erosion risk and stabilise stream banks throughout New Zealand. However, willows can also be detrimental in a wide range of situations, potentially acting as silt traps, or creating blockages within a channel that then promotes local scour or reduces the carrying capacity of the floodway; potentially exacerbating flooding of adjacent land.

Flood risk is predicted to increase as a result of climate change, and so careful consideration of flood management and mitigation options should be factored into any riparian actions, or the construction of new infrastructure that could be particularly vulnerable to flooding, or exacerbate the effects of flooding e.g. bridges. Heavy rainfall events and flooding can also increase the risk of erosion and mobilisation of sediment, further highlighting the importance of sediment mitigation in this catchment.

10.4 Biodiversity

As with all of New Zealand, this catchment has experienced a significant loss of biodiversity with indigenous forest areas, kanuka and manuka, matagouri and grey shrub collectively covering 1% of the catchment and herbaceous saline vegetation covering 0.9% of the catchment. The historic area of the wetland – estuary complex has significantly reduced in area, and the remaining area is affected by the presence of weed species, drainage and pastoral land use.

There is significant opportunity to better protect remaining areas with biodiversity values (such as the wetland – estuary complex), and to enhance biodiversity, including through the extensive planting programme being undertaken as part of the Toitū Te Hakapupu project.

Improvements in land management practices focused on water quality enhancements are anticipated to also support instream biodiversity. The presence of īnaka indicate that significant biodiversity gains can be made through riparian fencing and planting of spawning habitat in the lower reaches of the Hakapupu. Previous work undertaken by the Department of Conservation has mapped spawning sites in the catchments and should be used to inform targeted planting of suitable species. A more up to date īnaka spawning survey would benefit this work.

The presence of a high proportion of migratory fish highlights the importance of maintaining fish passage throughout the lower and mid reaches of the Hakapupu catchment. A fish passage survey would help identify whether these species have unrestricted access to suitable habitat, and how passage might be enhanced.

Protection and enhancement actions focused on freshwater species would also be likely to support mahika kai species.

Restoration work occurring within the catchment will require ongoing maintenance work to protect plant species from pest species - including pest plants and animals. The increasing area of plantation forestry may function as a reservoir for some of these pests so increased effort will be required for pest management due to both a greater sensitive area and higher pressure from them.

10.5 Te Hakapupu Pleasant River Estuary Wetland Complex

The estuary is a critical receiving environment in the catchment. It has declined to approximately 2% of its historic size but remains the largest wetland – estuary complex in the North Otago Freshwater Management Unit (FMU). It is classified as a Naturally Uncommon Ecosystem, meaning historically rare and as 'vulnerable' (ecosystem red-list criteria, International Union for Conservation of Nature) due to historic and ongoing loss in extent and decline in its ecological integrity.

The wetland – estuary complex has a range of natural values, including threatened species and mahika kai species, as well as recreational values. In addition, as with waterways throughout the catchment, Kāti Huirapa values are associated with the wetland – estuary complex including kaitiakitaka, mauri and mātauranga Māori, although these are currently degraded, or not able to be fully expressed. For example, without an abundant mahika kai resource, mātauranga Māori is not able to be passed on through practices associated with mahika kai practices to rangitahi.

There is significant scope for salt marsh protection and restoration, with the largest gains likely achieved through restoring the natural connectivity (i.e. removal of flapgates, causeways), and re-flooding areas of existing or previous estuary habitat, particularly in the upper estuary where herbfield vegetation persists. Active management to reduce catchment nutrient and

sediment loads, and to prevent further salt marsh losses and enhance existing habitat will be necessary to prevent further decline, or to support enhancement of the estuary. The remaining areas of salt marsh should also be protected and enhanced to prevent further losses with restoration undertaken in suitable areas (Roberts et al 2022).

10.6 Access

Feedback received at community workshops has indicated that there is a lack of access to parts of the catchment, including to the wetland – estuary complex, waterways, and the distinctive peaks situated within the catchment. Access to these places strengthens their connection to the catchment and fosters the stories, knowledge and history of the people and the place. Private landownership and the inability to follow historic trails or carry out traditional practices has particularly impacted Kāti Huirapa.

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Appendix A: Legislative Context

1 Overview

Legislation, regulations and planning instruments can be a driver for changes in land use and environmental management practices, or may restrict what landowners can do with their land. This section provides an overview of the regulatory context affecting land use and environmental management in Te Hakapupu.

The figure below provides an overview of hierarchy of legislation and planning instruments of managing landuse activities in New Zealand under the Resource Management Act, although it should be noted that the Government is repealing the Resource Management Act (RMA) and is undertaking a reform of New Zealand's environmental management legislation. The RMA will be replaced with three new Acts: the Spatial Planning Act, the Natural and Built Environment Act (NBA) and the Climate Adaptation Act.[8]

The Spatial Planning Bill provides for the development and implementation of long-term, strategic spatial planning across New Zealand, through the development of regional spatial strategies.

The NBA will take over important functions from the RMA, including national direction and consenting processes. The focus will shift from managing the effects of an activity to promoting positive outcomes, while also managing adverse effects.

The Climate Adaptation Act will be focused to addressing complex issues associated with managed retreat and funding and financing adaptation.

[8] https://environment.govt.nz/assets/publications/rm-reform-natural-and-built-environment-act.pdf

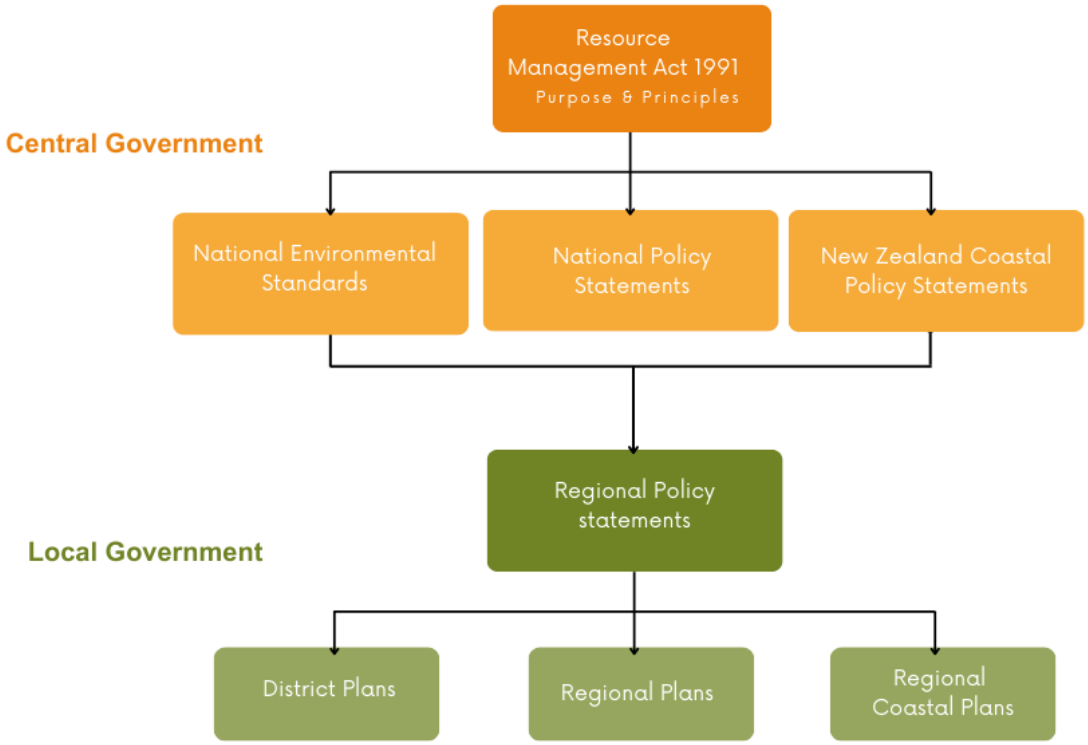

Figure 25 Hierarchy of legislation and planning instruments under the Resource Management Act 1991.

Regional councils also have a mandate under Part 2 of the Biosecurity Act 1993 to provide regional leadership in activities that prevent, reduce, or eliminate adverse effects from harmful species present in their region. The ORC Regional Pest Management contains the framework to manage or eradicate specified organisms in the Otago region.

Legislation and planning instruments of particular relevance to managing the effects of activities on freshwater are outlined below.

2 Resource Management Act 1991

The Resource Management Act 1991 (RMA) is the key piece of legislation setting out how the environment is to be managed in New Zealand. Its purpose is to achieve sustainable management of our resources. The RMA requires local authorities to set rules and requirements to manage activities affecting the environment.

Territorial authorities (district and city councils) manage activities such as sub-division and development (including earthworks), while regional councils manage activities which affect

natural resources such as water, air, soil or the coast. This includes managing activities impacting water quality and quantity such as the discharge of contaminants. Councils are responsible for developing plans that set objectives, policies and rules to manage the effects of activities to achieve sustainable management.

Under the RMA the government can develop National Policy Statements (NPS) for matters of national significance and must prepare a New Zealand Coastal Policy Statement. NPSs direct council management of particular resources or activities, to support a nationally consistent approach to issues. The National Policy Statement for Freshwater Management 2020 is of particular relevance to catchment management in the Hakapupu. This is discussed in further detail below.

While the National Policy Statement for Highly Productive Land and the New Zealand Coastal Policy Statement provide important context and guidance in terms of the value placed on productive land and our coastal environment, they are more relevant in areas where there is pressure from non-productive land uses (in the case of highly productive land) or managing the impacts of activities, subdivision and development (in the coastal environment) e.g. with regard to natural character and managing risks from coastal hazards. The Hakapupu catchment is not experiencing these pressures currently.

The RMA also enables central government to develop National Environment Standards (NES). These are regulations which prescribe technical standards, methods and requirements that councils must either apply as a minimum (councils may be able to impose stricter standards), or absolutely (i.e., a council cannot impose a stricter standard).

The key NESs of relevance to the Hakapupu catchment are the National Environmental Standards for Plantation Forestry 2017 and the National Environmental Standards for Freshwater 2020.

Central government can also develop regulations under the RMA for a range of matters including administrative and substantive matters, for example from the form or content of water permits, the practice and procedures of Environment Court. Of particular relevance is the ability of central government to prescribe measures for the purpose of excluding stock from water bodies. This has resulted in the development of The Resource Management (Stock Exclusion) Regulations 2020. These regulations are addressed in more detail below.

3 National Policy Statement for Freshwater Management 2020

The National Policy Statement for Freshwater Management 2020 (NPSFM) directs local authority management of freshwater under the Resource Management Act 1991.

Te Mana o te Wai is the fundamental concept underpinning the NPSFM. This is defined as:

> *"a concept that refers to the fundamental importance of water and recognises that protecting the health of freshwater protects the health and well-being of the wider environment. It protects the mauri of the wai. Te Mana o te Wai is about restoring and preserving the balance between the water, the wider environment, and the community." (clause 1.3)*

The NPSFM sets out a hierarchy of obligations, so that natural and physical resources are managed in a way that prioritises:

- First, the health and well-being of water bodies and freshwater ecosystems
- Second, the health needs of people
- Third, the ability for people and communities to provide for social, economic and cultural well-being, now and in the future.

The NPSFM requires an integrated approach which recognised the interconnectedness of the whole environment, including the impacts of land use and development on water bodies and receiving environments.

Councils are also required to manage freshwater through freshwater management units (FMUs). FMUs can be all or any part of a water body or water bodies, and their related catchments that regional council determines is appropriate for freshwater management.

The NPSFM contains a National Objectives Framework (NOF) which enables a consistent regulatory approach across New Zealand, including through rules in regional plans, setting limits on contaminants and resource use, as well as a consistent approach to monitoring. The approach set out in the NOF includes identification of values and desired environmental outcomes for these values. It also requires baseline and target states of waterbodies to be identified across a number of attributes.

The NPSFM also directs councils to develop action plans for achieving target attribute states. These plans are compulsory in certain cases (for fish passage, or to achieve target attribute states in Appendix 2B) and optional in others (to achieve other target attribute states including those in Appendix 2A or address degradation).

Attributes requiring a regional council to develop an action plan include fish in rivers, deposited fine sediment, dissolved oxygen, and macroinvertebrates. Action plans are not regulatory plans but do set out a regional council's commitment and approach to achieve targets for relevant targets attributes.

The Hakapupu catchment management plan (to be developed as part of the Toitū Te Hakapupu project) is not an action plan under the NPSFM, however it may inform any action plan developed by the ORC and can identify actions that can help protect or enhance attribute

states, to achieve environmental outcomes developed in consultation with tangata whenua and community.

4 National Environmental Standards for Freshwater

The National Environmental Standards for Freshwater (NESFW) sets out requirements for activities that pose risks to freshwater and freshwater ecosystems. This includes feedlots and stockholding areas, intensive winter grazing, works in or within 100 metres of wetlands, structures in rivers/streams, agricultural intensification (increases in the area of a farm used for dairy or dairy support, or increases in irrigation area).

The regulations affect all properties with

- 5ha or more of horticultural land use,
- 20ha or more of pastoral or arable land use, or
- 20ha or more of a combination of any two or more of the land uses.

Land use intensification

The NESFW also requires resource consent for land use intensification. This includes conversion of land to dairy farming, conversion of plantation forestry to pastoral use, and increases in irrigation area for dairy farming by more than 10ha.

Intensive winter grazing

Farms will require a consent to carry out intensive winter grazing where intensive winter grazing is greater than 50 ha or 10% of the farm, or on a slope greater than 10 degrees. In addition, stock must not be within 5 metres of a waterway and forage crops and intensive winter grazing must not be within a critical source area. Consents must be in place by 1 May 2023.

Nitrogen cap

The NESFW also applies a cap to the amount of nitrogen fertiliser than can be applied of 190kg N/yr on any hectare of pastoral land (land grazed by livestock).

Activities in, or within 10 m – 100 m of a natural inland wetland

Vegetation clearance, earthworks and the taking, damming or use of water within, or within 10 m of a natural inland wetland are only permitted if they relate to specified activities such as restoration, wetland maintenance, biosecurity work or scientific research, otherwise consent will be required.

Taking of water, damming, diversion and discharge of water within, or within 100 m of a natural inland wetland are only permitted if they relate to specified activities such as restoration work or scientific research, otherwise consent will be required. The water level range or function of any natural inland wetland is not permitted to be altered without a resource consent.

5 Resource Management (National Environmental Standards for Plantation Forestry) Regulations 2017

The National Environmental Standards for Plantation Forestry (NESPF) aims to maintain or improve the environmental outcomes associated with plantation forestry activities, and to increase certainty and efficiency in the management of plantation forestry activities.

The NESPF requires resource consent for activities where the environmental risk is higher and requires more site-specific oversight, or where permitted activity conditions cannot be complied with, and sets out conditions to be complied with.

Conditions on plantation forestry activities include:

- Harvesting machinery, afforestation and replanting setback requirements e.g. 5m setback from waterways with a channel width of less than 3 m, and wetlands larger than 0.25 ha, 10 m setback in a range of situations including significant natural areas and rivers with a channel width greater than 3 m (note that harvesting machinery operating can operate within setbacks in certain circumstances).
- implementation of erosion and sediment control measures
- requirements to provide notification for afforestation, earthworks, constructing and removal of river crossings, forestry quarrying and harvesting
- requirements to prepare, and comply with, management plans for earthworks, forestry quarrying and harvesting to enable site specific environmental risks to be identified and managed up-front

The NESPF contains tools that enable location specific assessment of risk:

- the Erosion Susceptibility Classification – classifies all land according to erosion risk, with consent requirements for specified forestry activities in high or very high-risk categories.
- Wilding Tree Risk Calculator – this includes factors such as type of species, prevailing wind, and downwind land use.
- Fish Spawning Indicator - used to manage the timing of activities that involve disturbance of the bed of a river or a lake, or a wetland in fish spawning locations.

Afforestation and forestry activities (such as river crossings, earthworks, harvesting) in the catchment that occurred since this NPSPF has come into effect are required to be in compliance with it. For existing forestry areas (that pre-date the NPSPF), some rules will only be given effect to at the time of 2nd or subsequent rotations e.g. setbacks and tree species.

6 Resource Management (Stock Exclusion) Regulations 2020

The Resource Management (Stock Exclusion) Regulations 2020 (referred to as the "stock exclusion regulations") require stock to be excluded from waterways by certain dates.

On existing farms[9]:

- All stock (beef cattle, dairy cattle, dairy support cattle, deer or pigs) must be completely excluded from wetlands:
    - Where the wetland is identified in an operative regional plan as a Regionally Significant Wetland, this applies as of 1 July 2023.
    - For other natural wetlands that fall within the regulations[10], stock exclusion must occur by 1 July 2025.
- Beef cattle and deer excluded a minimum of 3m from all lakes and rivers on land that has a slope of 10 degrees or less.
- Beef, cattle and deer excluded a minimum of 3m from all lakes and rivers, regardless of slope, where adjoining land is used for:
    - fodder-cropping; OR
    - break-feeding: OR
    - grazing on pasture irrigated within the previous 12 months.
- Dairy cattle (excluding dairy support) and pigs excluded a minimum of 3m from all lakes, rivers regardless of slope.

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[9] Existing at the date the regulations became operative on 3 September 2020.

[10] natural wetlands that:
a) support a population of threatened species as described in the National Policy Statement for Freshwater Management 2020; or is identified in a regional plan that becomes operative after 3 September 2020.
b) any natural wetland that is 500m2 or more on land that has a slope of 10 degrees or less.

- Dairy support cattle excluded a minimum of 3m from all lakes and rivers regardless of slope.

In all cases listed above, stock exclusion was required by 3 September 2020 for any new pastoral systems. Where all or part of a lake or river is already permanent fenced or has riparian vegetation that effectively excluded stock by 3 September 2020 they do not need to meet the 3m setback.

These regulations will impact landowners in the Hakapupu catchment, with cattle observed to have access to waterways in a number of locations throughout the catchment. As noted above (refer to Section 5) the identification of wetlands is being undertaken over a number of years by the ORC (as required under the NPSFW), and the number of identified wetlands in the catchment is anticipated to increase. However, this does not absolve landowners from working to identify wetlands on their own properties to ensure compliance with these regulations.

7 Part 9A of the Resource Management Act 1991 and Resource Management (Freshwater Farm Plans) Regulations 2023

Part 9A of the Resource Management Act require farms to have a freshwater farm plans to assist with managing and reducing the impact of farming on the freshwater environment. They are required where the farm is:

- 20 hectares or more in arable or pastoral use
- 5 hectares or more in horticultural use
- 20 hectares or more of combined use.

The regulations set out the requirements for these farm plans, including the identification of risks to freshwater, and actions to mitigate these risks. They are currently only required in parts of Waikato and Southland, but are likely to be required in Otago in 2024 (refer to Resource Management (Application of Part 9A—Freshwater Farm Plans) Order 2023), with the ORC indicating that they may be rolled out in the North Otago FMU first, possibly in early 2024 (ORC Council Meeting - 28 June 2023 Agenda Item 8.1. Freshwater Farm Plans).

8 Otago Regional Council Regional Policy Statement

The Otago Regional Policy Statement (ORPS) sets out the overarching policy framework for responding to significant resource management issues for the region. While the ORPS doesn't contain rules, all district and regional plans in Otago are required to give effect to an operative ORPS (and to have regard to a proposed RPS) when setting objectives, policies, methods, and rules for managing activities and resources.

Otago has a Partially Operative Otago Regional Policy Statement 2019, and a reviewed Regional Policy Statement was notified on 26 June 2021 (referred to as the 'proposed RPS 21'), with hearings on the non-freshwater parts of this version taking place at the time of writing.

The proposed RPS 21 identifies issues such as natural hazards, climate change, loss of biodiversity, impacts of pest species and declining water quality as significant issues for the region. With regard to declining water quality the proposed RPS 21 notes:

> "Sediment is a key issue for freshwater quality throughout Otago, including coastal estuaries where it can significantly impact the life supporting capacity of waterways…. Agricultural intensification also contributes to nutrients (nitrogen and phosphorus) leaching into underlying groundwater or running off into surface water bodies, and can also increase the risk of E.coli contamination from animal waste." (refer SRMR–I6)

In relation to the issues caused by economic and domestic activities and their impacts on resources

> "Sediment from development and forestry activities flow into streams and builds up in the coastal environment, smothering kelp forests and affecting rich underwater habitats." (SRMR–I10)

Objectives and policies are set out in relation to domains: air; coastal environment; land and freshwater. Objectives within the land and freshwater reflect the NPSFW with regard to Te Mana o Te Wai and highlight the relationship of Kai Tahu with water.

The proposed RPS 21 also sets out the FMUs for Otago, with the Hakapupu/Pleasant catchment included within the North Coast FMU. The vision identified for the North Otago FMU is set in LF–VM–O3:

'By 2050 in the North Otago FMU:

1. *fresh water is managed in accordance with the LF–WAI objectives and policies, while recognising that the Waitaki River is influenced in part by catchment areas within the Canterbury region,*
2. *the ongoing relationship of Kāi Tahu with wāhi tūpuna is sustained and Kāi Tahu maintain their connection with and use of the water bodies,*
3. healthy riparian margins, wetlands, estuaries and lagoons support thriving mahika kai, indigenous habitats and downstream coastal ecosystems,
4. indigenous species can migrate easily and as naturally as possible to and from the coastal environment,

5. *land management practices reduce discharges of nutrients and other contaminants to water bodies so that they are safe for human contact, and*
6. *innovative and sustainable land and water management practices support food production in the area and improve resilience to the effects of climate change.'*

The RPS also contains objectives and policies applying across the region focused on protecting and enhancing a range of values including freshwater, land and soil[11].

As these provisions are still to proceed through the freshwater hearing process, they are subject to change. However, they do provide an indication of the ORC's intended approach for the North Otago FMU and the management of natural resources in Otago.

9 Otago Regional Council Regional Plan: Water and Land and Water Regional Plan development.

The Regional Plan Water: for Otago is the operative ORC plan and is the primary planning document for managing activities affecting freshwater in the region. This plan is currently under review, and this review will result in a Land and Water Regional Plan (LWRP) for the Otago region.

The ORC has carried out 2 rounds of consultation on the LWRP. Feedback from this consultation will be used to help draft options for managing land and freshwater that might include FMU specific approaches to minimum flows, allocation limits, ensuring flow variability and enabling resilience. The ORC is planning on presenting draft management options during the next round of consultation in 2023, with the proposed plan likely to be released for public consultation in late 2023.

While provisions haven't been drafted for the LWRP yet, it will need to give effect to national planning instruments (including the NPSFM and the regional policy statement). This means that it will identify environmental outcomes for the North Otago FMU (including the Hakapupu catchment), and will set targets and limits (e.g. contaminant or allocation limits) to help achieve these outcomes.

[11] See for example LF–LS–P18 – Soil erosion which focuses on minimising soil erosion

10 Otago Regional Council Regional Pest Management Plan

Regional councils have a mandate under Part 2 of the Biosecurity Act 1993 to provide regional leadership in activities that prevent, reduce, or eliminate adverse effects from harmful species present in their region. The ORC Regional Pest Management contains the framework to manage or eradicate specified organisms in the Otago region.

Pest management programmes are used to control pests and any other organisms covered by the Plan. The programmes set out in the plan are:

1. Exclusion programme: to prevent the establishment of the subject, or an organism being spread by the subject, that is present in New Zealand but not yet established in an area.
2. Eradication programme: to reduce the infestation level of the subject, or an organism being spread by the subject, to zero levels in an area in the short to medium term
3. Progressive containment programme: to contain or reduce the geographic distribution of the subject, or an organism being spread by the subject, to an area over time.
4. Sustained control programme: to provide for ongoing control of the subject, or an organism being spread by the subject, to reduce its impacts on values and spread to other properties.
5. Site-led pest programme: that the subject, or an organism being spread by the subject, that is capable of causing damage to a place is excluded or eradicated from that place, or is contained, reduced, or controlled within the place to an extent that protects the values of that place.

Good neighbour rules are applied to pest species identified in the plan where pests would spread to nearby land and cause unreasonable costs to that adjacent occupier.

Organisms classified as pests within the plan that are present/likely to be present in Te Hakapupu include (listed according to the pest programme set out for these pests in the plan).

Progressive containment – rules for the species listed below require elimination of these species by occupiers. Good neighbour rules apply in some cases also.

- Old man's beard *Clematis vitalba* - good neighbour rule
- Perennial nettle *Urtica dioica*
- Wilding conifers (any introduced conifer tree) - good neighbour rule
- Spartina Spartina spp

Sustained control – no elimination rules apply to the species below within the Hakapupu catchment:

- Broom (common and montpellier) *Cytisus scoparius Teline monspessulana* - only the good neighbour rule applies for Te Hakapupu
- Gorse *Ulex europeaus* – only the good neighbour rule applies for Te Hakapupu
- Nodding thistle *Carduus nutans* - good neighbour rule
- Ragwort *Senecio jacobaea* - good neighbour rule
- Feral rabbit *Oryctolagus cuniculus* – control of rabbit densities and good neighbour rule

Site-led – note that there are no site led programmes for these species in the Hakapupu catchment

- Sycamore Acer pseudoplatanus
- Feral deer Cervus elaphus, C. nippon, C. dama
- Feral goat Capra aegagrus hircus
- Feral pig *Sus scrofa*
- Hedgehog Erinaceous europaeus
- Mustelids (ferret, stoat, weasel) Mustelo furo, M. ermine, M. nivalis
- Possum Trichosurus vulpecula

11 District Plan provisions

Most of the Hakapupu catchment lies within the Waitaki District, except for an area to the south of the estuary and part of Mt Watkin.

The Waitaki District Plan and the Dunedin 2nd Generation District Plan (2GP) set out provisions governing the use of land within this catchment.

Within the Waitaki District Plan the catchment is largely zoned rural general, with some inland rural areas zoned as 'rural scenic' within the Waitaki District Plan. Catchment areas within the 2GP are also largely zoned rural, except for a small rural residential subdivision to the south of the estuary.

Within the Waitaki District, farming and forestry (where forestry is compliant with the NPSPF) are permitted activities within the rural general zone, as are intensive farming (pigs and poultry) visitor accommodation, commercial activities associated with selling farm produce, residential activities (except in the Rural Scenic zone) and earthworks.

Forestry within the rural general zone is a permitted activity, however ‘production forestry to be avoided’ on Significant Natural Features identified in the catchment (Policy 16.8.3.6; Site Development Standards 4.4.7.4a).

Site standards (including for forestry as a permitted activity) require that no exotic tree planting occurs within 20 m of a lake, river, stream or wetland, or within any wetland, or within any significant natural feature. Earthworks and indigenous vegetation clearance is also restricted – including no earthworks within 20 m of waterways and wetlands, or on slopes with an angle of greater than 20 degrees. These setbacks are stricter than the setbacks set out in the NESPF but are currently still being applied by Waitaki District Council (pers. comm., Marian Weaver, Waitaki District Council planner, 31 March 2023).

Within the Dunedin City District, the 2GP also lists forestry and farming as permitted activities, unless forestry is within a significant natural landscape (SNL) area, in which case it is a restricted discretionary activity, with effects on landscape values to be considered. Conservation activity is also identified as a permitted activity in the rural zones.