MN02 Water Storage Reservoir

Preliminary Assessment of Ecological Values and Effects

7 December 2020

MN02 Stream Water Storage Reservoir – Preliminary Assessment of Ecological Values and Effects

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1. Introduction

Te Tai Tokerau Water Trust Board ('the applicant') have received provincial growth funding to provide improved water supply in Northland. Williamson Water and Land Advisory (WWLA) is leading the provision of a range of technical services to inform the project. Puhoi Stour Limited (PSL) and its subconsultant Tonkin & Taylor Limited (T+T) have collaborated to prepare this assessment of the potential ecological effects associated with a proposed water supply reservoir (referred to as 'MN02') off Te Ahu Ahu Road, in the Far North.

In brief, the applicant proposes to construct a new water supply reservoir, by constructing a dam across an unnamed tributary of the Waitangi River, and inundating headwater tributaries and surrounding land. The construction and ongoing operation of the water supply dam is anticipated to have the following effects on ecological values:

- 7,848 m^2 of stream habitat (along 4,797 m of permanent and 2,575 m of intermittent stream channels);
- 4.455 ha of indigenous wetland loss, which includes 4.05 ha of indigenous-dominated *Juncus* wetland, 0.06 ha of mānuka, kānuka gumland-*Machaerina* sedgeland, 0.19 ha of mānuka wetland, 0.06 ha of mānuka – kiokio - *Machaerina* wetland, 0.09 ha of *Eleocharis-Schoenoplectus-Machaerina* wetland and 0.005 ha of *Isolepis* turf wetland;
- Loss of 0.17 ha of secondary tōtara forest;
- Exotic-dominated habitat loss includes 1.26 ha of exotic forest, 0.13 ha of exotic-dominated *Juncus* wetland and 0.9 ha of improved pasture wetland; and,
- Habitat loss for indigenous fauna, including North Island brown kiwi and New Zealand pipit, and potentially lizards.

The scope of this report is to provide an assessment of the ecological values of the site and to report on the anticipated impacts of the project. Measures to avoid, remedy or mitigate effects are proposed and recommendations are made to further offset or compensate residual adverse effects that cannot be otherwise avoided, remedied, or mitigated.

2. Site description

The proposed MN02 Water Supply Reservoir site is located between Te Ahu Ahu Road and Waimate North Road, in the Far North District, Northland (Figure 1). MN02 borders two ecological districts, the Kaikohe Ecological District (ED) to the west and the Kerikeri Ecological District to the east (Figure 2 and 3).

The site is in the headwaters and discharges into the Waitangi River, approximately 3 km to the north of the site. Waitangi River flows over the Haruru Falls before discharging to the coast in Haruru, approximately 15 km to the east.

There are no mapped areas of ecological significance within the site however it is in close proximity to the following protected natural areas (Figure 2 and 3):

- Waitangi River Alluvial Remnants (PNAP P05/085) within 400 m to the east;
- Oromahoe Bush (PNAP P05/063) within 3 km to the east;
- Atkins Ohaio Bush (PNAP P05/075) within 1 km to the west; and,
- Okakako Road Remnant (PNAP P05/076) within 800 m to the west.

These protected natural areas are comprised of secondary forest on hillslope with key species including rimu, purīrī, tōtara and kahikatea, as well as kānuka shrubland and taraire-purīrī-tōwai forest, and provide habitat for native fauna, including the North Island brown kiwi, kukupa, kauri snail, and copper skink. Riparian margins within the protected natural areas provide favourable conditions for native fish in the catchment, including the banded kōkopu.

Vegetation cover in the area (and in the site) would have historically consisted of kauri, podocarp, broadleaved forest (WF11) and kahikatea, pukatea swamp forest (WF8)[1]. Much of the indigenous forest in the area has been cleared for farming and forestry, resulting in a fragmented landscape largely comprised of pasture paddocks. The site is an operational livestock farm and current modification of the landscape is typical of historical and ongoing agricultural land use.

[1] Singers, N.J. D. and Rogers, G. M. (2014). A classification of New Zealand's terrestrial ecosystems. The Department of Conservation, Science for conservation 325.

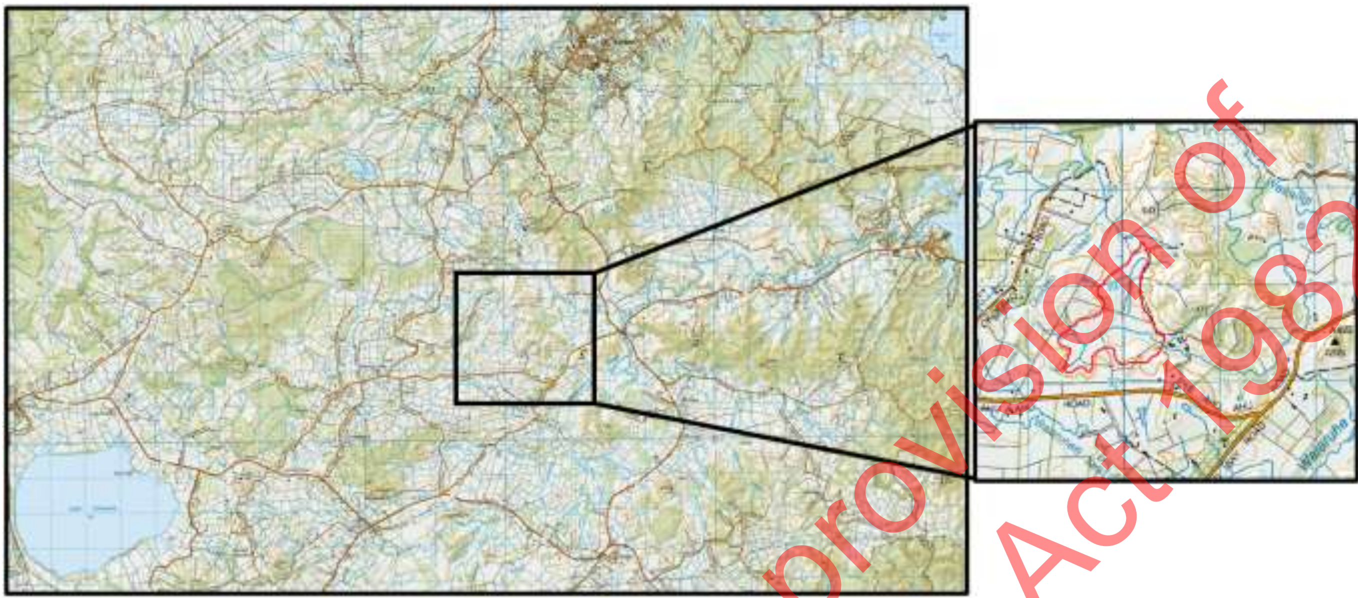

Figure 1: Location of proposed MN02 reservoir (in red outline) off Te Ahu Ahu Road, Waimate North.

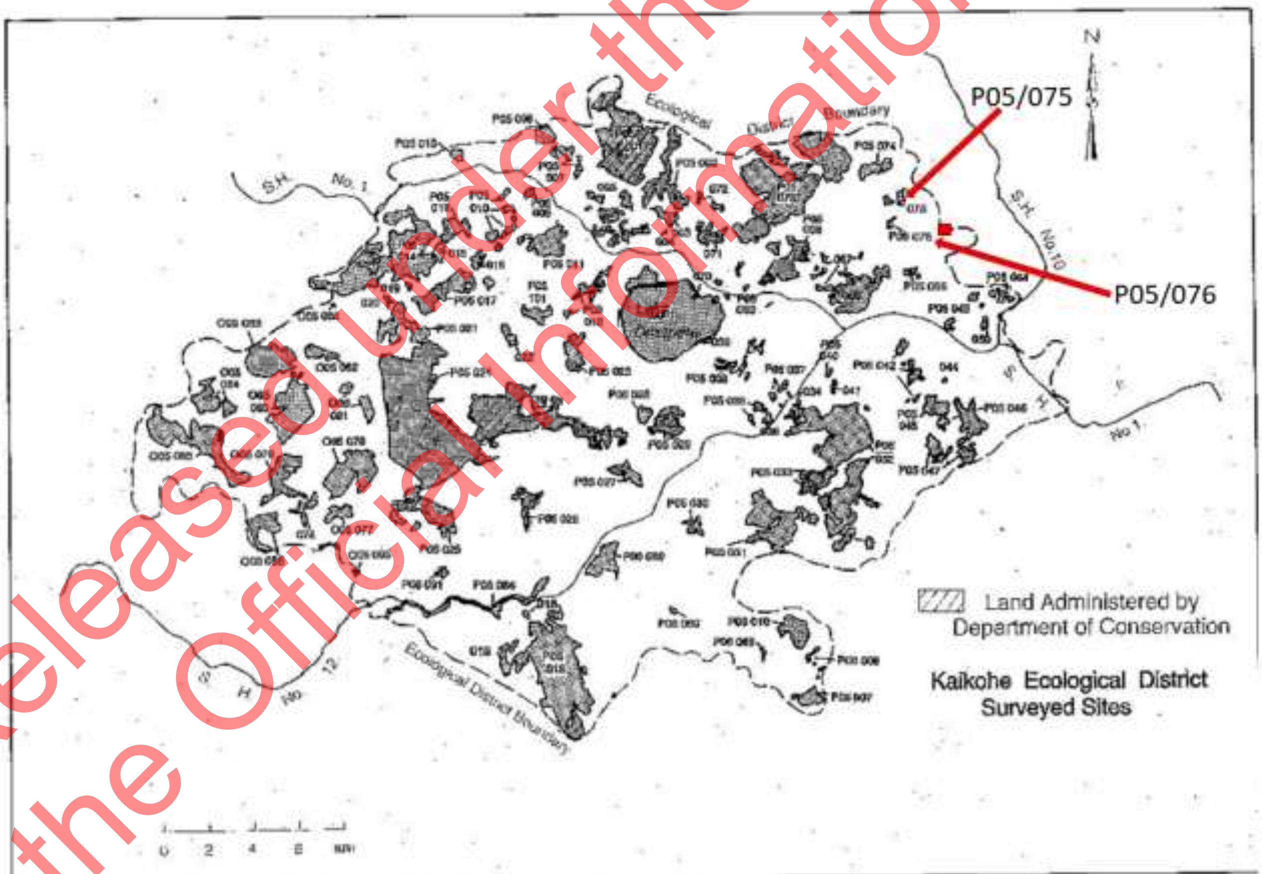

Figure 2: Location of proposed MN02 reservoir (red rectangle) in relation to nearby Protected Natural Areas in Kaikohe Ecological District (modified map from the Department of Conservation).

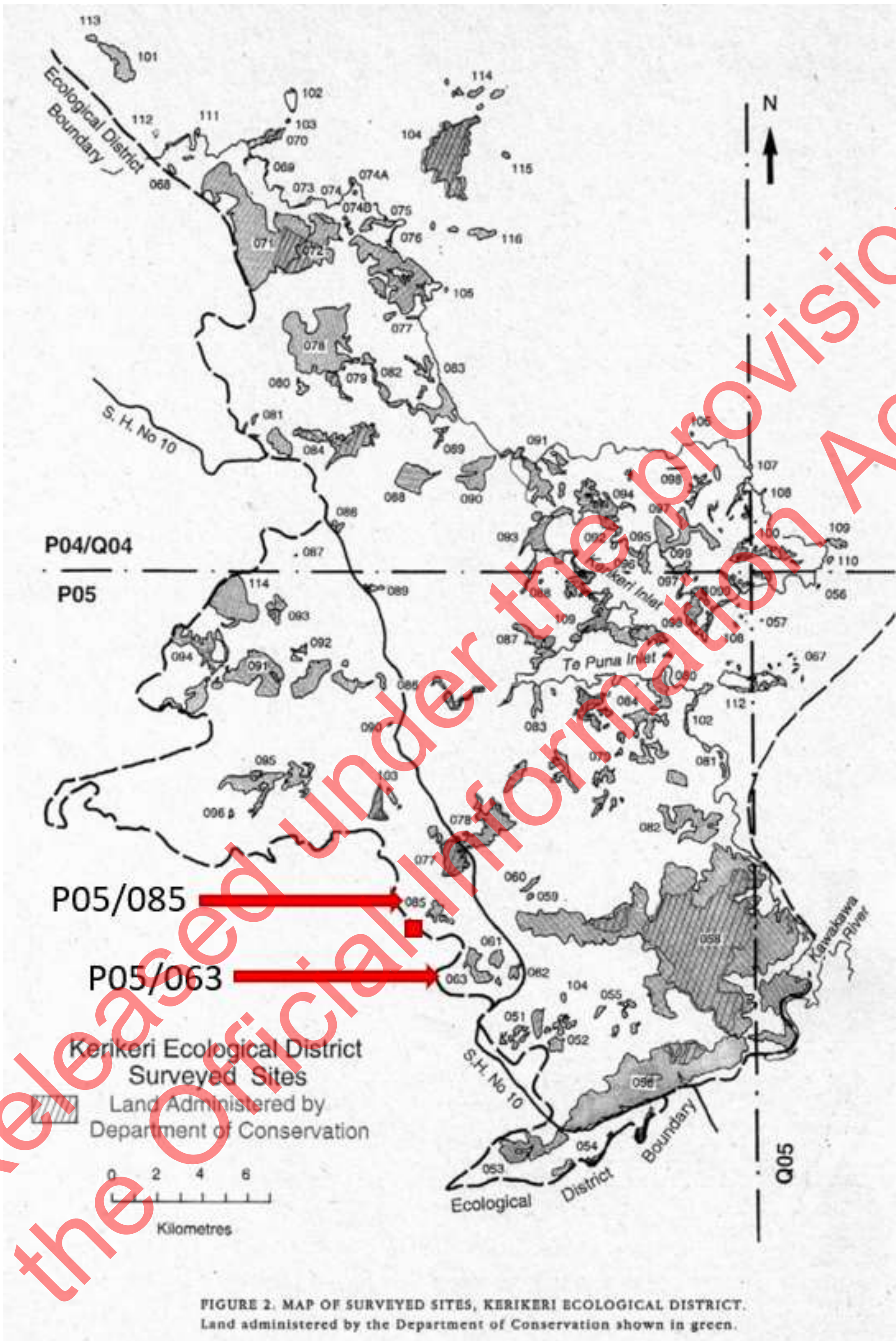

Figure 3: Location of proposed MN02 reservoir (red rectangle) in relation to nearby Protected Natural Areas in Kerikeri Ecological District (modified map from the Department of Conservation).

3. NES and NPS objectives and policies

The National Policy Statement for Freshwater Management (2020) (NPS) and the National Environmental Standards for Freshwater (2020) (NES) provides direction to the objectives and policies regarding freshwater management in New Zealand. These documents came into force on 3 September 2020 and consideration of these has been incorporated into this Assessment of Ecological Effects report.

Under the NES, reclamation of the bed of any river is a discretionary activity and the loss of river extent and values is to be avoided where practicable. Under the NES, drainage of natural wetlands is a prohibited activity unless certain criteria are met.

The NPS directs that the loss of river extent and values is avoided to the extent practicable, habitats of indigenous freshwater species are protected, and significant values of outstanding water bodies are protected (NPS part 2.2).

The proposed reservoir cannot be practicably constructed without inundating streams and therefore, the quantum of stream loss proposed for the reservoir is unavoidable. Adverse effects from inundating streams on site are recommended to be offset elsewhere (e.g. in the same or neighbouring catchment) through stream bank restoration and enhancement planting. Stream Ecological Valuation (SEV) and Environmental Compensation Ratio (ECR) calculations have been used to estimate 'no-net-loss' of ecological function and the principle of additionality in biodiversity offsetting will also be met.

Similarly, the NPS directs that 'there is no further loss of extent of natural wetlands, their values are protected, and their restoration is promoted' (NPS part 2.2). Wetlands within the site have been assessed using both the Northland Regional Council (NRC) definitions and those within the NPS FM. While recommendations to address the loss of wetlands are proposed, this is based on ecological assessment of the appropriate measures to address effects and does not negate the requirement for a full planning assessment as to the activity status, the policy direction and the overall application of the planning framework.

This assessment is not intended to be a complete assessment of the objective and policies, rather provides an initial technical ecological assessment of the relevant objectives and policies in the NES and NPS against the proposed activities associated with the reservoir. This should be read in conjunction with the planning assessment for the application.

4. Methods

A site visit to MN02 was undertaken on 14, 15 and 16 October 2020 to map and describe the freshwater and terrestrial ecological values on site. An assessment of the potential presence of any threatened freshwater and terrestrial species and/or habitats in the proposed reservoir development was undertaken.

Our assessment was undertaken to inform an assessment of ecological effects report. Field work included the following ecological assessments:

- Habitat mapping and development of vascular plant species and avifauna lists;
- Stream Ecological Valuations (SEV) across representative stream reaches;
- Undertake instream macroinvertebrate sampling;
- Use of fyke and gee-minnow nets to survey for freshwater fauna;
- Freshwater fauna night spotlighting;
- Vegetation (RECCE) plots to inform Biodiversity Offset and Accounting Models (BOAMs);
- Deployment of Automatic Bat Monitors (ABMs) across the site; and,
- Gecko night spotlighting and day-time skink manual searches.

The details of our site assessment are included in the following sections and all sampling sites are shown in Appendix A, Figure 1.

4.1 Desktop assessment

A desktop assessment of potential freshwater and terrestrial ecological values was undertaken through a review of:

- Ecological databases including:

- Herpetofauna Atlas;
- Department of Conservation National bat database;
- iNaturalist (www.iNaturalist.org);
- eBird (www.eBird.org);
- Kiwis for Kiwi North Island brown kiwi distribution 2016;
- New Zealand Plant Conservation Network distribution database; and,
- New Zealand Freshwater Fish Database (NZFFD) records for Waitangi River and Waiaruhe River, and the wider Waitangi River catchment;

- Proposed Regional Plan for Northland, Appeals Version – August 2020;
- National Policy Statement for Freshwater Management 2020;
- Natural areas of Kaikohe Ecological District, Reconnaissance survey report for the Protected Natural Areas Programme, dated 2000;
- Natural areas of Kerikeri Ecological District, Reconnaissance survey report for the Protected Natural Areas Programme, dated 1999;
- Northland Regional Council LocalMaps gallery, Northland Biodiversity Ranking and Biodiversity Wetlands layers;
- Matawii Storage Reservoir Assessment of Ecological Effects (Puhoi Stour, 2020);
- Te Ruaotehauhau Stream Water Storage Reservoir Assessment of Ecological Effects (Puhoi Stour, 2020; in preparation);
- Department of Conservation (2014), A classification of New Zealand's terrestrial ecosystems;
- Department of Conservation (2004). Wetland Types in New Zealand;
- Manaaki Whenua Landcare Research Soil Portal;
- NIWA, New Zealand fish passage guidelines for structures less than 4m, dated 2018; and,
- Other primary literature sources.

4.2 Freshwater values assessment

4.2.1 Stream classifications

During the site visit, all streams on site were classified in accordance with the definitions of continually or intermittently flowing river or stream set out in the Proposed Regional Plan for Northland[2] and RMA.

Stream classification was undertaken during and after 48 hours of fine weather to provide confidence that flowing water was not only a direct result of rainfall runoff. The streams were assessed according to several criteria that define a stream or river including:

- A well-defined channel, such that the stream bed and banks are distinguishable;
- There is evidence of substrate sorting processes, including scour and deposition;
- The absence of rooted terrestrial vegetation across the cross-sectional width of the channel;
- The presence of surface water more than 48 hours after rainfall;
- Organic debris present on the floodplain as a result from flood; and,
- Natural pools are present and is connected to the stream channel.

[2] Northland Regional Council (2020). Proposed Regional Plan for Northland, appeals version August 2020. Chapter B.

Streams were also assessed against the definitions of an artificial watercourse set out in the Proposed Regional Plan for Northland. This was defined as:

- A man-made channel constructed in or over land for carrying water for the supply of water for electricity power generation and farm drainage canals. It does not include a channel constructed in or along the path of any historical or existing river, stream, or natural wetland.

The stream channel network on site is in an historical and existing natural wetland, therefore, the streams channels do not meet the definitions of an artificial watercourse.

All streams within the reservoir footprint were walked to assess the presence and extent of aquatic habitat within the proposed reservoir development. These observations were recorded in ArcGIS with photographs for later analysis.

Due to the nature of the stream and wetland complex on site, there are areas where the boundary between stream channel and wetland habitat became blurred. This has been delineated on the maps produced, so as to keep each habitat separate (for the purposes of effects assessments) but it is recognised that the system should be considered as a whole.

4.2.2 Macroinvertebrates

A standard macroinvertebrate (kick net) sample was collected from an unnamed permanent stream partly shaded by riparian vegetation (Macro1) while another sample was collected from an unnamed permanent tributary with grazed grass banks (Macro2). Locations of the samples are provided in Appendix A, Figure 1.

Macroinvertebrate samples were collected in accordance with a soft-bottom semi-quantitative protocol (C2). The habitat sampled for Macro1 included woody debris, overhanging ferns, undercut banks, predominantly under canopy cover. The habitat sampled for Macro2 was limited to aquatic macrophytes. Submerged woody debris were brushed by hand while water poured over the material to dislodge macroinvertebrates. Root mats, overhanging fern fronds, and aquatic macrophytes were jabbed aggressively before completing cleaning sweeps to collect dislodged macroinvertebrates using a D-net for a collection effort area of approximately 0.3 m^2.

Macroinvertebrate identification was undertaken by EIA Limited according to the 200 Individual Fixed Count with Scan for Rare Taxa protocol (P2).

Results are presented as follows:

Taxonomic richness. This is a measure of the number of different types of macroinvertebrate present in each sample and is a reflection of the diversity of the sample;

Ephemeroptera, **Plecoptera** and **Trichoptera** ("**EPT**") richness. This index measures the number of pollution-sensitive macroinvertebrates (mayfly, stonefly, and caddisfly (excluding Oxyethira and Paroxyethira taxa because these are tolerant of degraded conditions) within a sample. Percent EPT richness represents the number of EPT taxa as a proportion of the total number of taxa within the sample;

Macroinvertebrate Community Index ("**MCI**"). The MCI is an index for assessing the quality class of a stream using presence or absence of macroinvertebrates; and

Quantitative Macroinvertebrate Community Index (**QMCI**). QMCI is another index-based tool, based on the relative abundance of taxa within a community, rather than just presence or absence.

The MCI and QMCI reflect the sensitivity of the macroinvertebrate community to changes in water quality and habitat, where higher scores indicate better stream condition. Macroinvertebrate index values are then translated to quality classes, which describe the ecological health of the stream (Table 1).

Table 1: Interpretation of macroinvertebrate biotic indices[3].

Quality class	MCI MCI-sb	QMCI QMCI-sb
Excellent	>119	> 5.99
Good	100 - 119	5.00 – 5.90
Fair	80 - 99	4.00 – 4.90
Poor	<80	< 4.00

4.2.3 Fish

Two nights of trapping were undertaken in October 2020. Fish survey locations were selected based on presence of suitable stream habitat and sufficient water depth and these locations are provided in Appendix A, Figure 1. The fish survey was undertaken in accordance with the New Zealand freshwater fish sampling protocols[4].

During the first night (14 October), un-baited gee minnow traps (GMT) (n = 12) and fyke nets (n = 6) were deployed along the main unnamed permanent channel that runs across the footprint of the proposed reservoir. During the second night (15 October), un-baited GMT (n = 4) and fyke nets (n = 2) were deployed along the same channel at the most downstream extent of the proposed reservoir footprint.

Further fish survey was undertaken by way of spotlighting on the night of 14 October (between 9 pm – 10 pm). Spotlighting a 150 m reach, free of any major tributaries, was carried out along the main unnamed permanent channel within the proposed footprint. The location of the spotlighting fish survey track is provided in Appendix A, Figure 1.

4.2.4 Stream ecological valuation

The stream ecological valuation (SEV) method was used to assess the aquatic ecological function of streams in the proposed reservoir as described in Storey et al. (2011), Neale et al. (2011), and Neale et al. (2016) [5].

Three representative SEV reaches were undertaken across the site and were selected based on the expected impact (in the centre of the proposed reservoir footprint). The locations are presented in Appendix A, Figure 1. SEV1 and SEV2 are considered representative of permanent streams on site; SEV1 being permanent streams with canopy cover and SEV2 being without or minimal canopy cover. SEV3 is considered representative of intermittent streams on site. All three SEV reaches assessed were ~100 m in length.

The SEV method assesses physical characteristics at a reach scale, involving transects and whole of reach parameters. These data are supplemented with collected macroinvertebrate and fish data to inform 29 variables which in turn feed into 14 stream ecosystem functions. These functions fall into four broad categories as described in Table 2. The SEV method is also used to quantify the ecological impact and proposed offset measures to achieve no net loss of ecological function.

The SEV results are reported on a scale of 0 to 1, where 1 is a pristine stream (i.e. native forest, non-modified) and values below this are a departure from those reference conditions. Each function is measured and compared to what would be

[3] Stark, J D, and Maxted, J R (2007). A user guide for the macroinvertebrate community index. Prepared for the Ministry of the Environment. Cawthron Report No. 1166. 58p.
[4] Joy, M., David, B., and Lake, M. (2013). New Zealand Freshwater Fish Sampling Protocols, Part 1 – wadeable rivers and streams.
[5] Storey, R G, Neale, M W, Rowe, D K, Collier, K J, Hatton, C, Joy, M K, Maxted, J R, Moore, S, Parkyn, S M, Phillips, N and Quinn, J M (2011). Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.
Neale M W, Storey R G, Rowe D K, Collier K J, Hatton C, Joy M K, Parkyn S M, Maxted J R, Moore S, Phillips N and Quinn J M (2011). Stream Ecological Valuation (SEV): A User's Guide. Auckland Council Guideline Document 2011/001.
Neale, M W., Storey, R G and Quinn, J L (2016). Stream Ecological Valuation: application to intermittent streams. Prepared by Golder Associates (NZ) Limited for Auckland Council. Auckland Council technical report, TR2016/023.

expected in 'reference conditions' and the final score is an aggregation of weighted attributes that identify how far from 'pristine' the stream reach is.

The SEV is a robust and internationally peer-reviewed method designed to quantify the ecological function of a stream reach. Further, when required, the method also provides a means to quantify offset requirements.

The SEV was developed for use in Auckland streams but has been successfully applied across New Zealand when local reference data has been incorporated into the SEV calculators. To our knowledge, Northland has not formally developed a SEV calculator with local reference data. For the purposes of our assessment the Auckland calculator has been used to inform the ecological values of the site.

Table 2: Stream Ecological Value (SEV) functions

SEV Functions
Hydraulic Functions
› Natural flow regime
› Floodplain effectiveness
› Connectivity for natural species migrations
› Natural connectivity to groundwater
Biogeochemical Functions
› Water temperature control
› Dissolved oxygen levels
› Organic matter input
› Instream particle retention
› Decontamination of pollutants
Habitat Provision Functions
› Fish spawning habitat
› Habitat for aquatic fauna
Biodiversity Provision Functions
› Fish fauna intact
› Invertebrate fauna intact
› Riparian vegetation intact

4.3 Terrestrial values assessment

4.3.1 Ecosystem and vegetation assessment

A site walkover and ecological assessment was undertaken on 14 and 15 October 2020 to survey and describe terrestrial ecosystem and vegetation values across the Project footprint.

The field assessment included mapping all terrestrial and wetland ecosystems, developing a vascular plant species list, and undertaking targeted searches for key At Risk and Threatened species according to the current threat rankings published by the Department of Conservation (DOC)[6]. Terrestrial and wetland ecosystems were assessed and classified according to Singers &

[6] Department of Conservation (n.d.).New Zealand Threat Classification Series. Accessed on 28 July 2020 from https://www.doc.govt.nz/about-us/science-publications/series/new-zealand-threat-classification-series/

Rogers (2014)[7] where the habitat remained intact, and in accordance with the Proposed Regional Plan definitions[8] and criteria set out in Appendix 5 of the Regional Policy Statement for Northland.

A single modified 10 x 10 m RECCE plot[9] was undertaken in each of:

- Tōtara forest;
- Mānuka, kānuka gumland, *Machaerina* sedgeland;
- Mānuka wetland;
- Mānuka – kiokio – *Machaerina* wetland;
- *Eleocharis* – *Schoenoplectus* – *Machaerina* wetland; and,
- Indigenous-dominated *Juncus* wetland.

Ecosystem attributes in each ecosystem type were measured including canopy height, canopy cover, Diameter at Breast Height (DBH) of each tree above 2.5 cm DBH to determine basal area, species richness and fauna proxy measures including flaky bark trees, leaf litter depth and coarse woody debris (above 10 cm diameter).

Habitat characteristics of other wetland types on site including exotic-dominated *Juncus* wetland and *Isolepis* turf wetland were able to be estimated visually (due to low variability in wetland habitat characteristics).

4.3.2 Bats

4.3.2.1 Overview

Bat surveys of the Project site comprised of desktop surveys, an assessment of potential bat habitat during the site walkover and an acoustic survey undertaken with automatic bat monitors to determine if the Project site is or could be utilised by long-tailed bats (*Chalinolobus tuberculatus;* Threatened – Nationally Critical[10]) and/or northern lesser short-tailed bats (*Mystacina tuberculata aupourica*; Threatened – Nationally Vulnerable[10]).

4.3.2.2 Desktop assessment

A desktop assessment was undertaken using aerial imagery of the landscape and historic records of bats provided in the DOC national bat database (current as of November 2020) to establish any nearby bat activity records and review the wider landscape for potential bat habitat.

4.3.2.3 Bat habitat assessment

Potential foraging and roosting habitat across the proposed footprint was assessed during the site walkover. Optimal foraging habitat included mature trees in areas with an abundance of flying insect prey such waterways, wetlands and vegetated areas. Linear features that may be utilised as commuting pathways were also identified during the site walkover and using aerial imagery.

Trees >15 cm diameter at breast height (DBH) with cracks, crevices, cavities, epiphytes, rot and/or flaking or peeling bark offer potential roosting habitat and were mapped during the site visit.

4.3.2.4 Acoustic bat survey

ABM deployment

An acoustic survey was undertaken across the Project footprint over 18 nights from 14 October to 2 November 2020 to detect the presence of long-tailed and/or short-tailed bats. Three automatic bat monitors (ABMs; ARM v1.31 DSP v1) manufactured by DOC were deployed to record bat activity across the site (sites shown on Appendix A, Figure 1).

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[7] Singers, N. J., & Rogers, G. M. (2014). *A classification of New Zealand's terrestrial ecosystems*. Department of Conservation.
[8] The definitions relating to wetlands are currently under appeal, however considered appropriate for this assessment.
[9] Hurst, J. M., & Allen, R. B. (2007). *The recce method for describing New Zealand vegetation – field protocols*. Landcare Research.
[10] O'Donnell, C.F.J., Borkin, K.M., Christie, J.E., Lloyd, B., Parsons, S. & Hitchmough, R.A. 2018: Conservation status of New Zealand bats, 2017. *New Zealand Threat Classification Series 21*. Department of Conservation, Wellington, New Zealand. 4 pp.

ABMs operate remotely by recording and storing echolocation calls (bat passes) as image files, along with the date and time of the event. The acoustic survey followed best practice directed by the DOC's bat inventory and monitory toolbox[11]. ABMs were deployed across the Project footprint in locations where bat activity was considered most likely (e.g. mature trees, near watercourses and wetlands, or on the edge of natural corridors). Each ABM was set to record from one hour before sunset until one hour after sunrise.

Bat data analysis

The ABM recordings were processed using an automated AI-based tool developed by T+T[12] which identifies long-tailed bat recordings. All results were then manually checked for quality assurance purposes and updated as necessary using the DOC BatSearch 3.11 programme. The DOC BatSearch 3.11 programme was used to identify any potential recordings of short-tailed bats. Bat data analysis was undertaken in accordance with best-practice methodologies[13].

The analysis of ABM data provides the following information:

- Presence or absence of bats within the Project footprint during the survey period;
- Distribution of bat activity within the Project footprint during the survey period;
- The number of bat echolocation calls within the detection area of each ABM (~ 50 m radius);
- Foraging echolocation calls within the detection area of each ABM. As a bat approaches an insect whilst foraging, the frequency of its echolocation calls increases to create a distinct 'feeding buzz' signature that can be interpreted during the data analysis process; and,
- Activity that may be indicative of roosting within or nearby the Project site.

It should be noted that ABM data provides an index of bat activity rather than bat abundance, as the number of bat calls does not necessarily correlate with the number of individual bats encountered.

Bat activity is influenced by certain weather conditions[14][15], as well as moon phase and amount of moonlight[16]. As such, weather data from the survey period was reviewed to ensure conditions were suitable for long-tailed bats to be active. Optimal weather conditions for bat activity are considered to be:

- Minimum temperature of 10 °C or higher in the first two hours following sunset;
- ≤ 2.5 mm rainfall over the first two hours after sunset; and,
- Minimum overnight relative humidity of 70%.

Weather data during the survey period was collected from the NIWA CliFlo website, both from the Kaikohe weather station (Agent No. 1134, 15 km away) and Kerikeri weather station (Agent No. 1056; 10 km away) as these were the nearest weather stations providing the necessary weather data.

4.3.3 Avifauna

To assess avifauna composition across the site, all incidental bird observations (seen or heard) were recorded during the site visit.

[11] Sedgeley, J. (2012). DOCDM-590733 Bats: Counting away from roosts – automatic bat detectors. Version 1.0. Department of Conservation.
[12] Comprehensive testing of the AI-based tool and its accuracy is currently being undertaken. Preliminary results where the tool has been used to independently re-count datasets that have previously been manually processed indicate that accuracy of the tool is in the order of 95%.
[13] Department of Conservation (2017). Bat Call Identification Manual for DOC's Spectral Bat Detectors. Author: Dr. Brian Lloyd.
[14] O'Donnell, C.F (2000). Influence of season, habitat, temperature, and invertebrate availability on nocturnal activity of the New Zealand long-tailed bat (*Chalinolobus tuberculatus*). New Zealand Journal of Zoology, 27(3), 207-221.
[15] Le Roux, D., Le Roux, N. & Waas, J. (2014). Spatial and temporal variation in long-tailed bat echolocation activity in a New Zealand city. New Zealand Journal of Ecology, 41:1, 21-31.
[16] Griffiths, R. (1996). Aspects of the ecology of a long-tailed bat, *Chalinolobus tuberculatus* (Gray, 1843), population in a highly fragmented habitat. Degree of Master of Science thesis. Lincoln University.

North Island brown kiwi (*Apteryx mantelli*) have been recorded at a high density in close proximity to the Project footprint as determined through a review of Northland kiwi distributions[17]. North Island brown kiwi in Northland are known to utilise existing fragmented habitat as foraging and roosting steppingstones across the landscape.

North Island brown kiwi habitat within the site was identified as having any of the following characteristics:

- Indigenous forest, scrub and dense rushes or sedges with boulders, hollow logs, large trees with roots for burrowing under or dense understorey cover; and,
- Exotic forest and scrub with similar habitat features as mentioned above.

The site walkover was used to assess habitat suitability for cryptic wetland birds through identifying potential areas of dense reeds, rushes, or other high value wetland areas.

Fernbird playback calls were undertaken in the indigenous-dominated *Juncus* wetland during site walkovers on both the 14 and 15 of October, however habitat was considered marginal due to stock browsing and related disturbance.

4.3.4 Herpetofauna

Potential herpetofauna (gecko and skink) habitat was identified and mapped when having any of the following potential lizard characteristics:

- Rank grass;
- Coarse woody debris;
- Deep leaf litter;
- Boulders and rocks;
- Exotic vegetation, including pampas; and,
- Native vegetation.

Manual habitat searching for skinks was undertaken on the 14 and 15 October 2020 by lifting any large coarse woody debris encountered during the site walkover.

Gecko spotlighting was undertaken on the 14 October 2020 between 8 and 9 pm for a total search effort of two person-hours within the mānuka kānuka gumland, *Machaerina* sedgeland (Appendix A; Figure 1).

4.3.5 Invertebrates

Potential kauri snail (*Paryphanta* spp.) habitat was assessed by identifying potential areas of deep leaf litter, fern skirts and logs, particularly where indigenous forest is present.

4.4 Assessment of effects

The method applied to this assessment of ecological effects broadly follows the Ecological Impact Assessment Guidelines (EcIAG) published by the Environment Institute of Australia and New Zealand (EIANZ)[18].Using a standard framework and matrix approach such as this provides a consistent and transparent assessment of effects.

Outlined in the following sections, the guidelines have been used to inform the following:

- The level of ecological value of the environment based on the information available;
- The magnitude of ecological effect from the proposed water supply reservoir on the environment;
- The overall level of effect to determine if further measure to address effects are required; and,

[17]Kiwis for Kiwi (2016). North Island Brown Kiwi Estimated distribution 2016.
[18] Roper-Lindsay, J., Fuller, S.A., Hooson, S., Sanders, M.D., and Ussher, G.T. (2018). Ecological Impact Assessment. EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd edition.

- The magnitude of effect and overall level of effect, taking into consideration the additional measures to avoid, remedy or mitigate effects and whether there are residual adverse effects that should be offset or compensated (s 104(ab) RMA).

Consideration was also given to Policy D.2.16 of the Proposed Regional Plan for Northland (Appeals Version June 2020) regarding managing adverse effects on indigenous biodiversity. Criteria set out in Appendix 5 of the Regional Policy Statement for Northland (updated 2018) were used in the assessments of ecological significance.

The framework for assessment provides structure to quantify the level of ecological effects but needs to incorporate sound ecological judgement to be meaningful. Deviations or adaptions from the methodology are identified within each of the following sections as appropriate. Further detail regarding these guidelines is included in Appendix B.

5. Freshwater ecological assessment

5.1 Freshwater values

5.1.1 Stream classification and values

The site is in the headwaters of the wider Waitangi River catchment. The network of streams on site are all unnamed tributaries of the Waitangi River, into which they flow approximately 3 km downstream. A small section of intermittent stream (approximately 50 m) at the top north of the proposed footprint drains north into a tributary of the Okokako Stream, which is also a tributary and sub-catchment of the Waitangi River. All remaining streams on site drains south-east into an unnamed tributary of the Waitangi River.

The network of streams on site are, for the most part, characterised by modified straightened and deepened channels. Streams comprised predominantly open channels along paddock margins while some were shaded by a narrow band of mixed native and exotic treelands.

Two main stems are classified as continuously flowing permanent streams situated along the centre of the proposed reservoir. One of the main stem flows out of a large wetland complex and appears as channels within the wetland in several sections. There are several tributaries that flow into the main stems throughout the site (shown in Appendix A, Figure 1). Some of the tributaries are located fully within the proposed reservoir while others extend further upstream and are fed by either springs or farm ponds outside the proposed reservoir footprint. Some tributaries have been classified as permanent, while other tributaries characterised by slow-trickling and shallow water depth have been classified as intermittent, given the likelihood of becoming periodically dry over summer.

The main permanent channels were approximately on average 1.26 m wide and had a depth of 35 cm. The intermittent tributaries were on average 0.58 m wide and had a depth of 0.05 m. For both permanent and intermittent tributaries, the streambed had high fine sediment loading and instream habitat was limited to aquatic macrophytes. Submerged and surface reaching macrophytes were dominant in most streams across site, particularly in open channels. Green filamentous algae was observed in sections online of wetlands where livestock had not been excluded, which is an indication of nutrient enrichment in the channels. Small amounts of woody debris and root mats were observed under canopy cover. Instream hydrological heterogeneity was low due to largely uniform channels and the presence of diverse pool depths, cascades and chutes were scarce.

Riparian vegetation was largely limited to two reaches along the main stem, on the western and eastern extent of the proposed reservoir footprint. Riparian vegetation at the western extent covered both banks and comprised a mix of mānuka and kānuka gumland, manuka-machaerina wetland, and an exotic forest made up of *Populus*, *Salix*, and *Eucalyptus*. The riparian vegetation at the eastern extent, at the proposed dam face, comprised of totara treeland, indigenous wetland mosaic, and exotic forest made up of redwood, *Populus*, and *Salix*.

Other riparian vegetation along the streams was limited to narrow strips of no more than 3 m wide, predominantly comprising mānuka and kānuka, pampas, blackberry, and *Populus*. Where streams lacked intact riparian vegetation, the margin was limited to either rank grass (fenced) or short grazed grass (unfenced). These sections of stream had 'very low' to 'no effective' shading.

Streams in the southern portion of the site were generally fenced from livestock (barbed wire and hot-wire) and were intact and well-maintained. The fences were roughly <2 m setback from the edge of the channel. Streams in northern portion of the site were not fenced from livestock and heavy trampling were observed. Water column visibility was particularly low in the downstream extent and through the online wetland.

Stream ecological valuations were undertaken on stream reaches considered to be representative of all remainder of the reaches on site. The main permanent stream channel with canopy cover (Watercourse 1), permanent stream without canopy cover (Watercourse 2), and the intermittent tributary (Watercourse 3) all have low current ecological value, with SEV scores of 0.4, 0.31, and 0.34, respectively (Table 3). This reflects the highly modified and uniform nature of the channels, the lack of vegetation along the riparian margins, limited instream habitat provisions for freshwater fauna, low fish biodiversity, and poor macroinvertebrate community.

The fish fauna intact (FFI) and invertebrate fauna intact (IFI) function in the SEV was included for the SEVi-C for SEV1 and SEV2. Fish observations and macroinvertebrate surveys were carried out along these two main stems, and so were considered representative.

Fish observations and macroinvertebrate surveys were not carried out in Watercourse 3, therefore FFI and IFI functions were not included in the SEV3 score.

SEV cross-section photographs are presented in Appendix C and locations of the SEV are presented in Appendix A, Figure 1.

Table 3: SEV values for three representative streams within the proposed reservoir footprint.

SEV ID	SEV1	SEV2	SEV3
Location	Watercourse 1 (under riparian canopy)	Watercourse 2 (open channel)	Watercourse 3
Classification	Permanent	Permanent	Intermittent
SEVi-C	0.40 (incl IFFI, FFI)	0.31 (incl IFFI, FFI)	0.34 (excl IFI, FFI)

A desktop review of the downstream environment outside of the reservoir was undertaken. The downstream environment appears to be similar to Watercourse 1 within the footprint. Of note, the stream downstream of the proposed reservoir predominantly traverses through a relatively intact riparian margin (both exotic and native trees). It is assumed that the instream substrates are similar to that observed in the most downstream portion of Watercourse 1 on site, consisting of soft-bottom substrates.

5.1.2 Macroinvertebrates

Two kick samples were collected across site, one in Watercourse 1 and the other taken from Watercourse 2.

Twenty-one invertebrate taxa were recorded from Watercourse 1. The invertebrate community indicates a 'poor' quality class with a SBMCI value of 57.7 and a QMCI-sb value of 2.8. No EPT taxa were recorded from the sample. Of note, *Sphaeriidae*, a tiny bivalve with high tolerance to polluted water (MCI score of 2.9) dominated the sample.

Fourteen invertebrate taxa were recorded from Watercourse 2 (a tributary of Watercourse 1). The invertebrate community sample indicates 'poor' water and habitat quality, with a SBMCI value of 45.4 and QMCI-sb value of 1.81. Of note, *Oxyethira*, a caddisfly larve and *Lymnaeidae*, an introduced freshwater snail, both with high tolerance to polluted water that are usually found in slow-flowing streams and ponds (MCI score of 1.2) collectively made up 46% of the sample.

The summary statistics for the samples collected in this survey are provided in Table 4, with full taxa list provided in Appendix D.

Table 4: Summary statistics for macroinvertebrates collected from Watercourse 1 and Watercourse 2, in the proposed MN02 reservoir footprint (October 2020).

Site name	Taxa richness	EPT richness	Number of individuals	SBMCI value	SBMCI class	QMCI-sb value	QMCI-sb class
Watercourse 1	21	0	274	57.71	Poor	2.82	Poor
Watercourse 2	14	0	56	45.43	Poor	1.81	Poor

5.1.3 Freshwater fauna

During the first night of trapping, four longfin eels (*Anguilla dieffenbachii*) (At Risk - Declining) ranging in size from 550 mm to 950 mm and one shortfin eel (*Anguilla australis*) at 400 mm in length were recorded along the main permanent stem (Photograph 1).

During the second night of trapping, three longfin eels ranging in size from 600 mm to 1000 mm were recorded from two separate fyke nets at the most downstream extent of Watercourse 1.

During the night spotlighting, four banded kōkopu (*Galaxias fasciatus*) ranging in size from 100 mm to 200 mm were observed in pools along the upper portions of Watercourse 1 under canopy cover. A shortfin eel was also observed half submerged in macrophytes.

A summary table of the freshwater fauna caught and observed in this survey is provided in Table 5. Of note, no exotic fish species were observed during the survey.

A desktop review, using the NZFFD, of streams in the wider Waitangi catchment was carried out including Waitangi River and Waiaruhe River. In addition to the fish species caught during our fish survey, a diverse range of fish species have been recorded downstream and outside the proposed reservoir footprint in the wider catchments. Native fish species include Cran's bullies (*Gobiomorphus basalis*) and common bullies (*Gobiomorphus cotidianus*), kēwai (*Paranephrops sp.*), and black mudfish (*Neochanna diver*sus) (At Risk - Declining). Additionally, exotic and pest fish species recorded include gambusia (*Gambusia affinis*), rudd (*Scardinius erythrophthalmus*), and tench (*Tinca tinca*). Some of these fish species may use the stream network onsite.

Black mudfish have been recorded at Kerikeri Airport gumland (SNA P05/103) in the wider Waitangi River catchment. While black mudfish are associated with wetlands, the wetlands assessed during the field survey were considered unlikely to support black mudfish. The following ecosystem types could potentially provide mudfish habitat:

- Mānuka, kānuka gumland, *Machaerina* sedgeland had high elevation on a terrace slope above an incised permanent stream channel (Watercourse 1) and was dry (Appendix G, Photograph 4);
- Mānuka wetland, a single-aged stand of mānuka located on the edge of an unnamed tributary leading to Watercourse 1, with stock trampling resulting in a highly degraded understorey (Appendix G, Photograph 5);
- Mānuka-kiokio-*Machaerina* wetland connected to an *Eleocharis-Schoenoplectus-Machaerina* wetland area at the downstream end of Watercourse 1, and surrounded by exotic forest, with stock accessing all areas of this complex (Appendix G, Photograph 6 and 7);
- Indigenous-dominated *Juncus* wetland consisting of 4.05 ha of Edgar's rush (*Juncus edgariae*) across the northern half of the proposed reservoir. Stock access and wetland drainage channels overgrown with macrophytes have affected the ecological integrity of this wetland area (Appendix G, Photograph 8); and,
- Exotic-dominated *Juncus* wetland areas located in the southern portion of the footprint.

The likelihood of black mudfish presence at this site is reduced by the following and have been identified as threats to their very specific habitat requirements[19],[20]:

- Historical and on-going wetland habitat loss from active draining on-site;
- Eutrophication (excessive nutrient inflows from land-use practices);
- Active trampling and grazing by livestock;
- Turbid water;
- Low presence of peat-bogs;
- High abundance of aquatic macrophytes; and,
- Presence of long-fin eels and banded kōkopu.

No black mudfish were captured during trapping effort. While they may still use some of the stream network on site this has been assessed to be of low probability.

The presence of longfin eel, an At Risk – Declining species, at the site meets the 'rarity/distinctiveness' criteria within Appendix 5 of the Regional Policy Statement for Northland. Therefore, the stream channels are classified as 'significant habitats of indigenous fauna'.

Table 5: Freshwater fauna recorded within the proposed MN02 reservoir footprint, survey methods, and threat statutes (including sampling undertaken in October 2020).

Common name	Scientific name	Gee-minnow (GMT)	Fyke net	Night spotlighting	Threat status[10, 21]	Ecological value[22]
Tuna/longfin eel	*Anguilla dieffenbachii*	-	7	1	At Risk - Declining	High
Tuna/shortfin eel	*Anguilla australis*	-	1	3	Not threatened	Moderate
Banded kōkopu	*Galaxias fasciatus*	-	-	4	Not threatened	Moderate

[19] Department of Conservation (2011). Mucking in for mudfish.
[20] Hicks, B., and Barrier, R. (1996). *Habitat requirements of black mudfish (Neochanna diversus) in the Waikato region, North Island, New Zealand*. New Zealand Journal of Marine and Freshwater Research, 30: 135-151.
[21] Dunn, N. R., Allibone, R. M., Closs, G. P., Crow, S. K., David, B. O., Goodman, J. M., Griffiths, M., Jack, D. C., Ling, N., Waters, J. M., and Rolfe, J. R. (2017). *Conservation status of New Zealand freshwater fishes*. Department of Conservation.
[22] Roper-Lindsay, J., Fuller, S., Hooson, S., & Sanders, M. (2018). Ecological impact assessment guidelines for New Zealand, 2nd Edition. Environment Institute of Australia and New Zealand Inc.

Photograph 1: Longfin eels caught during trapping (left and centre) and banded kōkopu observed during spotlighting (right).

5.1.4 Summary of freshwater ecology values

Based on the combination of stream characteristics observed during our site walkover, low SEV scores for representative stream reaches across the site, poor macroinvertebrate communities, the freshwater ecology values of both intermittent and permanent streams are assessed as **low**. However, even though the SEV scores are low and macroinvertebrate communities poor, a reflection of the highly modified stream systems of site, the main permanent streams on-site support native At-Risk species (long-fin eel) and other native species (banded kōkopu and shortfin-eel) and is part of a wider wetland complex of high ecological values and so is considered to have **moderate** ecological values.

5.2 Assessment of ecological effects - freshwater

5.2.1 Sedimentation during construction

Works within and adjacent to the bed of wetlands and streams ('streamworks') can result in an uncontrolled discharge of sediment laden water during construction.

The effect of excess in-stream sedimentation is recognised as a major impact of changing land use on river and stream health, through changes in water clarity and sediment deposition dynamics. Sediment entering stream systems can impact water clarity through sediment suspended within the water column ('suspended sediments'). Many native species (including longfin eels) are tolerant of elevated suspended sediment, measured either by turbid water or high concentrations of total suspended solids ("TSS")[23].

Banded kōkopu (*Galaxias fasciatus*) is however a notable exception, known to exhibit avoidance behaviours at 25 NTU[24]. They were observed on site in the upstream portion of Watercourse 1, where the water column was noticeably less turbid and had good water clarity. Banded kōkopu have also been recorded downstream in the immediate and wider catchment where the riparian margin is predominately a mix of native and exotic trees. Banded kōkopu would likely be adversely affected by excess in-stream sedimentation. Sedimentation can also have noticeable effects on physical habitat in streams when it is deposited on the streambed ('deposited sediments'). Excess deposited sediment can clog the small spaces (interstitial) between hard stream

[23] For summary of research see Clapcott, J.E., Young, R.G., Harding, J.S., Matthaei, C.D., Quinn, J.M. and Death, R.G. (2011) Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.

[24] NTU is a Nephelometric Turbidity Unit. NTU is the unit used to measure the turbidity of a fluid or the presence of suspended particles in water.

substrates which impacts aquatic macroinvertebrates, alters food sources (i.e. macroinvertebrates for predation by fish), and removes egg-laying sites for native freshwater fauna.

The streams on site are generally degraded by historical and on-going agricultural land-use, including stock trampling and pugging of unfenced streams and through the online wetland. Fine sediment loading and areas of anaerobic sediment were observed in low-velocity habitats. Fine sediment loading was particularly pronounced in streams immediately downstream of the indigenous-dominated Juncus wetland located in the centre of the proposed reservoir footprint. Of note, the water column in the downstream portion of the site had poor clarity even when there had been no rainfall in the 48 hours prior to or during our site visit. No sensitive macroinvertebrate community taxa (mayflies, stoneflies, and caddisflies) were observed in the streams which is an indication of poor water and habitat quality.

It is recommended that any streamworks are undertaken during earthworks season when there is less flow and potential effects are expected to be easier to manage. It is recommended that the streamworks specific provisions are incorporated into the sediment and erosion controls for the site in accordance with best practice recommendations. We recommend using Auckland Council Guidance Document 5 (GD05).

The streamworks methodology for dewatering, mucking out, and diversion of clean/dirty water has not yet been prepared and therefore, is not included in this assessment. Given that the construction of the reservoir will result in complete and irreversible loss of stream habitat, there are likely to be opportunities to utilise in-line treatment (e.g. sediment traps) that wouldn't normally be in accordance with best practice because they would impact significantly on stream habitat. We recommend those opportunities be considered in the development of the construction methodology. Additionally, to minimise potential adverse effects on banded kōkopu, it is recommended that specific controls are incorporated and is in accordance with GD05. These specific controls could include setting discharge limits and/or use of flocculant treatment device before discharged offsite. At the time of writing we do not have any detail pertaining to the construction methodology or staging. Subject to the implementation of best practice methodologies, there are no known site constraints or characteristics that suggest that the short-term effects of sedimentation associated with instream works could not be appropriately mitigated.

The stream habitat is considered to have **low** ecological value. The freshwater fauna presence is considered to have a **high** ecological value, based on the presence of longfin eel which are classified as At Risk – Declining and banded kōkopu which are sensitive to higher concentrations of total suspended solids. The magnitude of effects associated with construction of the reservoir was assessed as potentially **high** without sediment management, therefore giving an overall level of effects of **very high**. With the appropriate construction and sediment and erosion control methodologies to mitigate sediment and erosion control effects, the magnitude of effects could be reduced to **low**, and so the overall level of effects could be reduced to **low** level.

5.2.2 Injury or mortality of freshwater fauna

Construction of the proposed reservoir could cause injury or mortality to native freshwater fauna during works in streams and wetlands. The magnitude of potential effect on native freshwater fauna is driven by the nature of the activity, the area of stream disturbance, density of fish present in each area, the ability of fish to escape disturbance and the controls applied. The conservation status of fish species is also relevant when assessing the potential overall level of effect.

The full construction method is unknown at this stage, but it is anticipated that the streams and wetland will require mechanical modification to form the reservoir basin. The potential impact of these works on stranding, injury and mortality can be minimised by implementing appropriate freshwater fauna salvage methods prior to works commencing. Some sections of the streams to be inundated may not be subject to physical streamworks and in those instances fish may be able to move upstream without salvage. Provided the reservoir is not filled too rapidly we expect some fauna (e.g. eels) within the site to find suitable habitat unaided but should be considered further in the Freshwater Fauna Relocation Plan (FFSRP).

If black mudfish are found to be present during streamworks in the footprint of the reservoir, then as many mudfish as possible will be removed from site via a salvage and relocation methodology as they will be unable to establish in the lake.

We recommend a Freshwater Fauna Salvage and Relocation Plan (FFSRP) is prepared as part of the reservoir construction methodology to minimise potential injury or mortality during streamworks and reservoir filling.

Longfin eel are classified as At Risk – Declining and so the freshwater fauna potentially affected by the activity is considered to have a **high** ecological value. The potential magnitude of effects of freshwater fauna stranding, injury, or mortality are assessed as **high**. Therefore, the overall level of effects would be **very high** in the absence of controls. With appropriate salvage and relocation methodologies detailed in a FFSRP to minimise effects on fish during construction and reservoir filling, the magnitude of effects could be reduced to **low** and the overall level of effects to **low**.

5.2.3 Fish passage

Many of New Zealand's native fish are diadromous, meaning they migrate to and from the sea as part of their lifecycle. Artificial structures and poor culvert design can restrict fish migration. Often this occurs as a result of culverts being perched, too steep or long, subsequent increases in water flow or a resultant laminar flow with insufficient roughness to allow effective fish movement[25]. Placement of dam structures on streams and rivers can also restrict fish movement unless particular provision is made for them to pass. In addition, temporary restrictions to fish passage during construction may impact a population's reproductive success. The resultant decrease in fish mobility can cause fragmented populations, a reduction in population size, and limit overall available habitat for freshwater fauna. However, the fish community at this location is likely to be affected by the presence of Haruru Falls downstream, which will provide a migration barrier for some species of fish.

Longfin eels, shortfin-eels, and banded kōkopu are present in the stream network on site. Eels are catadromous in that they live in freshwater but migrate to sea to breed, with juveniles returning to freshwater. Longfin-eels and shortfin-eels are accomplished climbers and are well adapted to negotiating barriers to reach catchment headwaters.

Banded kōkopu are diadromous in that the adults live and breed in freshwater, while the larvae migrate to the sea and return to freshwater as juveniles. When considering their ability to pass barriers, banded kōkopu are classified as good climbers[26]. Banded kōkopu are likely able to pass natural waterfall structures, such as the Haruru Falls located downstream of the Waitangi River. Banded kōkopu are considered good climbers, however they are unlikely able to climb dry walls of dams and could be adversely affected by dams.

Based on aerial imagery, there is estimated to be in the order of 3 km of stream habitat upstream of the proposed reservoir. Of that, there is estimated to be only ~0.3 km of fully or partly shaded stream habitats. This section of stream is also located upstream of the wetland complex (via Watercourse 2) but may be seasonally disconnected by a perched culvert observed across the farm track. Additionally, the water clarity is also visually poor compared to Watercourse 1. The remaining ~2.7 km appears to be relatively open channels, with little shading and no intact riparian margins.

The proposed reservoir and the remaining upstream unshaded channels are unlikely to provide suitable habitat for banded kōkopu. The downstream habitat (outside the proposed reservoir footprint) is considered more favourable. Therefore, the provision of fish passage (upstream and downstream) into the proposed reservoir is recommended for eels only to enable access to the habitat within and upstream of the proposed reservoir. An elver pass for eels could be constructed up the face of the dam. If this is not feasible, then a trap and haul programme could be established to stock the reservoir with elvers, noting that the long-term costs of this approach would quickly exceed those of constructing an elver pass.

Providing downstream passage for migrant adult eels is more problematic but this could be managed by undertaking a periodic trap & haul programme. Consideration for downstream movement of migrant eels should be included in spillway design to minimise the potential for injuries to occur. Providing passage is important to realising the compensatory replacement of stream habitat for eels with lake habitat in the reservoir. While passage will not be provided for banded kōkopu, to avoid impeding migration, it is recommended that construction timing be undertaken outside of banded kōkopu migration season. Migration season for banded kōkopu are May and September (inclusive), peak June and July[27].

[25] Franklin, P., Gee, E., Baker, C. & Bowie, S. (2018). New Zealand Fish Passage Guidelines for Structures up to 4 metres. NIWA CLIENT REPORT No: 2018019HN.
[26] Stevenson, C., Baker, C. (2009). Fish passage in the Auckland Region – a synthesis of current research. Prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Report 2009/084.
[27] NIWA (2015) Freshwater fish spawning and migration periods. MPI technical paper no. 2015/17.

It is recommended that upstream and downstream fish passage for eels be included in the design of the reservoir. This approach will be the most cost-effective in the long-term and is critical to enabling the use of the proposed reservoir habitat by eels to compensate for the loss of stream habitat that will occur. It is recommended that fish passage is not provided for swimming species, to prevent the potential movement of pest fish species into the reservoir. Approval of any fish pass design or dispensation to not install a fish pass is required from the Director-General of the Department of Conservation under Section 43 of the Freshwater Fish Regulations 1983.

Longfin eels are classified as At Risk – Declining, meaning that the potential affected fauna is of **high** ecological value. Longfin eels are accomplished climbers and are typically found to inhabit headwater catchments, therefore the magnitude of effect caused by impeding fish passage is considered **moderate**. This would result in an overall level of effect of **high**, but further dam design to incorporate eel passage is recommended to enable passage and contribute to the compensation package resulting from stream habitat loss.

Banded kōkopu are not classified as At Risk or Threatened[28] and common in the Kerikeri Ecological District[29] so is of **low** ecological value. Banded kōkopu are climbing species and can typically be found to inhabit headwater catchments. The proposed reservoir will result in the removal of headwater streams in this catchment of the Waitangi River; however, the headwater stream network is predominately open channels with a lack of riparian cover. Therefore, magnitude of effect caused by impeding fish passage for banded kōkopu is considered **moderate**. This would result in an overall level of effect of **low**. The dam design will not incorporate passage for banded kōkopu and so the overall level of effect remains as **low**. However, it is recommended that construction timing is restricted to outside of banded kōkopu migration range (between May and September, inclusive) (or peak migration between June and July) to avoid impediments to migration and further headwater catchment enhancement planting in the neighbouring catchment be undertaken as part of the compensation package for stream habitat loss.

5.2.4 Permanent modification of stream habitat

The proposed reservoir will inundate the gully system resulting in modification of approximately 4,797 m (~6,343 m^2 streambed area) continually flowing permanent stream and approximately 2,575 m (~1,505 m^2 streambed area) of intermittently flowing stream. The length of online ponds has been included as they provide habitat for freshwater fauna and is connected to natural streams. The length and area of stream bed affected has been estimated based on stream length identified during our site visit and measured wetted widths cross sections from our SEV surveys, therefore will require confirmation on site to determine the actual extent. The filling of the reservoir will impact the main stems and tributaries across the site, turning them from relatively modified, straightened and deepened, soft-bottom stream channels to lake habitat.

Due to the nature of the effect, being a substantive change to the functionality of the stream system, the effects are difficult to mitigate at the point of impact. Even though the construction of a reservoir will likely provide additional habitat, the habitat is not the same as stream habitat. Therefore, measures are required to address the effects associated with the loss of stream habitat.

The stream habitat is considered to have **low** current ecological value based on a combination of modified, straightened and deepened soft-bottom streams, poor macroinvertebrate community scores, and stream function SEV scores. However, the stream habitat supports At Risk longfin eels and other native species including banded kōkopu, therefore it is considered to have **moderate** ecological value. The magnitude of effects is considered **very high** due to the permanence and quantity of stream loss. Therefore, the overall level of effects from the permanent loss of stream habitat is **high**.

5.2.4.1 Stream offset required

To define the quantum of enhancement or restoration required to offset the effects of the proposed reservoir, an environmental compensation ratio (ECR) can be calculated using SEV scores.

[28] Dunn, N., Allibone, R., Closs, G. Crow, S., David, B., Goodman, J., Griffiths, M., Jack, D., Ling, N., Waters, J., and Rolfe, J. (2017). Conservation status of New Zealand freshwater fishes. Department of Conservation.
[29] Goodman, J. (2018). Conservation, ecology, and management of migratory galaxiids and the whitebait fishery. Department of Conservation.

The ECR is a tool used to quantify the amount of streambed area that is required to be restored, which takes into account the extent and type of stream impacted or lost and the type of enhancement works proposed. The objective is to achieve a 'no-net-loss' in ecological function as a result of the activities. The ECR calculation formula requires SEV scores to be calculated for both the impact and proposed mitigation (or offset, if applicable) sites. This provides a basis from which to quantify and scale the likely loss in values and functions at an impact site with the increase in stream ecological values and functions at a compensation or mitigation site.

ECR = [(SEVi-P – SEVi-I) / (SEVm-P – SEVm-C)] × 1.5

Where: *SEVi-P is the potential SEV value for the site to be impacted.*
SEVi-I is the predicted SEV value of the stream to be impacted after impact.

SEVm-C is the current SEV value for the site where environmental compensation is applied.
SEVm-P is the potential SEV value for the site where environmental compensation is applied.

Restoration length required = (impact area × ECR) / restoration channel width.

Table 6 presents the summary SEV scores for the current (SEVi-C) and modelled potential (SEVi-P) values for the impact permanent (SEV1 and SEV2) and intermittent (SEV3) reaches. Fish fauna intact (FFI) and invertebrate fauna intact (IFI) are excluded from the current SEV score for the purpose of ECR calculations. All other streams on site are similar in their characteristics, and so the SEV scores are applied as follows:

- Watercourse 1 (under riparian canopy) is representative of permanent channels with riparian vegetation margins,
- Watercourse 2 (open channel with no riparian canopy) is representative of permanent channels lacking riparian vegetation margins, and
- Watercourse 3 is representative of all intermittent tributaries.

Potential scores for the impact streams have been modelled on a maximum 20 m riparian enhancement planting of native woody vegetation. The assumptions applied also include improvements to the following functions in the SEV: Vlining, Vrough, Vshade, Vdod, Vripar, Vmacro, Vsurf, Vripfilt, Vphyshab, and Vwatqual. Assumptions applied to the current SEV scores and modelled potential SEV scores for SEV1, SEV2, and SEV3 are provided in Appendix E.

Impact scores (SEVi-I) are considered to be 0.2, because while the inundation of the stream will result in a permanent loss of stream habitat type, the resulting reservoir feature will still provide habitat for the fish and macroinvertebrate species observed on site and so it provides some functional value.

Table 6: Measured and modelled stream ecological valuation (excluding FFI and IFI functions) results used to determine the estimated ECR.

Stream ID	SEV ID	SEVi-C	SEVi-P	SEVi-I	SEVm-C[30]	SEVm-P[30]
Watercourse 1 (under riparian canopy)	SEV1	0.40	0.60	0.2	-	-
Watercourse 2 (open channel with no riparian canopy)	SEV2	0.29	0.60	0.2	0.29	0.60
Watercourse 3 (intermittent channel with no riparian canopy)	SEV3	0.34	0.65	0.2	0.34	0.65

[30] SEVm-C and SEVm-P scores for permanent and intermittent reaches are hypothetical scores as offset locations have yet to be identified. It is assumed that the impact reaches are similar to nearby streams in the Te Ruaotehauhau Stream catchment.

An estimated area of 7,848 m^2 streambed area will be impacted by the reservoir along 4,797 m of permanent and 2,575 m of intermittent stream.

While an offset planting location(s) has not yet been identified and confirmed, hypothetical SEVm-C and SEVm-P scores (using estimated SEV scores across site) have been used to estimate the quantum of stream offset required to achieve no net loss of ecological function. Scores for SEV2 and SEV3 have been used as indicative offset sites and the assumptions associated with this are presented in Appendix E.

Based on the hypothetical SEV values in Table 6 and 7, an estimated ECR of 1.93 for both permanent channels with and without riparian vegetation margins, and 2.18 for intermittent channels is calculated. This means approximately 12,278 m^2 and 3,277 m^2 (collectively 15,555 m^2) of similar permanent and intermittent streambed area habitat enhancement in nearby catchments is required to achieve no net loss of ecological function.

The ECR could be higher if streams in nearby catchments differ in stream functions from that estimated on site and SEV gains are less, which is likely if planting alongside highly modified stream channels, or infill planting into existing vegetation. This could result in an ECR of more than 5. Consequently, the quantum of streambed area required will increase or decrease accordingly to achieve no net loss of ecological function.

It is considered that the effects associated with habitat modification can be offset by enhancing existing stream systems, the quantum of which will be updated using the SEV and ECR methodology following enhancement sites are sought. While the offset quantum are currently estimations, the SEV scores are consistent with reference SEV scores in rural catchments dominated by agricultural land-use practices.

The estimated recommended offset requirements are considered positive effects, however it cannot contribute to reducing the magnitude of adverse effect. As such the magnitude of effects remains the same as 'before mitigation' (being **very high**) and subsequently the overall level of effects remain **very high**. Notwithstanding, the proposed offset package measures outlined above are recommended to be consistent with biodiversity offsetting principles.

An Offset and Compensation Plan (OCP) is recommended to identify the location(s) of the proposed planting, updated current on site SEV scores, updated offset SEV scores and ECR calculations, species list, size, spacing, and weed maintenance programme to support the establishment of plantings.

Table 7: Modelled potential SEV scores and ECR's and offset areas required to achieve no net loss of ecological function for the proposed inundation of permanent and intermittent streams across the proposed MN02 reservoir footprint.

Impact Sites Stream ID	SEVi-C	SEVi-P	Average width (m)	Length (m)	Impacted Streambed area (m2)	Stream ID	ECR*	Streambed area compensation required (m2)
Permanent streams (with riparian margins)	0.40	0.60	1.2	560	**666**	**Similar permanent stream without riparian margins**	1.94	**1,290**
Permanent streams (without or minimal riparian margins)	0.29	0.60	1.3	4,237	**5,677**	**Similar permanent stream without riparian margins**	1.94	**10,988**
Intermittent streams	0.34	0.65	0.6	2,575	**1,505**	**Similar intermittent stream**	2.18	**3,277**
Totals				**7,372**	**7,848**			**15,555**

*As described above, the ECR may increase depending on the offset site identified and the ecological gains that can be achieved.

5.2.5 Downstream water quality effects

Reservoirs can impact downstream water quality depending on how long water is stored and where outlets are located. We understand the reservoir outlet will draw water from the base of the dam. Placement of the outlet in this location will mean that residual flows will be drawn from deeper, cooler water.

An outlet drawn from deeper water is preferable to drawing water from the shallow water layers that will likely be warmer than stream flows and potentially support algal growths, which can be toxic. The downstream channels appear to be predominantly open and lacking riparian vegetation and so fauna present may be less impacted by a potential decrease in temperature (as opposed to increases in temperature). Subject to the reservoir outlet being from deeper water, we consider the effect on native freshwater fauna from changes in stream temperatures will be low. Further consideration of measures to minimise potential downstream effects will be incorporated into detailed design discussions with the project engineers.

We recommend a Water Quality Monitoring Plan is prepared as part of the on-going freshwater fauna management and reservoir operations to assess potential changes in the downstream habitat. This would involve monitoring for periphyton growth and water quality parameters as indicators to ensure any potential adverse downstream effects are no more than anticipated.

Based on aerial desktop assessment, the stream habitat downstream appears different to that observed on site. The downstream habitat appears to relatively natural with intact riparian cover for most of the stream. The downstream habitat is likely to also support At Risk longfin eels and other native species including banded kōkopu, therefore it is considered to have **high** ecological value. In the absence of well-designed outlet structures and flow management, the magnitude of effect could be **moderate** or higher. With flow management the magnitude of the potential impact on water quality is likely to be **low**, and so the overall level of effects is considered **low**, but further assessment will be required to determine the magnitude and level of effect if the outlet is designed differently from our understanding.

5.2.6 Downstream habitat effects

The construction of a reservoir will interrupt downstream transport of coarse and fine sediment and this may impact on downstream channel form and aquatic habitat as well as reduce the storage capacity of the reservoir over time[31]. The magnitude of this effect is difficult to predict, but due the small area being impacted, may be relatively small.

The construction of the reservoir will modify the flow regime downstream of the reservoir. The reservoir will reduce overall flow volumes to the downstream reaches outside the reservoir. Minimum flows will be maintained through the dam outflow. However, provisions for periodic flushing flows are recommended to discourage periphyton growth as well as provisions for dissipating flow energy to minimise potential streambed scouring and erosion at the discharge outlet.

Modifications to the flow regime may affect fish species more indirectly through changes to water quality, periphyton cover and macroinvertebrate production. The current flow observed on site appear to be steady through the downstream extent of the on-site stream network and fast flowing in the upper tributaries and Waitaia Stream. The freshwater community downstream of the reservoir under existing conditions may experience changes to flow regimes, but environmental flow and flushing flow management investigations are recommended to fully assess the effects of changes in flow regime.

To minimise these impacts, it is recommended that flushing flow management be investigated by project engineers and ecologist and be included into the detailed design of the reservoir.

Based on aerial desktop assessment, the stream habitat downstream appears different and of higher value to that observed on site. The downstream habitat appears to relatively natural with intact riparian cover for most of the stream. The downstream habitat is likely to also support At Risk longfin eels and other native species including banded kōkopu, therefore it is considered to have **high** ecological value. In the absence of a suitable flow regime and the incorporation of periodic flushing flows, the magnitude of effect could be **moderate** or higher. The magnitude of this impact and the overall level of effects is likely to be **low** after flow regime management, but further assessment will be required to determine the magnitude and therefore the overall level of effect.

6. Terrestrial and wetland ecological assessment

6.1 Terrestrial and wetland ecosystem ecological values

The site comprises fragmented areas of terrestrial and wetland ecosystems degraded by stock access and other modifications such as dug drainage channels through wetland areas (Appendix A; Figure 1).

Terrestrial ecosystem types are comprised of fragmented areas of secondary tōtara forest degraded by sheep trampling and grazing, and some weed invasion. Mature planted exotic forest is present as riparian margin at the upstream and downstream ends of Watercourse 1.

Historically, the site would have comprised of kahikatea, pukatea swamp forest (WF8) in the middle of the gully system, with kauri podocarp broadleaf forest (WF10) on higher slopes with better drainage. Clearance of these forest communities has resulted in acidic soils and remnant patches of regenerating ‘gumland’ consisting of degraded mānuka, kānuka gumland *Machaerina* sedgeland where drainage is moderate, and mānuka-dominated wetlands where drainage is poor.

All remnant wetland extents on site have been affected by hydrological modifications and/or stock access, resulting in a loss of habitat quality and depauperate species richness. However, remaining wetlands sheltered by exotic forest at the downstream

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[31] Kondolf, G. M., Gao, Y., Annandale, G. W., Morris, G. L., Jiang, E., Zhang, J., Cao, Y., Carling, P., Fu, K., Guo, Q., Hotchkiss, R., Peteuil, C., Sumi, T., Wang, H.-W., Wang, Z., Wei, Z., Wu, B., Wu, C., & Yang, C. T. (2014). Sustainable sediment management in reservoirs and regulated rivers: Experiences from five continents. Earth’s Future, 2(5), 256–280. https://doi.org/10.1002/2013EF000184

end of Watercourse 1 retain indigenous species dominance despite sheep grazing and trampling, and the main farm wetland area (in the centre and north of the proposed reservoir) is dominated by native Edgar's rush (*Juncus edgariae*).

The proposed reservoir avoids a high value raupō – dominated farm pond and high value mature tōtara forest (which has been classified as a WF11 - kauri, podocarp, broadleaved forest[32]) which are present on the western and eastern edges of the proposed reservoir respectively (Appendix A; Figure 1).

Of the plant species observed on site, all are classified as nationally Not Threatened[33], except for kānuka and mānuka. Kānuka is classified as Threatened – Nationally vulnerable and mānuka as At Risk – declining due to the potential threat of myrtle rust (*Austropuccinia psidii*) to these species. They are otherwise a common species in the wider environment. Not Threatened species are considered of **low** ecological value while kānuka is considered as having a **very high** ecological value and mānuka as **high** ecological value due to their threat classification.

The historic ecosystem present on site of kahikatea, pukatea forest wetland (WF8) would have been considered a 'swamp'. Presently, dug drainage channels and conversion of land use to farming has resulted in changes to the hydrology of the system and overall loss of wetland extent. Table 8 presents a summary of each wetland ecosystem described below and its associated definition and significance criteria as described in the Regional Policy Statement for Northland 2018, proposed Regional Plan for Northland 2020, and National Policy Statement for Freshwater Management 2020.

To be considered 'Significant' under the Proposed Regional Plan, a natural wetland must exceed any of the following area thresholds:

- Swamp greater than 0.4 ha in area;
- Bog greater than 0.2 ha in area;
- Wet heathland (including gumland and ironstone heathland) greater than 0.2 ha in area; or,
- Marsh, fen, ephemeral wetland or seepage greater than 0.05 ha in area.

The indigenous-dominated *Juncus* wetland habitat comprises 4.05 ha within the Project footprint. Drainage channels and stock impacts have severely degraded this area, resulting in a near-monoculture of approximately 50% native *Juncus* cover and 50% exotic pasture grass cover. Considering the defined area retains wetland features (including hydrological features such as pooling, typical wetland gully landform, and indigenous wetland plants), this area has been classified as a swamp[34] and therefore exceeds the Regional Policy Statement for Northland (updated 2018) significance threshold for this wetland type.

The ecological site[35] contains wet heathlands (gumland) which include the mānuka, kānuka gumland *Machaerina* sedgeland, mānuka wetland and mānuka, kiokio, *Machaerina* wetland together constituting 0.31 ha. These areas, although not contiguous, together exceed the Regional Policy Statement significance threshold. The Proposed Regional Policy Statement thresholds relate to the ecological site under assessment, as opposed to contiguous areas of vegetation.

All other wetland types on site are not considered to meet the thresholds as described in the Regional Policy Statement for Northland (updated 2018) significance thresholds.

[32] Northland Regional Council (n.d.) Selected Land-use Register. Northland Biodiversity Ranking – Ecosystem Rarity. Accessed from https://localmaps.nrc.govt.nz/localmapsviewer/?map=65b660a9454142d88f0c77b258a05f21 on 19 November 2020.
[33] De Lange, P. J., Rolfe, J. R., Barkla, J. W., Courtney, S. P., Champion, P. D., Perrie, L. R., Beadel, S. M., Ford, K. A., Breitwieser, I., Schönberger, I., Hindmarsh-Walls, R., Heenan, P. B. & Ladley, K. (2017). Conservation status of New Zealand indigenous vascular plants. New Zealand Threat Classification Series 22. 82 p.
[34] Department of Conservation (2004). Wetland types in New Zealand. Peter Johnson & Phillipe Gerbeaux.
[35] See definition in Regional Policy Statement for Northland (updated 2018).

Table 8: Wetland ecosystem types present, their size, and their classification under the Regional Policy Statement for Northland, proposed Regional Plan for Northland, and National Policy Statement for Freshwater Management 2020.

Wetland ecosystem type	Size (ha)	Regional Policy Statement for Northland (updated 2018) – Significant wetland	Proposed Regional Plan for Northland 2020 - Natural wetland classification	NPS FM – Natural wetland classification
Mānuka, kānuka gumland *Machaerina* sedgeland	0.06	Yes	Natural wetland	Natural wetland
Mānuka wetland	0.19	Yes	Natural wetland	Natural wetland
Mānuka – kiokio – *Machaerina* wetland	0.06	Yes	Natural wetland	Natural wetland
Eleocharis – Schoenoplectus – Machaerina wetland	0.09	No	Natural wetland	Natural wetland
Indigenous-dominated *Juncus* wetland	4.05	Yes	Natural wetland	Natural wetland
Exotic-dominated *Juncus* wetland	0.13	No	Natural wetland	Natural wetland
Isolepis turf wetland	0.005	No	Natural wetland	Natural wetland
Improved pasture wetland	0.90	No	Excluded	Excluded
Constructed farm pond	0.03	No	Excluded	Excluded

6.1.1 Tōtara forest

Secondary tōtara (*Podocarpus totara*) forest is present among exotic trees in at the downstream end of Watercourse 1 on the eastern side of the proposed reservoir, as well as on the eastern edge of the proposed reservoir 270 m north of this area. The forest in both areas has been degraded by sheep access and subsequently the understorey is degraded by browsing and trampling. The forest is relatively young, with trees approximately 12 m in height, with the largest at 27 cm Diameter at Breast Height (DBH).

Tōtara and kahikatea (*Dacrydium dacrydioides*) are the main canopy species at the downstream end of Watercourse 1, with a single rimu (*Dacrycarpus cupressinum*), occasional kānuka (*Kunzea robusta*), red matipo (*Myrsine australis*), māhoe (*Melicytus ramiflorus*), silverfern (*Cyathea dealbata*) and wheki (*Dicksonia squarrosa*) in the subcanopy, mātā (*Histiopteris incisa*), rasp fern (*Doodia australis*), *Diplazium australe* and sickle spleenwort (*Asplenium polyodon*) in the understorey, and a groundcover of patchily distributed basket grass (*Oplismenus hertillus* subsp. *imbicillis*). Some sections have been invaded by gorse (*Ulex eurpaeus*). Exotic Taiwan cherry (*Prunus campanulata*) is also present.

The tōtara forest 270 m north of this area consists of mature forest of 1.7 ha (classified as WF11 – kauri, podocarp, broadleaved forest), of which approximately 0.01 ha of edge habitat is within the impact area. The area of 0.01 ha consists of a monoculture stand of small to medium sized tōtara with pasture grass understorey. Stock currently have access to this area. In total, 0.17 ha of tōtara forest is within the proposed Project footprint.

Tōtara forest within the footprint is considered as having **moderate** ecological value. The forest provides habitat for indigenous birds and potentially lizards, however trees are moderately sized, and the forest has been impacted by grazing and weed invasion. Species richness is lower than would be expected in a tōtara forest protected from stock access.

6.1.2 Exotic forest

Approximately 1.26 ha of exotic forest is present within the proposed reservoir footprint. Exotic forest formed the main canopy in the eastern forested block at the downstream end of Watercourse 1 and forms the main riparian margin at the upstream end of Watercourse 1.

Exotic forest consisted of mature pine (*Pinus radiata*), redwoods (*Sequoia sempervirens*), poplar (*Populus spp.*) and blackwoods (*Acacia melanoxylon*) at the downstream end of Watercourse 1. This forest encompasses areas of tōtara forest and a small wetland complex adjacent to Watercourse 1. Ring fern (*Paesia scaberula*) forms dense ground cover beneath these trees. Mature trees are approximately 50 cm DBH, with some trees up to 80 cm DBH – no crevices or cracks were identified from the ground for long-tailed bats (*Chalinolobus tuberculatus*), however trees are large and crevices may be present at the tops of trees outside of eyesight.

At the upstream end of watercourse 1, exotic forest consisted of mature poplars (*Populus spp.*), eucalyptus (*Eucalyptus spp.*) and occasional crack willow (*Salix* x *fragilis*). Exotic grasses form the main understorey component of this area, and the forest surrounds an area of mānuka, kānuka gumland, *Machaerina* sedgeland described in Section 6.1.3.

An area of 0.02 ha of willow-leaved hakea (*Hakea salicifolia*) treeland with degraded understorey was present halfway up the eastern side of the Project footprint at the upstream end of Watercourse 3.

Exotic forest was providing the ecological services of stream protection through shade and erosion control and may provide habitat for Threatened - Nationally Critical long-tailed bats[36]. It is therefore considered to be of **moderate** ecological value.

A moderate ecological value was determined through following the EIANZ guidelines, specifically assigning:

- A **low** value for representativeness (e.g. exotic-dominated ecosystem);
- A **high** value for rarity/distinctiveness (e.g. Threatened long-tailed bats and At-Risk North Island brown kiwi may be present);
- A **low** value for diversity and pattern (e.g. low overall indigenous diversity); and,
- A **moderate** ecological value in regards to ecological context (e.g. provides a moderate value stepping stone for forest birds, provides some buffering to streams, and are of a relatively large size considered together).

Therefore, the area rates high for one of the assessment matters and low or moderate for the remainder, resulting in an overall **moderate** ecological value.

6.1.3 Mānuka, kānuka gumland, *Machaerina* sedgeland (WL1)

A small area (0.06 ha) of mānuka, kānuka gumland, *Machaerina* sedgeland was present within the western forest area at the upstream end of Watercourse 1 and was surrounded by mature exotic trees. Vegetation was approximately 7 m tall and consists of a mix of mānuka and kānuka. The understorey is dominated by native tussock swamp twig rush (*Machaerina juncea*), *Machaerina arthrophylla*, silverfern, abundant pink bindweed (*Calystegia sepium* subsp. *roseata*), occasional tetraria (*Tetraria capillaris*) and exotic species including exotic buttercup (*Ranunculus repens*), broom sedge (*Carex scoparia*) and exotic grasses.

Stock are presently excluded, but past stock access is apparent due to a degraded understorey, trampling and areas dominated by rank grass.

[36] O'Donnell, C.F.G., Borkin, K.M., Christie, B. L., Parsons, S., Hitchmough, R. A. (2017). Conservation status of New Zealand bats. New Zealand Threat Classification Series 21. 4 p.

Kānuka is known to be a common co-dominant with mānuka shrublands in the Kerikeri ED which are one of the most common types of shrublands in the ED[37]. Nonetheless, gumlands are classified as a Critically Endangered[38] ecosystem nationally, therefore this ecosystem is considered as having **very high** ecological value.

6.1.4 Mānuka wetland

Mānuka wetland (0.04 ha) was present in a small cluster at the upstream end of a tributary leading into Watercourse 1, and present on riparian margins of streams on site, primarily Watercourse 1 and related tributaries (Appendix A; Figure 1). The total quantum of mānuka wetland loss is 0.19 ha.

The mānuka wetland cluster at the upstream end of the tributary leading to Watercourse 1 has been affected by stock trampling and browse. Trees were approximately 5 m high and the understorey is dominated by rank grass with occasional *Isolepis cernua* var. *cernua.* During the survey period waterlogging was apparent.

Individual mānuka trees border Watercourse 1 and associated tributaries and were protected from stock through temporary electric fencing. These areas generally consist of 1 m wide riparian wetland extents, with other species including kumarahou (*Pomaderris kumarahou*), ring fern (*Paesia scaberula*), silverfern, bracken (*Pteridium esculentum*) and tussock swamp twig rush. Exotic blackberry (*Rubus fruticosus agg.*) and rank grass dominated some areas of this riparian margin.

Wetlands are a nationally Threatened habitat type constituting less than 10% of their original extent nationally and less than 5% remaining in Northland[39]. These mānuka wetlands would likely support additional gumland species if not for stock impacts.

Due to the indigenous dominance of these wetland areas, high threat status of wetlands, and as gumlands are classified as a Critically Endangered ecosystem nationally, mānuka wetlands are classified as having **very high** ecological value.

6.1.5 Mānuka – kiokio – *Machaerina* wetland

Mānuka – kiokio – *Machaerina* wetland (0.06 ha) formed part of a riparian wetland complex in the eastern bush block at the downstream extent of Watercourse 1. The wetland consisted of scattered mānuka trees with kiokio (*Parablechnum novae-zelandiae*) forming the main understorey component, alongside occasional swamp kiokio (*Parablechnum minus*), rautahi (*Carex geminata*), swamp sedge (*Carex virgata*) and ring fern with jointed twig rush (*Machaerina articulata*), mamaku (*Cyathea medullaris*), *Isolepis prolifera* and *Isolepis cernua* var. *cernua* on the edges. The presence of *Machaerina* and mānuka indicate low fertility soils and therefore this area is also considered to be a gumland ecosystem.

Sheep have access to this area and have degraded the quality of this wetland through grazing and trampling.

Due to the indigenous dominance of these wetland areas, high threat status of wetlands, and as gumlands are classified as a Critically Endangered ecosystem nationally, mānuka-kiokio-*Machaerina* wetlands are classified as having **very high** ecological value.

6.1.6 *Eleocharis – Schoenoplectus - Machaerina* wetland

The mānuka – kiokio – *Machaerina* wetland transitions to an *Eleocharis* – *Schoenoplectus* – *Machaerina* wetland of 0.09 ha downstream where drainage is poor (Appendix A; Figure 1). This area consisted of discrete clumps of kutakuta (*Eleocharis sphacelata*), sharp spike sedge (*Eleocharis acuta*), kuawa (*Schoenoplectus tabernaemontani*) and *Macaherina arthrophylla*. Whekī were present on the drier edges of this area.

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[37] The Department of Conservation (1999). Natural areas of Kerikeri Ecological District. Reconnaissance Survey Report for the Protect Natural Areas Program. New Zealand Natural Areas Programme 43.
[38] Holdaway, R. J., Wiser, S. K., & Williams, P. A. (2012). Status assessment of New Zealand's naturally uncommon ecosystems. *Conservation Biology*, *26*(4), 619-629.
[39] Ausseil, A. G., Gerbeaux, P., Chadderton, W. L., Stephens, T., Brown, D., & Leathwick, J. (2008). Wetland ecosystems of national importance for biodiversity: criteria, methods and candidate list of nationally important inland wetlands. Landcare Research Contract Report LC0708/158.

Gorse was present on the edge of this ecosystem type, and exotic broom sedge was present in wetter areas. The wetland was shaded by mature exotic forestry.

Due to the indigenous dominance of this wetland area and high threat status of wetlands, *Eleocharis – Shoenoplectus – Machaerina* wetlands are classified as having **high** ecological value

6.1.7 Indigenous-dominated *Juncus* wetland

Indigenous-dominated *Juncus* wetland is the most common wetland extent within the Project footprint comprising 4.05 ha and consists of a near-monoculture of native Edgar's juncus (*Juncus edgariae*). The wetland hydrology was modified by dug drainage channels, and stock access had impacted the intactness of the wetland through trampling and grazing. Occasional exotic soft rush (*Juncus effusus*), native *Isolepis cernua* var. *cernua* and *Isolepis prolifera* were present in dug stream channels. Exotic pasture grasses were abundant.

Due to the size and general connectedness of the delineated area, its indigenous dominance and high threat status of wetlands, indigenous-dominated *Juncus* wetlands are classified as having **high** ecological value. It is not considered to be of very high value due to the impacts on the wetland of stock browse and drainage channels.

6.1.8 Exotic-dominated *Juncus* wetland

Exotic-dominated *Juncus* wetlands consisted of areas with greater than 50% exotic soft rush. These areas were uncommon across the site and consisted of soft rush monocultures among grazed pasture grass.

Under the Proposed Regional Plan for Northland wet pasture containing patches of rushes are not considered 'Natural Wetlands'. The areas of exotic-dominated *Juncus* wetland however provide consistent cover of rushes across the defined area (as opposed to patches) and therefore are considered 'Natural Wetlands' under the Proposed Regional Plan.

The NPS FM 2020[40] has further defined 'Natural Wetlands' and includes all wetlands that meet the RMA definition, with three exclusions (clause c of the NPS FM 'natural wetland definition'). One of these exclusions includes the following conditions, which, if met, exclude a wetland area from being considered 'Natural':

- Wetlands dominated by more than 50% exotic pasture grasses;
- Wetlands which are areas of improved pasture; and,
- Are subject to temporary rain-derived water pooling.

The defined areas of exotic-dominated *Juncus* wetlands (Appendix A; Figure 1) are dominated by more than 50% exotic rushes (as opposed to pasture species). The exclusion is therefore not met, and therefore these areas are included as 'Natural Wetlands' requiring offsetting. Given the degraded state of these wetlands with low indigenous dominance, these areas are considered as having **moderate** ecological value.

6.1.9 *Isolepis* turf wetland

There was a small area (0.005 ha) of *Isolepis cernua* var. *cernua* – dominated wetland on the western arm of the proposed site adjacent to an unnamed tributary. This wetland area consists of *Isolepis cernua* var. *cernua* with occasional exotic grasses and is subject to grazing and trampling from stock.

Given the combined characteristics of its small size, low diversity, degradation, but also the high threat status of wetlands, it is considered as having **moderate** ecological value.

6.1.10 Improved pasture wetland

Improved pasture wetlands (0.90 ha) were dispersed across the site in discrete areas (Appendix A; Figure 1). These areas consisted of improved pasture grasses of more than 50% cover, interspersed with occasional soft rush, *Isoleis cernua* var. *cernua* and *Isolepis prolifera*. These areas were grazed and pugged due to stock access.

[40] New Zealand Government (2020). National Policy Statement for Freshwater Management 2020. August 2020.

Under the Proposed Regional Plan for Northland pasture wetlands with patches of rushes are not considered 'Natural Wetlands'. However, the NPS FM 2020 has further defined 'natural wetlands' and includes all wetlands that meet the RMA definition, with three exclusions (clause c of the NPS FM 'natural wetland definition') as described in Section 6.1.8 Exotic-dominated *Juncus* wetland

It is considered that areas of improved pasture wetland meet all of the conditions of the exclusions described in Section 6.1.8 are therefore are not considered 'Natural Wetlands' and are considered of **low** ecological value.

6.1.11 Constructed farm ponds

Constructed farm ponds were present at the heads of two tributaries on site and have likely been constructed for farming purposes (e.g. water for stock). These ponds were relatively shallow with no riparian margin and would provide only marginal or temporary habitat for wetland birds including diving ducks or waterfowl.

Under the Proposed Regional Plan for Northland constructed wetlands are not considered a 'Natural Wetland'. The NPS FM 2020 has further defined 'Natural Wetlands' and includes all wetlands that meet the RMA definition with three exclusions. One of these excludes wetlands from being considered 'Natural' if it is: 'a wetland constructed by artificial means (unless it was constructed to offset impacts on, or restore, an existing or former natural wetland)'. Constructed farm ponds are therefore not considered 'Natural' and are of **low** ecological value.

6.2 Bats

6.2.1 Bat habitat assessment

Long-tailed bats (*Chalinolobus tuberculatus*)

Potential roost habitat for long-tailed bats was identified during the site walkover within the areas of mature exotic forest at the upstream and downstream ends of Watercourse 1 (Appendix A; Figure 1). These habitats contain large mature trees (DBH > 0.8 m) such as pine, wattle, redwood and eucalypts with occasional cracks and crevices that could potentially be used by long-tailed bats for roosting (Appendix A; Figure 2; Appendix G; Photograph 3). In total, approximately 20 exotic trees were deemed to be suitable for potential bat roosting. The trees present in the tōtara forest are likely too small to support roosting bats, with no suitable cracks, crevices or epiphytes observed and with the maximum size of trees at 27 cm DBH.

Additionally, forests, wetlands and streams provide potential foraging habitat for long-tailed bats as these habitats often provide an abundance of insect prey. The watercourses and riparian vegetation that run through the Project footprint provide natural linear features that could be utilised by bats as a commuting 'highway'. Stream length with riparian trees forming vegetated 'highways' are disjointed and comprise sheltered commuting habitat of 200 m at the upstream end and 175 m at the downstream end of Watercourse 1 (Appendix A; Figure 2).

It is therefore considered that the Project site contains habitat suitable to be used by long-tailed bats for roosting, foraging and/or commuting pathways that will be removed as part of the construction of the proposed reservoir. This includes approximately 1.26 ha of potential roosting habitat (pine forest, wattle, eucalypts) and an additional 4.6 ha of wetland foraging habitat (including gumlands, *Juncus* wetlands and *Eleocharis – Schoenoplectus – Machaerina* wetlands).

Long-tailed bats have been recorded at Puketi forest[41] and at the Te Ruaotehauhau Stream Water Storage site[42], 17 and 7.5 km away from the project footprint respectively. Bats can fly at over 60 km/h and have large territorial ranges and therefore may potentially utilise the Project footprint.

Short-tailed bats (*Mystacina tuberculata*)

Short-tailed bats primarily inhabit contiguous areas of old-growth native forest but low numbers of bats have been recorded in habitats such as logged forest, scrubland and farmland[43]. As the nearest area of old-growth forest (Puketi Forest) is

[41] Sourced from Department of Conservation National Bat Database
[42] Puhoi Stour (2020). Te Ruaotehauhau Stream Water Storage Assessment of Ecological Effects (in preparation).
[43] Lloyd, B. (2002). The Ecology and Molecular Ecology of the New Zealand Lesser Short-tailed Bat *Mystacina tuberculata*. Degree of Doctor of Philosophy thesis, Massey University, Palmerston North.

approximately 17 km away, the Project site is likely further away than the distance a short-tailed bat is expected to fly from their core home range.

6.2.2 Acoustic survey results

No long-tailed or short-tailed bat passes were recorded from the three ABMs across the site over the 18-night survey period.

Weather conditions were 'optimal' for acoustic surveying of bats on 17 of the 18 survey nights (Appendix H). On the night of the 22 of October 2020, rainfall was above the optimal condition of < 2.5 mm and totalled 3.9 mm within 2 hours after sunset.

The acoustic survey results suggest that bats did not use the site for foraging or roosting during this survey period. However long-tailed bats may forage or roost within the footprint at other times as long-tailed bats change foraging and roosting sites across the landscape at different times of the year.

Due to long-tailed bats having a high threat status of Threatened – Nationally Critical[44], and the available habitat on site for commuting, foraging and roosting, this species is considered to be of **very high** ecological value and is conservatively assumed to be present periodically.

Short-tailed bats are considered unlikely to utilise the habitats within the Project footprint.

6.3 Avifauna

A total of twenty-four bird species were identified during the site visit, which included 15 indigenous species (Appendix F; Table 2).

Birds typical of farmland, degraded wetlands and fragmented habitat were present and included indigenous paradise shelduck (*Tardorna variegata*), spur-winged plover (*Vanellus miles*), kōtare/sacred kingfisher (*Todiramphus sanctus*), white-faced heron (*Egretta novaehollandiae*), pīwakawaka/New Zealand fantail (*Rhipidura fuliginosa*), welcome swallow (*Hirundo neoxena*), pūkeko (*Porphyrio melanotus*) and kāhu/swamp harrier (*Circus approximans*). Pied stilts (*Himantopus himantopus*) and southern black-backed gulls (*Larus dominicanus*) were observed on the edges of a farm pond outside of the project footprint and are expected to intermittently use the site for foraging.

Forest birds identified during the site visit included kukupa (*Hemiphaga novaeseelandiae*), shining cuckoo (*Chrysococcyx lucidus*) and tūī (*Prosthemadera novaeseelandiae*). New Zealand pipit (*Anthus novaeseelandiae*) was also identified foraging on site.

The location of the site is within a 'High Density' (indicated by five or more calls per hour) area for North Island brown kiwi[45]. Roosting and foraging habitat availability is abundant for kiwi which are known to roost in dense rushes, or in other dense shrub-like vegetation (e.g. *Machaerina* sedgeland). It is conservatively assumed that North Island brown kiwi use the site for foraging and roosting, however nesting habitat was marginal - present in the form of a small area of dense *Machaerina* sedgeland at the upstream end of Watercourse 1.

The wetlands on site were considered too degraded and prone to regular disturbance to support cryptic wetland bird nesting habitat (e.g. spotless crake (*Porzana tabuensis*), marsh crake (*Porzana pusilla*), fernbird (*Bowdleria punctata*) and Australasian bittern (*Botaurus poiciloptilus*)) in its current condition. It was considered marginal potential habitat for fernbirds, however no fernbirds were identified during playback surveys. Australasian bittern (Threatened – Nationally Critical) are mobile organisms and may intermittently use farm drains and wetland areas on site for foraging and therefore are conservatively assumed to be present. Australasian bittern have been observed within 15 km of the site[46].

[44] O'Donnell, C.F.G., Borkin, K.M., Christie, B. L., Parsons, S., Hitchmough, R. A. (2017). Conservation status of New Zealand bats. New Zealand Threat Classification Series 21. 4 p.
[45] Kiwis for Kiwi (2016). North Island Brown Kiwi Estimated distribution 2016.
[46] The Northland Age (2019). A comeback for bats and bitterns at Ōpua? 22 August 2019. Peter Jackson.

If stock continue to access all wetlands within the footprint until construction commences, cryptic wetlands birds are not expected to be breeding on site due to continued disturbance and suppression of the growth of wetland plants (i.e. wetland bird habitat and food).

Of the species identified during the site visit, New Zealand pipit and North Island brown kiwi are classified as At Risk – declining[47], while all other species are classified as Not Threatened. Additionally, kukupa and North Island brown kiwi are noted as Regionally Significant species[48].

Kukupa and North Island brown kiwi are considered as having **high** ecological value as they are considered Regionally Significant. Australasian bittern and New Zealand pipit are considered as having **very high** and **high** ecological value respectively due to their threat classifications.

Tūī are considered as having **moderate** ecological value as a key pollinator and seed disperser. All other Not Threatened and exotic birds observed during the site visit are considered as having **low** ecological value as they are common in the wider landscape.

6.4 Herpetofauna

Through desktop assessment and assessment of habitat on site, five herpetofauna species were identified as potentially utilising the site. These include nationally At Risk – Declining[49] forest gecko (*Mokopirirakau granulatus*), elegant gecko (*Naultinus elegans*), Northland green gecko (*Naultinus grayii*), nationally At Risk – Relict Pacific gecko (*Dactylocnemis pacificus*) and Not Threatened copper skink (*Oligosoma aeneum*).

No herpetofauna were observed during the site walkover or during gecko spotlighting. Overall, marginal skink and gecko habitat was identified across the site. Mānuka, kānuka and tōtara trees provide potential habitat for indigenous geckos, however habitats were fragmented and small, with degraded understoreys, reducing the likelihood of herpetofauna presence.

Stock have access to all areas of the site and subsequently there are few suitable habitat areas available for indigenous skinks. Coarse woody debris is largely absent from the site, and grass areas are trampled or grazed. Occasional pampas may provide habitat for small populations of copper skink (*Oligosoma aeneum*), but habitat is not deemed to be suitable for other skink species (e.g. ornate skink *Oligosoma ornatum*).

If present, it is expected that herpetofauna will be in low abundance.

Forest gecko, elegant gecko and Northland green gecko are considered as having a **high** ecological value due to their threat status of At Risk – Declining. Pacific geckos are considered as having a **moderate** ecological value due to their threat status of At Risk -relict, while copper skink are considered as having a **low** ecological value due to their threat status of Not Threatened.

6.5 Invertebrates

Habitat was not deemed to be suitable for indigenous kauri snails due to the site being heavily grazed and modified. Blue damselflies (*Austrolestes colensonis*) were noted within the eastern wetland complex and are common throughout New Zealand and Northland.

[47] Robertson, H. A., Baird, K., Dowding, J. E., Elliott, G. P., Hitchmough, R. A., Miskelly, C. M., McArthur, N., O' Donnell, C. F. J., Sagar, P. M., Scofield, R. P. & Taylor, G. A. (2016). Conservation status of New Zealand birds. New Zealand Threat Classification Series 19. 27 p.
[48] Conning, L. and Miller, N. (2000). Natural areas of Kaikohe Ecological District Reconnaissance Survey Report for the Protected Natural Areas Programme. Department of Conservation. 29pp.
[49] Hitchmough, R., Barr, B., Lettink, M., Monks, J., Reardon, J., Tocher, M., van Winkel, D. & Rolfe, J. (2015). Conservation status of New Zealand reptiles. New Zealand Threat Classification Series 17. 14 p.

6.6 Assessment of ecological effects – Terrestrial

6.6.1 Vegetation and habitat effects

It is expected that all vegetation within the reservoir footprint will be removed. The total quantity of indigenous vegetation loss is 4.625 ha, with an additional 1.26 ha of exotic forest, 0.13 ha of exotic dominated *Juncus* wetland, 0.90 ha of improved pasture wetland and 0.03 ha of constructed farm ponds being impacted.

This includes a total of:

- 0.17 ha of tōtara forest;
- 1.26 ha of exotic forest consisting of pine, eucalypts, redwoods and poplars;
- 0.06 ha of mānuka, kānuka gumland *Machaerina* sedgeland;
- 0.19 ha of mānuka wetland;
- 0.06 ha of mānuka – kiokio – *Machaerina* wetland;
- 0.09 ha of *Eleocharis - Schoenoplectus - Machaerina* wetland;
- 4.05 ha of indigenous-dominated *Juncus* wetland;
- 0.13 ha of exotic-dominated *Juncus* wetland;
- 0.005 ha of *Isolepis* turf wetland;
- 0.90 ha of improved pasture wetland; and,
- 0.03 ha of constructed farm pond.

Without mitigation, offset or compensation, removal of vegetation will result in the loss of habitat and foraging resources for indigenous fauna, increased landscape fragmentation and loss of connectivity, and the loss of nationally threatened wetland habitats and indigenous plant species.

6.6.1.1. Magnitude and overall level of effect

This section outlines the predicted magnitude of effect on each of the affected ecosystem types and Threatened and At Risk plant species. Through combining the magnitude of effect with the ecological value of the relevant ecological element, the overall level of ecological effect is determined.

Removal of 0.17 ha of tōtara forest is considered a **moderate** magnitude of effect for this habitat. Tōtara forests are relatively common in the wider landscape and the loss of this habitat type is expected to have a moderate impact on the known range of this habitat in the Ecological District. In the context of the site, a substantial portion of larger tōtara are present in gullies outside the proposed footprint (e.g. 80 ha of mature forest within 1 km of the proposed site). A **moderate** ecological value combined with a **moderate** magnitude of effect results in an overall **moderate** ecological effect.

Removal of 1.26 ha of exotic forest is considered a **moderate** magnitude of effect for this ecosystem, as pine is common in the wider landscape, however permanent removal of a substantial quantity of vegetation is proposed in the context of the site. A **moderate** ecological value with a **moderate** magnitude of effect results in an overall **moderate** ecological effect.

Removal of 0.06 ha of mānuka, kānuka gumland *Machaerina* sedgeland is considered a **high** magnitude of effect for this ecosystem, due to the rarity of gumlands. A **very high** ecological value with a **high** magnitude of effect results in an overall **very high** ecological effect.

Removal of 0.19 ha of mānuka wetland is considered a **high** magnitude of effect for this ecosystem, due to the threat status of wetlands and the low proportion of wetlands left in Northland. A **very high** ecological value with a **high** magnitude of effect results in an overall **very high** ecological effect.

Removal of 0.06 ha of mānuka – kiokio – *Machaerina* wetland is considered a **high** magnitude of effect for this ecosystem, due to the threat status of wetlands and the low proportion of wetlands left in Northland. A **very high** ecological value with a **high** magnitude of effect results in an overall **very high** ecological effect.

Removal of 0.09 ha of *Eleocharis - Schoenoplectus - Machaerina* wetland is considered a **high** magnitude of effect for this ecosystem, due to the threat status of wetland and the low proportion of wetlands left in Northland. A **high** ecological value combined with a **high** magnitude of effect results in an overall **very high** ecological effect.

Removal of 4.05 ha of indigenous-dominated *Juncus* wetland is considered a **very high** magnitude of effect for this ecosystem, due to the high quantum of wetland loss, threat status of wetlands and the low proportion of wetlands left in Northland. A **high** ecological value combined with a **very high** magnitude of effect results in an overall **very high** ecological effect.

Removal of 0.13 ha of exotic-dominated *Juncus* wetland is considered a **high** magnitude of effect for this ecosystem, due to the threat status of wetlands and the low proportion of wetlands left in Northland. A **high** ecological value combined with a **moderate** magnitude of effect results in an overall **high** ecological effect.

Removal of 0.005 ha of *Isolepis* turf wetland is considered a **moderate** magnitude of effect for this ecosystem, due to the threat status of wetlands, but a very small proportion of this degraded wetland type being removed. A **moderate** ecological value combined with a **moderate** magnitude of effect results in an overall **moderate** ecological effect.

Removal 0.9 ha of improved pasture wetland is considered a **moderate** magnitude of effect for this ecosystem as improved pasture wetlands are relatively common in Northland and are not considered 'natural wetlands'. A **low** ecological value with a **moderate** magnitude of effect results in an overall **low** ecological effect.

The magnitude of effect on 0.03 ha of constructed farm ponds is considered **positive** for this ecosystem as the construction of the reservoir will provide an overall increase in this habitat type. A **low** ecological value combined with a **positive** magnitude of effect results in an overall **net gain** ecological effect.

Removal of kānuka and mānuka individuals constitutes a **moderate** magnitude of effect as these species are common locally and nationally, however 0.48 ha of habitat containing these species is being affected by the proposed works. Furthermore, mānuka and kānuka grow more slowly in gumlands than they would in more fertile environments. A **very high** ecological value with a **moderate** magnitude of effect results in a **high** ecological effect for kānuka and a **high** ecological value with a **moderate** magnitude of effect results in a **high** ecological effect to mānuka. For all other Not Threatened plant species, a **moderate** magnitude of effect combined with a **low** ecological value results in an overall **low** ecological effect.

6.6.1.2 Vegetation and habitat effects management

Residual effects resulting from vegetation removal and habitat loss can be offset and compensated through revegetation planting and enhancement of existing ecosystems which may be degraded. Such enhancement will include planting, installation of artificial bat houses, and the provision of coarse woody debris for indigenous fauna.

An area of approximately 1.7 ha of mature tōtara forest degraded by stock access is may be available for retirement (e.g. fencing to allow understorey regeneration). The location of this forest is immediately adjacent to the proposed reservoir on the eastern edge where a small quantum of tōtara forest (0.01 ha) will be impacted.

An Ecological Offset and Compensation Plan will be required prior to construction to provide the details of such revegetation and enhancement actions.

Offset calculations for vegetation and habitat type are provided in Table 9 below following the recommendations of the Biodiversity Offset Accounting Model (BOAM)[50].

6.6.1.3 Biodiversity accountancy offsetting model

The BOAM has been developed to provide a transparent, robust, and structured means of assessing an offset proposal. Based on data inputs, the model calculates whether a 'no-net-loss'/'net-gain' biodiversity outcome will be achieved, whilst accounting for uncertainty and time lag between loss at impact sites and gain being created at offset sites. In summary, the model:

- Accounts for 'like-for-like' biodiversity trades/currencies aimed at demonstrating 'no-net-loss' or 'net-gain';

[50] Maseyk et al. (2015). A Biodiversity Offsets Accounting Model for New Zealand. Contract report prepared for the Department of Conservation, Hamilton Service Centre Private Bag 3072 Hamilton New Zealand

- Calculates the present biodiversity value to estimate whether 'no-net-loss' or 'net-gain' can be achieved;
- Incorporates the use of a time discount rate to account for time lag. We will use a discount rate of 3% to account for the temporal-lag between the impact occurring (due to the development) and the biodiversity gains being generated (due to the offset actions). The worked examples provided in the User Manual apply a discount rate of 3%, as informed by research conducted as part of DOC's research project on biodiversity offset in New Zealand; and,
- Makes an allowance for uncertainly of success (i.e. a degree of confidence) in relation to proposed offset actions.

It is acknowledged that there are inherent limitations to offsetting, and therefore residual effects not addressed through offsetting are compensated for through bush retirement with enrichment planting (1.7 ha of mature forest) and 10 m of wetland buffer plantings around all wetland offsetting (including gumlands).

6.6.1.4. Biodiversity offsetting and compensation results

Offset modelling has been undertaken for wetland ecosystems as well as indigenous terrestrial ecosystems with an overall ecological effect of moderate or higher as determined through the EIANZ process. Data from RECCE plots and surveys undertaken during site visits were used as input into models, with benchmark data derived from the literature.

Data derived from RECCE plots undertaken at other water reservoir sites where 'pristine' ecosystems were present were further used to estimate benchmark values[51].

A summary of the impact quantity and the proposed offset quantum is presented in Table 9, while Appendix I presents the assumptions and model outputs for each of the ecosystems being offset. The primary management measure to achieve the targets for each component is planting and weed control, with plantings undertaken in fenced areas and protected in perpetuity. Positive net present biodiversity values were achieved for all biodiversity components.

All plantings will be set out in a manner that provide landscape connectivity and will be undertaken in close proximity to the impact site. Overall, 10.13 ha of restoration planting is proposed which includes wetland and terrestrial ecosystem planting. Threatened and At Risk plants (e.g. kānuka and mānuka) will be offset and compensated through planting equivalent species in revegetation plantings. Furthermore, to achieve the outcomes of some biodiversity components such as number of flaky bark trees, specific requirements have been proposed such as the planting of a specific proportion of tōtara, mānuka and kānuka.

The information included in the assumptions of the offset modelling are based on best knowledge of potential offset sites (e.g. degraded exotic wetlands for restoration) and have been made using conservative estimates, such as planting into wetlands which already contain some indigenous species. Desktop assessment suggests potential wetland and terrestrial offsetting areas are available near the proposed reservoir. Once offset sites have been identified and confirmed, the BOAMs will be updated to determine the final quantum of planting required to achieve no net loss. The overall quantum of restoration may change if offset site characteristics differ from the estimates used in the assumption and justification tables.

During the selection process for potential wetland offset sites, consideration will need to be given to existing hydrology and wetland connectivity measures to achieve successful habitat restoration. Plantings will be selected which will provide nesting and foraging habitat for wetland birds. Legal protection is proposed to protect all areas of offset planting for perpetuity.

[51] Tonkin and Taylor Ltd. (2020). Te Ruaotehauhau Stream Water Storage Reservoir Assessment of Ecological Values and Effects report.

Table 9: Offsetting and compensation requirements at MN02 for ecosystems which have an ecological effect of moderate or higher, as well as all wetlands.

Ecosystem type	Impact area (ha)	Offset quantum (ha)
Tōtara forest	0.17	1.4
Mānuka, kānuka gumland, *Machaerina* sedgeland	0.06	0.76
Mānuka wetland	0.19	1.3
Mānuka – kiokio – *Machaerina* wetland	0.06	0.2
Eleocharis – *Schoenoplectus* – *Machaerina* wetland	0.09	0.24
Indigenous-dominated *Juncus* wetland	4.05	6.0
Exotic-dominated *Juncus* wetland	0.13	0.2
Isolpeis turf wetland	0.005	0.03
Total proposed offsetting requirement	4.755	**10.13**
Threatened kānuka and At Risk mānuka	0.48 ha of habitat (Tōtara forest, mānuka, kānuka gumlands, mānuka wetlands).	High proportion of kānuka and mānuka in offset plantings.
All ecosystems.	Residual effects not accounted for through offset modelling.	1.7 ha of bush retirement, and 10 m buffer plantings around all wetlands (including gumland wetlands).

Monitoring will be undertaken at the planting sites at years 1, 3, 5 ,10 and 25 to assess whether offsetting targets are being met using RECCE plots. A total of one permanent 10 x 10 m RECCE plot for every two hectares of planting will be established, with at least one RECCE plot in each ecosystem type being offset. Adaptive management will be used where offset targets are not being met which may include increasing the total planting area.

Where residual impacts cannot be fully compensated for through avoidance, remedying or offsetting due to limitations on fully capturing every ecosystem component (such as cavity numbers), bush retirement and wetland buffer planting is proposed. Compensation measures proposed for this project include bush retirement with enrichment planting and 10 m buffer plantings around wetland offset areas (including gumlands). Buffer plantings are proposed to protect wetland areas from nutrient run-off and reduce weed invasions.

Furthermore, it is recommended that an overall Net Gain to impacts to exotic-dominated *Juncus* wetlands and indigenous-dominated *Juncus* wetlands be achieved through 'trading up'. Trading up has recently been used on Te Ahu a Turanga: Manawatū Tararua Highway for 'low' value wetlands, through planting of kahikatea forests to address impacts to degraded *Juncus* wetlands. This does not meet the 'like-for-like' offsetting principal, however the overall ecological condition of the restored wetland is considered to be of higher ecological value than the impacted wetland.

6.6.1.5 Measures to reduce vegetation ecological effects summary

The overall level of ecological effects on vegetation can be offset and compensated through recommendations outlined in the above sections. Implementing these recommendations in full will ensure 'No Net Loss' of vegetation and habitat values can be achieved.

6.6.1.6 Accidental discovery of At Risk or Threatened species

Wetland and gumland habitats can provide habitat for cryptic At Risk and Threatened plant species, such as sun orchids (*Thelymitra spp.*). If, during any additional ecological surveys for construction works an At Risk or Threatened species is identified, the Department of Conservation is to be notified and an approved management plan implemented to address any effects to the species.

6.6.2 Fauna effects

Without mitigation, vegetation removal can result in the injury or mortality of nesting birds, eggs and fledglings, roosting bats, and lizards. Fauna Management Plans will be utilised to mitigate impacts to fauna on site and will be implemented prior to construction commencing. Fauna Management Plans will include vegetation removal protocols and seasonal vegetation clearance constraints which minimise injury and mortality to native fauna.

6.6.2.1 Magnitude and overall level of effect without management recommendations

The magnitude of effect of vegetation removal on native bats (if present) is considered **high** due to the potential for injury and mortality of long-tailed bats during clearance of potential roost trees. A **very high** ecological value combined with a **high** magnitude of effect results in a **very high** level of effect.

The magnitude of effect on forest birds of forest removal is considered **moderate** due to the potential of injury or mortality to breeding birds, as well as habitat loss. Forest birds are common in the landscape, therefore the magnitude of effect is considered to be moderate. For kukupa, a **high** ecological value with a **moderate** magnitude of effect results in a **high** ecological effect.

For tūī, a **moderate** ecological value combined with a **moderate** magnitude of effect results in a **moderate** ecological effect. For other common forest birds, a **low** ecological value combined with a **moderate** magnitude of effect results in a **low** ecological effect.

The magnitude of effect on Australasian bittern is considered **moderate** due to the potential loss of foraging habitat (although it is not known if bittern use this site for foraging). A **very high** ecological value combined with a **moderate** magnitude of effect results in a **high** overall ecological effect.

The magnitude of effect on North Island brown kiwi is **high** given the possibility of mortality of kiwi during construction activities. Mortality might occur during vegetation clearance or during construction. Adult kiwi are generally capable of escaping from disturbance, however are particularly sensitive during the kiwi breeding season (July to March inclusive). A **high** ecological value combined with a **high** magnitude of effect results in a **very high** ecological effect.

The magnitude of effect rank grass removal on New Zealand pipit is considered **moderate**, due to the potential loss of eggs or chicks during breeding season. A **high** ecological value combined with a **moderate** magnitude of effect results in a **high** ecological effect on New Zealand pipit.

The magnitude of effect on native lizards on site is considered **high** due to the potential of injury or mortality of lizards and habitat loss. A **high** magnitude of effect combined with **high** ecological values results in a **very high** ecological effect for forest gecko, elegant gecko and Northland green gecko. A **moderate** ecological value with a **high** magnitude of effect results in a **moderate** ecological effect for Pacific gecko. A **low** ecological value with a **high** magnitude of effect results in a **low** ecological effect on copper skinks.

6.6.2.2 Fauna effects management

Bat management

It is possible that potential roost habitat within the footprint is at least intermittently used as part of a wider roost network for long-tailed bats. Considering this, the possibility exists that individual bats (or in the worst case, an active communal maternity roost) may be harmed or killed during clearance of vegetation. To minimise the risk of long-tailed bat injury or mortality during vegetation removal, a Vegetation Removal Protocol will be prepared and implemented for the Project and will contain suitable recommendations(following industry standard best practice) for long-tailed bat protection through the vegetation removal process.

Impacts related to the loss of habitat for long-tailed bats will be covered in the Offset and Compensation Plan. These will include:

- Planting trees that will provide potential commuting, foraging and roost habitat in the future to offset 1.26 ha of potential roosting habitat and 4.6 ha of foraging habitat;
- Selecting revegetation sites that will provide suitable foraging and commuting habitat such as wetlands and stream riparian habitat; and
- Should any confirmed bat roosts be found during the vegetation clearance works (following the recommended vegetation removal protocols, refer to Section 6.2.2.2) we propose erecting artificial bat roost boxes to compensate for the loss of roosting habitat. To compensate for the loss of roost habitat, if identified during clearance, it is recommended that 5 artificial bat roost boxes are installed within the chosen offset sites or within existing mature vegetation adjacent to the proposed footprint (i.e. one for every c. 2,500 m^2 of lost habitat).

Avifauna management

The implementation of an Avifauna Management Plan (AMP) will avoid, minimise and/or mitigate effects to avifauna. The AMP will include vegetation removal protocols and bird nest check protocols. Most adult birds can fly away from construction-related impacts but are vulnerable during bird breeding season when nesting. Terrestrial vegetation should be removed outside of the peak bird breeding season (September to December inclusive) to avoid impacts to indigenous forest birds. Bird nest checks can be undertaken where low stature vegetation (e.g. Edgar's rush) is to be removed during the bird breeding season.

A monitoring and management programme is proposed for North Island brown kiwi and will be detailed in the AMP. Certified kiwi dog-handlers shall be used to prior to tree clearance to determine the potential presence of any kiwi within identified kiwi habitat on site. Identified kiwi shall be translocated outside of the impact footprint into suitable habitat. Where appropriate, kiwi exclusion fencing shall be deployed to prevent kiwi entering construction zones.

Any kiwi eggs (or chicks) found in nests close to the construction area that risk being disturbed will be collected (when the eggs are old enough to be moved safely) and taken to kiwi incubation and chick-rearing facilities.

Offset and compensation plantings will be undertaken to maximise landscape connectivity for North Island brown kiwi and other bird species.

Herpetofauna management

All native herpetofauna are protected by the Wildlife Act 1953. Lizards are more active during warmer months (October to April inclusive) during fine weather, and therefore vegetation clearance of lizard habitat as well as lizard salvaging should only be undertaken during this period to minimise impacts to lizards.

Destructive habitat searching prior to vegetation clearance and construction-assisted salvaging are recommended to avoid impacts to native skinks. This method will involve manually searching through pampas, and turning over any coarse woody debris identified on site, as well as being onsite during clearance of indigenous terrestrial vegetation .

Spotlighting for geckos is recommended prior to the clearance of indigenous vegetation. After felling, vegetation will be searched for geckos, and vegetation left in situ beside existing indigenous forest prior to mulching.

To avoid, minimise and/or mitigate impacts to lizards, a Lizard Management Plan (LMP) will be implemented, which outlines key methodologies used to mitigate impact to skinks and geckos. The LMP will include details such as:

- Species to be targeted;
- Vegetation removal protocols and timings;
- Salvaging methodology, including destructive habitat searching for skinks and gecko spotlighting;
- Relocation site characteristics and location;
- Other mitigation measures which will benefit lizards such as restoration planting and habitat enhancement; and,
- Personnel undertaking lizard salvaging.

Offset planting will be used to offset and compensate for potential loss of lizard habitat.

6.6.3 Measures to reduce fauna ecological effects summary

The overall level of ecological effects on fauna with and without mitigation measures are outlined in Table 10. If the recommendations outlined in this report are implemented in full, then the overall effects to fauna on site are all considered to be '**Low**' or '**Very low**'. In addition, vegetation offset and compensation planting will provide habitat for most of the fauna being impacted.

No offset models have been developed to address effects on bats, birds or lizards as the overall level of effect after mitigation measures are implemented are expected to be low. However, habitat restoration will indirectly benefit bats, birds and lizards, through the establishment of vegetation which is preferred by keystone species such as North Island brown kiwi, kukupa and Australasian bittern. This amounts to 8.73 ha of wetland and gumland revegetation and 1.4 ha of terrestrial revegetation with considerable potential to increase overall forest and wetland landscape connectivity at the site. Additionally, bush retirement of 1.7 ha of tōtara forest as well as 10 m wetland buffer plantings are proposed to address residual effects not accounted for through offsetting.

Habitat restoration will indirectly benefit bats through habitat creation in the long-term such as riparian vegetation creation allowing connected flyway corridors for long-tailed bat foraging. Furthermore, the deployment of artificial bat houses are proposed to provide habitat for long-tailed bats if bats are identified as roosting on site following further monitoring during vegetation clearance protocols.

Table 10: Ecological effects on fauna without mitigation compared to the overall ecological effect if mitigation implemented in full. Bolded overall ecological effects have changed as a result of recommended mitigation measures.

Species	Overall level of effect without recommended management	Overall level of effect with recommended management	Notes
Long-tailed bat	Very high	**Low**	Vegetation Removal Protocols will be followed to minimise the risk of injury and mortality to long-tailed bats. The loss of long-tailed bat habitat will be offset and compensated through replacement habitat planting and the installation of artificial bat houses (if required).
Kukupa	High	**Low**	Offset and compensation plantings will provide additional habitat. AMP will involve seasonal clearance constraints and bird nest checks, further reducing the magnitude of effect by avoiding disturbance and mortality impacts to nesting birds, chicks and eggs.
Tūī	Moderate	**Low**	
Other Not Threatened avifauna	Very low	**Very low**	
North Island brown kiwi	Very high	**Low**	AMP will detail kiwi monitoring and management protocols.
New Zealand pipit	High	**Low**	Seasonal clearance constraints and bird nest checks as outlined in AMP.
Forest gecko, elegant gecko Northland green gecko	High	**Low**	LMP includes seasonal vegetation clearance and salvaging protocols. Salvaging protocols will include construction-assisted habitat searches and gecko spotlighting.
Pacific gecko	Moderate	**Low**	
Copper skink	Low	**Very low**	

7. Recommendations to manage effects

This assessment of ecological effects has been undertaken in the absence of a detailed construction methodology or final design details for the Water Storage Reservoir. Therefore, a variety of assumptions have been made when determining the magnitude of impact and the measures required to adequately address these effects. The actual and potential adverse effects resulting from the proposed water supply reservoir construction and operation vary across freshwater and terrestrial habitats. These include:

- Sedimentation effects from construction activities;
- Injury or mortality to aquatic fauna;
- Impediments to fish passage;
- Permanent modification and loss of stream habitat;
- Impacts on water quality and habitat downstream of the proposed dam;
- Removal of threatened ecosystem types; and
- Direct and indirect effects on native terrestrial fauna.

We recommend consulting and collaboratively working alongside DOC and local iwi to implement some of the following recommendations as required to provide a minimum standard to address ecological effects, which are summarised in Table 11. Further measures may also be required, or a different level of detail required, to actually manage effects.

- Require a construction methodology to be developed for in-stream works that is consistent with GD05 and specifically works to minimise potential effects of deposited sediment on the stream system;
- Develop and implement a Freshwater Fauna Salvage and Relocation Plan (FFSRP) for all parts of the site where works will occur in-stream or aquatic habitat will be inundated;
- Provide for upstream and downstream passage for longfin eels in the design, construction, and operation of the reservoir;
- Consider the sediment management in the design and operation of the reservoir to minimise downstream effects and long-term storage loss;
- Identify and confirm stream enhancement areas to update hypothetical SEV scores (SEVm-C and SEVm-P) and estimated ECR calculations to determine the required quantum of stream bed habitat enhancement to achieve no net of ecological function and to be detailed through a comprehensive Offset and Compensation Plan;
- Complete an environmental flows assessment to identify and manage potential effects caused by flow modification associated with the reservoir;
- Develop and implement a Water Quality Monitoring Plan to monitor water quality parameters and periphyton growth to identify potential changes to the downstream receiving habitat;
- Exploration of suitable offset sites near to the proposed reservoir; and,
- Prepare and implement the following plans to manage ecological effects on site:
    - Freshwater Fauna Salvage and Relocation Plan;
    - Offset and Compensation Plan to address on both freshwater and terrestrial residual effects;
    - Vegetation Removal Protocols to manage effects on long-tailed bats;
    - Avifauna Management Plan;
    - Lizard Management Plan;
    - Water Quality Management Plan; and,
    - Eel Migration Monitoring Plan.

Given the size of the proposed reservoir, high value terrestrial ecosystems have largely been avoided, with the footprint encroaching only on the edges of mature forest habitats and affecting a relatively small extent of secondary tōtara forest. Wetland extents on site are highly degraded due to stock impacts and hydrological changes as a result of artificial drainage channels.

If the above management recommendations are implemented in full, and subject to further site visits to confirm potential offset and compensation input data and areas, it is considered that effects to terrestrial and wetland ecosystems can be mitigated, offset and compensated for sufficiently, primarily through revegetation planting and fauna management plans. Similarly, effects on freshwater ecosystems and fauna can be mitigated through implementation of management plans and residual adverse effects addressed through offset or compensation measures on similar habitats in the wider catchment.

Table 11: Summary of ecological values, magnitude of effects (before and after mitigation) and overall level of effect associated with each activity.

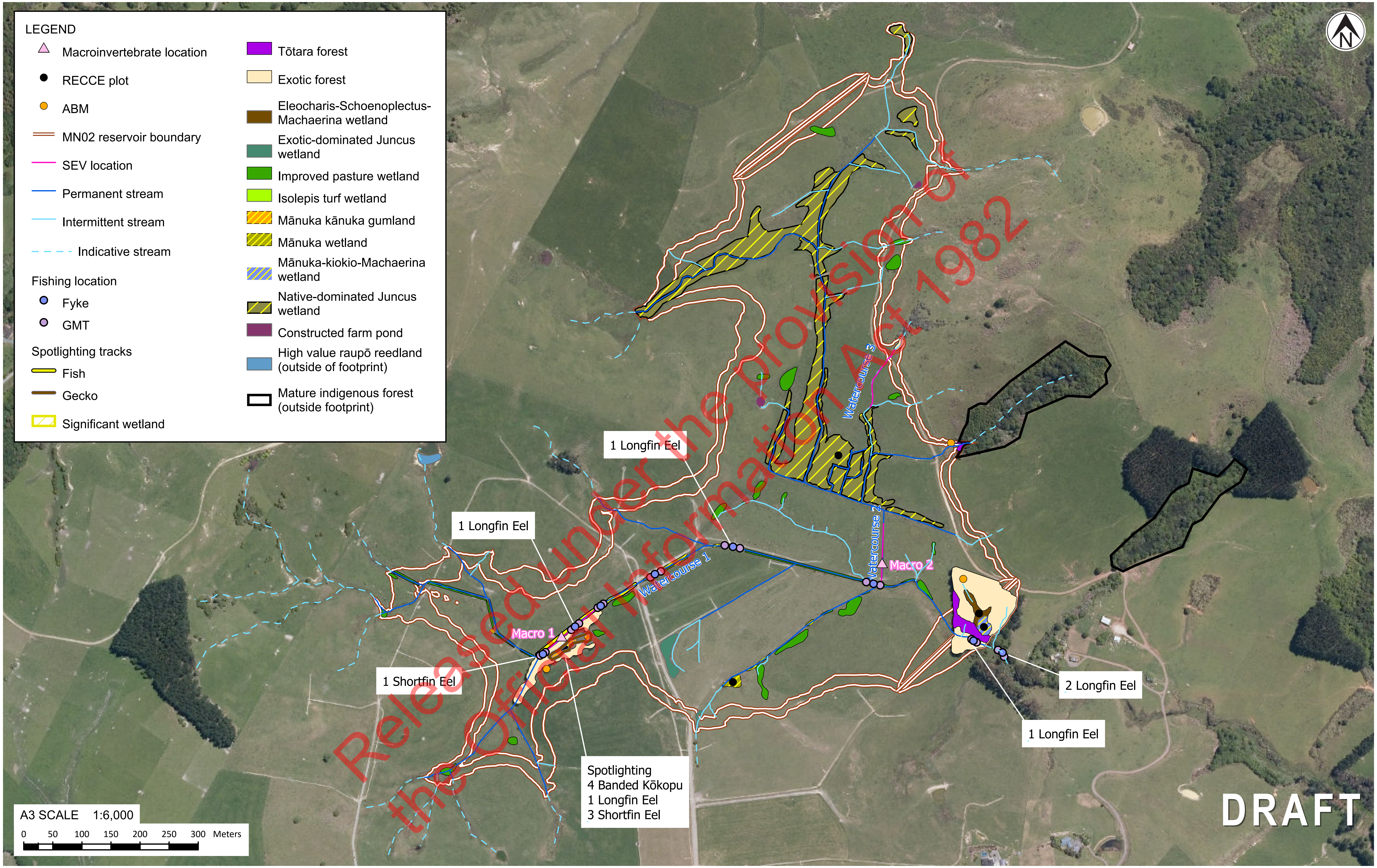
Activity	Ecological values	Magnitude of effect (prior to management measures)	Magnitude of effects (after management measures)	Overall level of effect (if management measures implemented in full)
Sedimentation effects from construction activities	High	High	Low	Low
Injury or mortality to aquatic fauna	High	High	Low	Low
Impediments to eel passage	High	Moderate	Low	Low
Impediments to banded kōkopu passage	Low	Moderate	Low	Low
Permanent modification and loss of stream habitat	Moderate	Very High	High	High (can be offset)
Impacts on water quality and habitat downstream of the proposed dam	High	Moderate	Low	Low
Removal of threatened trees and vegetation (refer section 5.2.1 for detail)	Low to Very High	Low to High	Low to Very High	Low to Very High (can be offset and compensated)
Direct and indirect effects on native terrestrial fauna	As described in Table 10			

8. Report applicability

This report has been prepared for WWLA with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than WWLA, without our prior written agreement. We understand and agree that this report will be submitted as part of an application for resource consent and that Northland Regional Council and the Far North District Council as the consenting authorities will use this report for the purpose of assessing that application.

9. Appendices

Appendix A Ecological values and sampling locations across MN02



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REV	DESCRIPTION	GIS	CHK	DATE
0	First version	SHEG	JORB	24/11/20

LOCATION PLAN: Northland

PROJECT No.	1012828.3000	
DESIGNED	SHEG	DEC.20
DRAWN	SHEG	DEC.20
CHECKED	JORB	DEC.20
APPROVED		DATE

CLIENT PUHOI STOUR
PROJECT MN02 ECOLOGICAL ASSESSMENT OF EFFECTS
TITLE TERRESTRIAL AND FRESHWATER ECOLOGICAL FEATURES
SCALE (A3) 1:6,000 FIG No. FIGURE 1. REV 0

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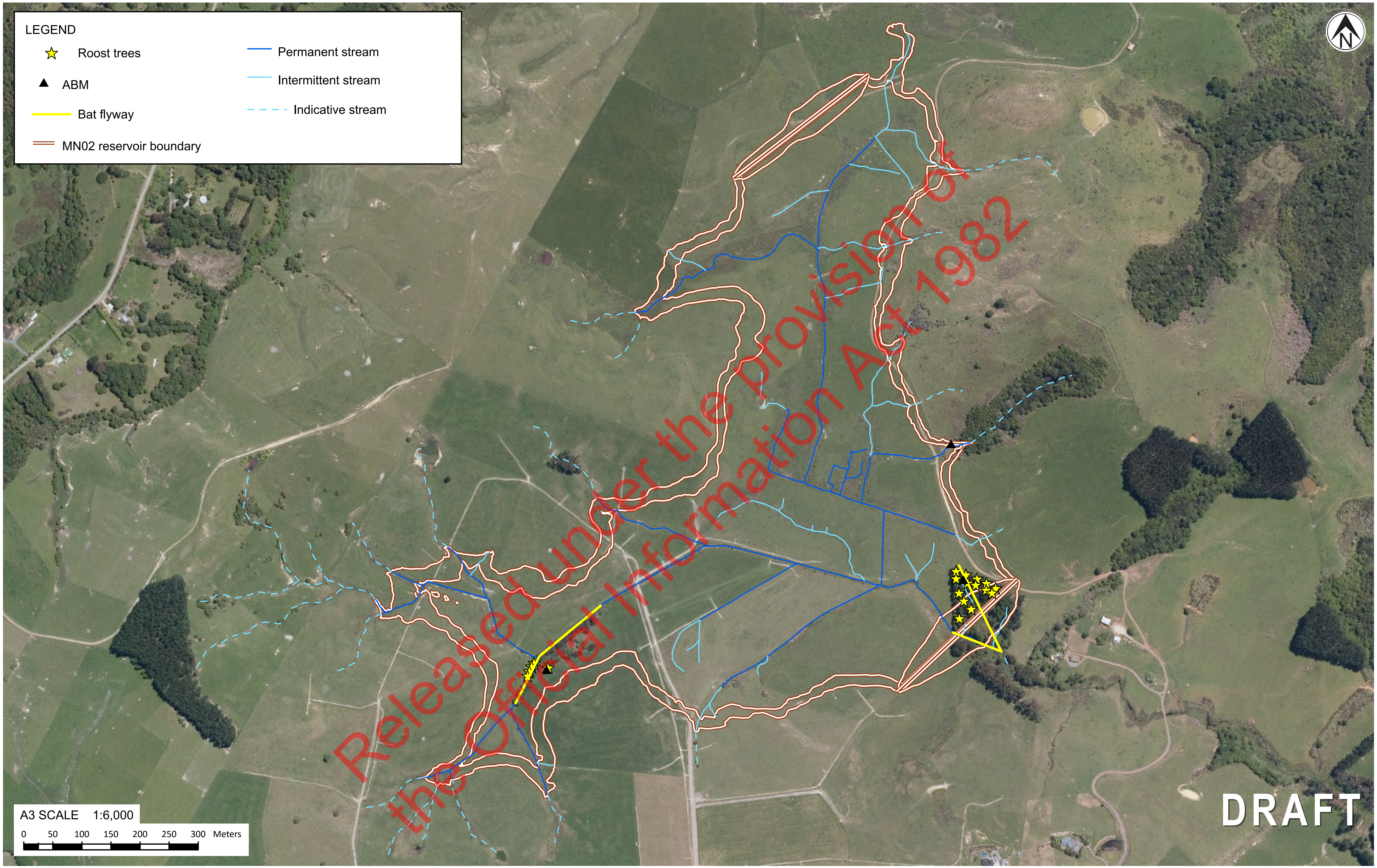
P:\1012828\1012828.1003\WorkingMaterial\4-GIS\02 - Map space\MN02 map\MN02 map 19 Nov - Bat habitat.aprx   Layout: T+T A3 Landscape Map Template   2020-Nov-25 8:38 am   Drawn by SHEG



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REV	DESCRIPTION	GIS	CHK	DATE
0	First version	SHEG	JORB	24/11/20

LOCATION PLAN: Northland

PROJECT No.	1012828.3000	
DESIGNED	SHEG	NOV.20
DRAWN	SHEG	NOV.20
CHECKED	JORB	NOV.20
APPROVED		DATE

CLIENT: PUHOI STOUR
PROJECT: MN02 ECOLOGICAL ASSESSMENT OF EFFECTS
TITLE: LONG-TAILED BAT POTENTIAL ROOST HABITAT AND FLYWAYS
SCALE (A3): 1:6,000   FIG No. FIGURE 2.   REV 0

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Appendix B EIANZ ecological impact assessment guidelines

Factors to consider in scoring sites freshwater values in relation to species representativeness, rarity, diversity and pattern, and ecological context (adapted from EIANZ, 2018).

Value	Explanation	Characteristics
Very high	A reference quality watercourse in condition close to its pre-human condition with the expected assemblages of flora and fauna and no contributions of contaminants from human induced activities including agriculture. Negligible degradation e.g., stream within a native forest catchment.	Benthic invertebrate community typically has high diversity, species richness and abundance. Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and settled sediments. Benthic community typically with no single dominant species or group of species. MCI scores typically 120 or greater. EPT richness and proportion of overall benthic invertebrate community typically high. SEV scores high, typically >0.8. Fish communities typically diverse and abundant. Riparian vegetation typically with a well-established closed canopy. Stream channel and morphology natural. Stream banks natural typically with limited erosion. Habitat natural and unmodified.
High	A watercourse with high ecological or conservation value but which has been modified through loss of riparian vegetation, fish barriers, and stock access or similar, to the extent it is no longer reference quality. Slight to moderate degradation e.g., exotic forest or mixed forest/agriculture catchment.	Benthic invertebrate community typically has high diversity, species richness and abundance. Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and settled sediments. Benthic community typically with no single dominant species or group of species. MCI scores typically 80-100 or greater. EPT richness and proportion of overall benthic invertebrate community typically moderate to high. SEV scores moderate to high, typically 0.6-0.8. Fish communities typically diverse and abundant. Riparian vegetation typically with a well-established closed canopy. No pest or invasive fish (excluding trout and salmon) species present. Stream channel and morphology natural. Stream banks natural typically with limited erosion. Habitat largely unmodified.
Moderate	A watercourse which contains fragments of its former values but has a high proportion of tolerant fauna, obvious water quality issues and/or sedimentation issues. Moderate to high degradation e.g., high-intensity agriculture catchment.	Benthic invertebrate community typically has low diversity, species richness and abundance. Benthic invertebrate community dominated by taxa that are not sensitive to organic enrichment and settled sediments. Benthic community typically with dominant species or group of species. MCI scores typically 40-80. EPT richness and proportion of overall benthic invertebrate community typically low. SEV scores moderate, typically 0.4-0.6. Fish communities typically moderate diversity of only 3-4 species.

		Pest or invasive fish species (excluding trout and salmon) may be present. Stream channel and morphology typically modified (e.g., channelised) Stream banks may be modified or managed and may be highly engineered and/or evidence of significant erosion. Riparian vegetation may have a well-established closed canopy. Habitat modified.
Low	A highly modified watercourse with poor diversity and abundance of aquatic fauna and significant water quality issues. Very high degradation e.g., modified urban stream	Benthic invertebrate community typically has low diversity, species richness and abundance. Benthic invertebrate community dominated by taxa that are not sensitive to organic enrichment and settled sediments. Benthic community typically with dominant species or group of species. MCI scores typically 60 or lower. EPT richness and proportion of overall benthic invertebrate community typically low or zero. SEV scores moderate to high, typically less than 0.4. Fish communities typically low diversity of only 1-2 species. Pest or invasive fish (excluding trout and salmon) species present. Stream channel and morphology typically modified (e.g., channelised). Stream banks often highly modified or managed and maybe highly engineered and/or evidence of significant erosion. Riparian vegetation typically without a well-established closed canopy. Habitat highly modified.

Factors to consider in scoring sites terrestrial values in relation to species representativeness, rarity, diversity and pattern, and ecological context (adapted from EIANZ, 2018).

Value	Species Values	Vegetation/Habitat Values
Very High	Nationally Threatened - Endangered, Critical or Vulnerable.	Supporting more than one national priority type. Nationally Threatened species found or likely to occur there, either permanently or occasionally.
High	Nationally At Risk - Declining,	Supporting one national priority type or naturally uncommon ecosystem and/or a designated significant ecological area in a regional or district Plan. At Risk - Declining species found or likely to occur there, either permanently or occasionally.
Moderate	Nationally At Risk - Recovering, Relict or Naturally Uncommon.	A site that meets ecological significance criteria as set out the relevant regional or district policies and plans.
Moderate	Not Nationally Threatened or At Risk, but locally uncommon or rare	A site that does not meet ecological significance criteria but that contributes to local ecosystem services (e.g. water quality or erosion control).
Low	Not Threatened Nationally, common locally	Nationally or locally common with a low or negligible contribution to local ecosystem services.

Criteria for describing the magnitude of effect (adapted from EIANZ, 2018).

Magnitude	Description
Very High	Total loss of, or very major alteration to, key elements/features/ of the existing baseline[1] conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature
Moderate	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature
Low	Very slight change from the existing baseline condition. Change barely distinguishable, approximating the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature

[1] Baseline conditions are defined as 'the conditions that would pertain in the absence of a proposed action' (Roper-Lindsay et al., 2018).

Timescale for duration of effect (adapted from EIANZ, 2018).

Timescale	Description
Permanent	Effects continuing for an undefined time beyond the span of one human generation (taken as approximately 25 years)
Long-term	Where there is likely to be substantial improvement after a 25 year period (e.g. the replacement of mature trees by young trees that need > 25 years to reach maturity, or restoration of ground after removal of a development) the effect can be termed 'long term'
Temporary[1]	• Long term (15-25 years or longer – see above) • Medium term (5-15 years) • Short term (up to 5 years) • Construction phase (days or months)

[1]Note that in the context of some planning documents, 'temporary' can have a defined timeframe.

Criteria for describing overall levels of ecological effects (adapted from EIANZ, 2018).

	Ecological value				
Magnitude	**Very high**	**High**	**Moderate**	**Low**	**Negligible**
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very low	Very low	Very low	Very low
Positive	Net gain	Net gain	Net gain	Net gain	Net gain

Interpretation of assessed ecological effects against standard RMA terms (adapted from EIANZ, 2018).

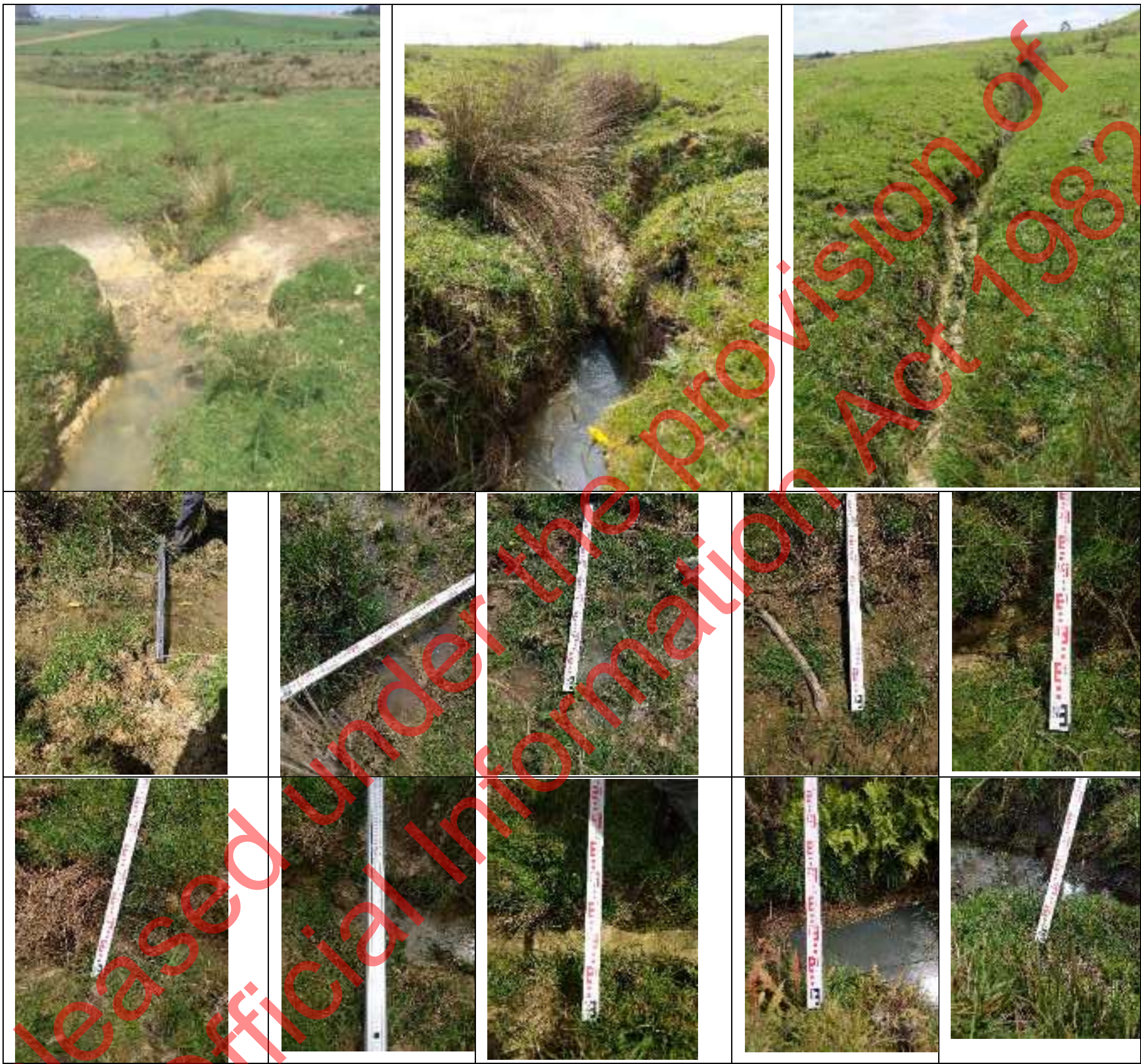
Level of ecological effect	**RMA interpretation**	**Description**
Very high	Unacceptable adverse effects	Extensive adverse effects that cannot be avoided, remedied or mitigated.
High	Significant adverse effects that could be remedied or mitigated	Adverse effects that are noticeable and will have a serious adverse impact on the environment but could potentially be mitigated or remedied.
Moderate	More than minor adverse effects	Adverse effects that are noticeable and may cause an adverse impact on the environment, but could be potentially mitigated or remedied.
Low	Minor adverse effects	Adverse effects that are noticeable but that will not cause any significant adverse impacts.
Very low	Less than minor adverse effects	Adverse effects that are discernible from day to day effects but which are too small to adversely affect the environment.
Nil	Nil effects	No effects at all.

Appendix C Photographs of streams for SEV and cross-sections

SEV 1 (Watercourse 1, under riparian canopy – permanent stream)

SEV 2 (Watercourse 2, without riparian margins – permanent stream)

SEV 3 (Watercourse 3, intermittent stream)



Appendix D Macroinvertebrate sample results for MN02

		Watercourse 1 Permanent channel With riparian margin SEV 1	Watercourse 2 Permanent channel Without riparian margin SEV 2
Caddisfly	Oxyethira		16
Damselfly	Austrolestes	28	2
Damselfly	Ischnura	24	
Damselfly	Xanthocnemis	4	3
Bug	Anisops	3	
Bug	Mesovelia	2	
Bug	Sigara		1
Beetle	Dytiscidae	1.00	1
Beetle	Hydrophilidae	7.00	2
True Fly	Austrosimulium	1	1
True Fly	Corynoneura	3	
True Fly	Culicidae		2
True Fly	Hexatomini	20	
True Fly	Orthocladiinae	3	1
True Fly	Stratiomyidae	1	
True Fly	Tanytarsini	1	
Crustacea	Cladocera		4
Crustacea	Ostracoda	1	
Mollusc	Lymnaeidae	20	10
Mollusc	Potamopyrgus	24	3
Mollusc	Sphaeriidae	108	
OLIGOCHAETES		7	5
LEECHES		1	
FLATWORMS		5	
NEMERTEANS		10	5
Number of Taxa		**21**	**14**
EPT Value		**0**	**0**
Number of Individuals		**274**	**56**
% EPT		**0.00**	**0.00**
% EPT Taxa		**0.00**	**0.00**
Sum of recorded scores		**60.6**	**31.8**
SBMCI Value		**57.71**	**45.43**
Sum of abundance load		**772.90**	**101.60**
QMCI-sb Value		**2.82**	**1.81**

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Appendix E SEV modelling assumptions

Function Category	Variable	ID: SEV1 Stream ID: Permanent stream (with riparian margins) SEV: SEVm-P Offset: max 20 m riparian margin enhancement on both banks (including infill planting) + weed control	ID: SEV2 Stream ID: Permanent stream (without riparian margin) SEV: SEVm-P Offset: max 20 m riparian margin enhancement on both banks + weed control
Hydraulic	Vchann	Assumes no changes to stream channel – no instream enhancement	Assumes no change to stream channel – no instream enhancement (still straightened and deepened channel).
	Vlining	Assumes slight reduction of fine silt loading from riparian margin and improved filtering.	Assumes slight reduction in fine silt from riparian margin.
	Vpipe	Assumes no change, one pipe observed.	Assumes no pipe.
	Vbank	Assumes no change to current bank conditions, floodplain present but channel incised.	Assumes no change to current bank conditions of floodplain present but connectivity restricted by channel modification.
	Vrough	Assumes 20 m planting on each bank, infill planting with native regenerating vegetation in late stage of succession, some low diversity regenerating bush (excluded from stock) and remnant mature exotic trees (eucalyptus and poplar).	Assumes 20 m planting on each bank, dominated by native regenerating vegetation in late stage of succession, some low diversity regenerating and stock exclusion and mature flax and sedges wetland margins.
	Vbarr	Assumes no change to current with no physical barriers observed.	Assumes no change to current with no physical barriers.
	Vchanshape	*Autopopulated*	*Autopopulated*.
Biogeochemical	Vshade	Assumes very high, high, and moderate shading from 20 m riparian margin enhancement along entire length.	Assumes very high, high, and moderate shading from 20 m riparian margin enhancement along entire length.
	Vdod	Assumes optimal dissolved oxygen from the reduction of fine silt cover across the streambed and reduction of macrophytes from shading.	Assumes improvements to optimal dissolved oxygen following reduction of fine silt cover across streambed and reduction of macrophytes from shading.
	Vveloc	Assumes no change to flow measured on site.	Assumes no change to flow measured during site.
	Vdepth	Assumes no change to estimated depth observed during site.	Assumes no change to estimated depth observed during site.
	Vripar	Assumes a full 20 m riparian margin covered in trees and/ shrubs.	Assumes a full 20 m riparian margin.
	Vdecid	Assumes no change to current low presence of deciduous trees on bank.	Assumes no change from no deciduous (no deciduous observed on site).
	Vmacro	Assumes reduction of macrophytes after shading from canopy cover.	Assumes reduction of macrophytes after shading from canopy cover.
	Vretain	*Autopopulated*	*Autopopulated*.
	Vsurf	Assumes slight increase in woody debris and leaf litter organic material input.	Assumes slight increase in woody debris and leaf litter organic material input.

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	Vripfilt	Assumes improvements to very high, high, and moderate filtering activity from the 20 m vegetation margin on each bank.	Assumes mostly high and moderate filtering activities following planting.
Habitat Provision	**Vgalspwn**	Assumes no change to existing gradients observed on site.	Assumes no change to existing gradients observed on site.
	Vgalqual	Assumes unsuitable for spawning due to incision, no changes to bank/slope.	Assumes unsuitable due to no changes to bank/slope.
	Vgobspawn	*Autopopulated*	*Autopopulated*.
	Vphyshab	Assumes slight increase in aquatic habitat diversity including wood, undercut banks, and rooted aquatic vegetation that are evenly distributed along reach. Assumes minor changes to existing hydrological heterogeneity. Assumes overall very high channel shade and vegetation integrity with 20 m planting on both banks.	Assumes slight increase in aquatic habitat diversity including wood, undercut banks, and rooted aquatic vegetation that are evenly distributed along reach. Assumes slight improvements to existing hydrological heterogeneity. Assume very high channel shade and vegetation integrity with 20 m planting on both banks.
	Vwatqual	Assumes minimal improvement to water quality from planting due to near headwaters.	Assumes minimal improvement to water quality from planting due to near headwaters.
	Vimperv	Assumes no change to existing 0% impervious (pastural land).	Assumes no change to existing 0% impervious (pastural land).
Biodiversity	**Vfish**	-	-
	Vmci	-	-
	Vept	-	-
	Vinvert	-	-
	Vripcond	*Autopopulated*.	*Autopopulated*.
	Vripconn	Assumes no change to current with stream connection impeded by channel incision.	Assumes no change to current, some impediments to connection.

Function Category	**Variable**	**ID: SEV3** **Stream ID: Intermittent tributary (without riparian margin)** **SEV: SEVm-P** **Offset: max 20 m riparian margin enhancement on both banks + weed control**
Hydraulic	**Vchann**	Assumes improvements to channel from reduction of excessive roughness elements.
	Vlining	Assumes reduction in fine silt from riparian margin.
	Vpipe	Assumes no pipe/no change to existing.
	Vbank	Assumes no change to current bank conditions.
	Vrough	Assumes 20 m of planting on each bank, dominated by native regenerating vegetation in late stage of succession, some low diversity regenerating with stock excluded and wetland enhancement on edges.
	Vbarr	Assumes no change to current with no physical barriers.
	Vchanshape	*Autopopulated*.
Bio geo che.	**Vshade**	Assumes very high, high, and moderate shading from 20 m riparian margin enhancement along entire length.

	Vdod	Assumes slight improvement to sub-optimal.
	Vveloc	Assumes no change to measured gentle flow on site.
	Vdepth	Assumes no change to measured depth on site.
	Vripar	Assumes a full 20 m riparian margin.
	Vdecid	Assumes no change from no deciduous (no deciduous observed on site).
	Vmacro	Assumes reduction in macrophytes following shading and planting.
	Vretain	*Autopopulated.*
	Vsurf	Assumes slight increase in woody debris and leaf litter input.
	Vripfilt	Assumes improvement in filtering activities (very high, high, and moderate) following planting.
Habitat Provision	**Vgalspwn**	Assumes no change to existing gradients.
	Vgalqual	Assumes medium quality following planting, largely from shading.
	Vgobspawn	*Autopopulated.*
	Vphyshab	Assumes increase in aquatic habitat diversity including wood, undercut banks, and rooted aquatic vegetation that are evenly distributed along reach. Assumes slight changes to existing hydrological heterogeneity. Assume very high channel shade and vegetation integrity with 20 m planting each bank.
	Vwatqual	Assumes slight improvement due to enhancement near headwaters.
	Vimperv	Assumes no change to current no expected change to pastural land-use.
Biodiversity	**Vfish**	-
	Vmci	-
	Vept	-
	Vinvert	-
	Vripcond	*Autopopulated.*
	Vripconn	Assumes no change to existing.

Appendix F Species lists

Table 1: **Vascular plant species list developed from site walkover. Bolded species are introduced.**

Common name	Species name	Threat classification	Mānuka, kānuka gumland, *Machaerina* sedgeland	Mānuka wetland	Tōtara forest	*Eleocharis* – *Schoenoplectus* – *Machaerina* wetland	Mānuka – kiokio – *Machaerina* wetland	Indigenous-dominated Edgars rush wetland
Blackwood	***Acacia melanoxylon***	**Introduced**			X			
Sickle spleenwort	*Asplenium polyodon*	Not Threatened			X			
Pink bindweed	*Calystegia sepium* subsp. *roseata*	Not Threatened	X					
Rautahi	*Carex geminata*	Not Threatened					X	
Broom sedge	***Carex scoparia***	**Introduced**	X			X	X	
Swamp sedge	*Carex virgata*	Not Threatened					X	
-	*Centella uniflora*	Not Threatened						
Thin-leaved coprosma	*Coprosma areolata*	Not Threatened						
Pampas	***Cortaderia selloana***	**Introduced**						
Silverfern	*Cyathea dealbata*	Not Threatened	X		X			
Mamaku	*Cyathea medullaris*	Not Threatened						
Rimu	*Dacrydium cupressinum*	Not Threatened						
Kahikatea	*Dacrydium dacrydioides*	Not Threatened			X			
-	*Deparia petersenii*	Not Threatened						
Wheki	*Dicksonia squarrosa*	Not Threatened				X		
-	*Diplazium australe*	Not Threatened						
Rasp fern	*Doodia australis*	Not Threatened			X			
Sharp spike sedge	*Eleocharis acuta*	Not Threatened				X		
Kutakuta	*Eleocharis sphacelata*	Not Threatened				X		
Willow-leaved hakea	***Hakea salicifolia***	**Introduced**						
Mata	*Histipoteris incisa*	Not Threatened			X			
Yorkshire fog	***Holcus lanatus***	**Introduced**	X					

Slender clubrush	*Isolepis cernua* var. *cernua*	Not Threatened		X			X	X
-	*Isolepis prolifera*	Not Threatened						X
Edgar's rush	*Juncus edgariae*	Not Threatened						X
Soft rush	***Juncus effusus***	**Introduced**	X	X				X
Kānuka	*Kunzea robusta*	Threatened - Nationally Vulnerable	X		X			
Mānuka	*Leptospermum scoparium*	At Risk - Declining	X	X			X	
-	*Machaerina arthrophylla*	Not Threatened	X			X		
Jointed twig rush	*Machaerina articulata*	Not Threatened					X	
-	*Machaerina juncea*	Not Threatened	X					
Red matipo	*Myrsine australis*	Not Threatened			X			
Basket grass	*Oplismenus hertillus* subsp. *Imbicillus*	Not Threatened			X			
Fragrant fern	*Paesia scaberula*	Not Threatened				X		
Swamp kiokio	*Parablechnum minus*	Not Threatened					X	
Kiokio	*Parablechnum novae-zelandiae*	Not Threatened					X	
Harakeke	*Phormium tenax*	Not Threatened					X	
Tōtara	*Podocarpus totara*	Not Threatened			X			
Kumarahou	*Pomaderris kumarahou*	Not Threatened		X				
Taiwan cherry	***Prunus campanulata***	**Introduced**			X			
Bracken	*Pteridium esculentum*	Not Threatened		X				
Buttercup	***Ranunculus repens***	**Introduced**	X					X
Blackberry	***Rubus fruticosus* var. *fruticosus***	**Introduced**		X				
Kuawa	*Schoenoplectus tabernaemontani*	Not Threatened				X		
African clubmoss	***Selaginella kraussiana***	**Introduced**						
Tetraria	*Tetraria capillaris*	Not Threatened	X					
Gorse	***Ulex europaeus***	**Introduced**				X		

Table 2: Avifauna species identified during the site visit and associated threat classification.

Common name	Species name	Threat classification
Common myna	*Acridotheres tristis*	Introduced
Eurasian skylark	*Alauda arvensis*	Introduced
New Zealand pipit	*Anthus novaeseelandiae*	At Risk - Declining
North Island brown kiwi*	*Apteryx mantelli*	At Risk - Declining
European goldfinch	*Carduelis carduelis*	Introduced
Shining cuckoo	*Chrysococcyx lucidus*	Not Threatened
Kāhu/Swamp harrier	*Circus approximans*	Not Threatened
White-faced heron	*Egretta novaehollandiae*	Not Threatened
Yellowhammer	*Emberiza citrinella*	Introduced
Australian magpie	*Gymnorhina tibicin*	Introduced
Kukupa	*Hemiphaga novaeseelandiae*	Not Threatened
Pied stilt	*Himantopus himantopus*	Not Threatened
Welcome swallow	*Hirundo neoxena*	Not Threatened
Southern black-backed gull	*Larus dominicanus*	Not Threatened
Wild turkey	*Meleagris gallopavo*	Introduced
House sparrow	*Passer domesticus*	Introduced
Common pheasant	*Phasianus colchicus*	Introduced
Eastern rosella	*Platycercus eximius*	Introduced
Pūkeko	*Porphyrio melanotus*	Not Threatened
Tūī	*Prosthemadera novaeseelandiae*	Not Threatened
Pīwakawaka/New Zealand fantail	*Rhipidura fuliginosa*	Not Threatened
Paradise shelduck	*Tadorna variegata*	Not Threatened
Kōtare/Sacred kingfisher	*Todiramphus sanctus*	Not Threatened
Spur-winged plover	*Vanellus miles*	Not Threatened
Silvereye	*Zosterops lateralis*	Not Threatened

*Not observed during site visit but likely to be present (at least intermittently).

Appendix G Site visit photographs

Photograph 1. Tōtara forest of which 0.01 ha (e.g. the edge trees in the above photo) are within the proposed reservoir footprint.

Photograph 2. Tōtara forest at downstream end of watercourse 1 showing degraded understorey.

Photograph 3. Exotic pine trees at downstream end of watercourse 1.

Photograph 4. Mānuka kānuka gumland, *Machaerina* sedgeland.

 Photograph 5. Mānuka wetland showing pugged and grazed understorey.	 Photograph 6. Mānuka – kiokio – *Machaerina* wetland.
 Photograph 7. *Eleocharis* wetland showing kutakuta and sharp spike sedge.	 Photograph 8. Indigenous-dominated Edgar's rush wetland.

 Photograph 9. Soft rush wetland.	 Photograph 10. Pugged and grazed *Isolepis cernua* var. *cernua* wetland.

Appendix H Weather conditions during bat surveys

Minimum overnight temperature, minimum temperature 2-hours after sunset, humidity and rainfall 2-hours after sunset recorded at the weather stations nearest to the Project site. Minimum overnight temperature was recorded at Kaikohe weather station (Agent No. 1134). The remaining data was collected at Kerikeri weather station (Agent No. 1056). Data highlighted grey indicate instances of weather conditions not meeting optimum conditions for bat activity.

Date	Sunset time	Moon phase	Min. overnight temp (°C)	Min temp (2 hr post-sunset)	Rain 2 hrs post-sunset (mm)	Min overnight humidity %
Valid condition				**<10**	**<2.5**	**<70%**
14/10/2020	19:37		6.9	13.4	0.1	71
15/10/2020	19:38		7.3	12.2	0	77
16/10/2020	19:39		7.2	12.2	0	77
17/10/2020	19:40	New moon	5.9	10.6	0	72
18/10/2020	19:41		7.8	13.7	0	73
19/10/2020	19:42		11.1		0	76
20/10/2020	19:43		11.9		0	79
21/10/2020	19:44		10.9		0	76
22/10/2020	19:45		9.9	15	3.9	92
23/10/2020	19:46		13.5		0	88
24/10/2020	19:47	First quarter	14.1		0	88
25/10/2020	19:48		14.1		0	83
26/10/2020	19:49		10		0	83
27/10/2020	19:50		12.4		0	79
28/10/2020	19:51		13.8		0	88
29/10/2020	19:52		14.7		0	87
30/10/2020	19:53		14		0	80
31/10/2020	19:54		14.6		0.9	96
1/11/2020	19:55	Full moon	14.6		0	75
2/11/2020	19:56		11.8		0	87

Appendix I Offset data input, output and assumptions and justifications made during the offsetting process

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of mānuka, kānuka gumland Machaerina scrub sedgeland (WL1).

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact Value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity Value
Canopy	Indigenous canopy cover (%)	90	Assumes only minor canopy gaps.	70 (10)	It is assumed indigenous mānuka and kānuka will dominate canopy after 10 years. A reduced canopy cover above 1.35 m due to slow growth on gumland soils.	70	Restoration planting and fencing to exclude livestock.	0.06/0.76	0.31
	Average height (m)	30	NZPCN height of kānuka (de Lange, P.J. 2020a).	1.3 (10 years)	Mean annual height growth rate of mānuka in gumlands of 11.90 cm per year (Clarkson et al. 2011). Note that these gumlands were highly nutrient poor, with all vegetation less than 2 m tall. Reduced to 10 cm per year as a conservative estimate. The presence of kānuka indicates soils are drier than the pure mānuka wetland stands on site and therefore growth rates are expected to be slightly higher for this ecosystem type. Assumes planted vegetation will be 40 cm high when established.	4	Restoration planting and fencing to exclude livestock.		0.01

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity Value
					This estimate is conservative given kānuka can grow up to 1 m per year on good soils (Tane's Tree Trust, n.d.).				
	Basal area (m²/ha)	25	Mānuka gumland RECCE plot at Aratapu Water Storage Reservoir site returned a basal area of 19. Average basal area of kānuka plots on Te Ahu a Turanga: Manawatū Tararua Highway returned a value of 23. Increased to 25 as a conservative 'pristine' kānuka mānuka gumland. Kānuka forests can reach a value of 70 m² per ha (Smale, 1994), however due to this being a mixed stand and in gumland, this benchmark is not considered appropriate.	10 (10)	A study on kānuka forest (in the Bay of Plenty) found basal area of 8m²/ha in a stand of kānuka 6 years old to 70 m²/ha in another with an age of 8 years old (Smale, 1994). Basal area growth can be highly variable, and a conservative estimate of 10 after 10 years has been used to reflect the mixed mānuka kānuka stand being restored on relatively nutrient-poor soils.	22.6	Restoration planting and fencing to exclude livestock.		0.15
Diversity	Diversity of native species (no. per 100 m²)	40	40 species observed at kānuka heaths (Smale, 1994) in the Bay of Plenty.	5 (10)	At least 5 native species will be planted to achieve the species richness target. It is expected seed rain will increase this total number in time.	7	Restoration planting and fencing to exclude livestock.		0.06
Understorey	% cover of understorey species	90	High understorey cover assumed due to species associated with gumlands capable of forming dense swathes of high-cover vegetation such as Macaherina juncea.	30 (10)	30% understorey cover a conservative estimate, given planting of Macaherina spp. which are capable of forming dense understorey areas.	50	Restoration planting and fencing to exclude livestock.		0.12

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until endpoint)	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity Value
Fauna habitat and food provision	Litter depth (mm)	0	Litter from mānuka and kānuka not expected.	0 (10)	No litter expected.	0	Restoration planting and fencing to exclude livestock.		0
	Flaky bark trees (no./ha)	2000	The number of flaky bark trees decreases with time due to self-thinning (Smale, 1994). The value of 2000 estimated from Smale (1994).	500 (10)	After 10 years mānuka and kānuka are expected to be at approximately 5000 stems /ha assuming 1.5 m spacing. However, only a few of these plantings are expected to comprise flaky bark due to their young age. 500 of these trees (i.e. 10%) have been conservatively estimated as having flaky bark that will support fauna.	4200	Restoration planting and fencing to exclude livestock. Where flaky bark tree measure after offsets are not being met, closed cell foam covers, hole drilling or weta motels may be used to provide similar fauna habitat values.		0.06
	Coarse woody debris (m^3/ha)	56	Median value in New Zealand forests (not including standing dead trees; Richardson et al., 2009). Potentially appropriate CWD measure for a benchmark kānuka mānuka gumland which does not have large trees.	10 (10)	Woody debris from felled vegetation as part of construction will be salvaged and used in restoration plantings to provide habitat for indigenous fauna.	0	Restoration planting and fencing to exclude livestock. Salvaged logs and log discs deployed in restoration areas.		0.11

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of mānuka wetland.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
Canopy	Indigenous canopy cover (%)	90	Assume an almost full canopy.	80 (10)	80% canopy cover a standard and achievable goal for offset planting after 10 years.	60	Restoration planting and fencing to exclude livestock.	0.19/1.3	0.56
	Average height (m)	5	NZPCN height of mānuka (de Lange, 2020b).	1.3 (10 years)	Mean annual height growth rate of mānuka in gumlands of 11.90 cm per year (Clarkson et al. 2011). Note these gumlands all contained mānuka less than 2 m in height and therefore highly infertile. Reduced to 10 cm per year as a conservative estimate. Assumes planted vegetation will be 40 cm high when established.	5	Restoration planting and fencing to exclude livestock.		0.01
	Basal area (m^2/ha)	25	Mānuka gumland RECCE plot at Aratapu Water Storage Reservoir site returned a basal area of 19. Average basal area of kānuka	6 (10)	Basal area of mānuka stands at Tongariro returned an average of 29.36 after 25 years (Scott et al., 2000)	22.6	Restoration planting and fencing to exclude livestock.		0.01

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
			plots on Te Ahu a Turanga: Manawatū Tararua Highway returned a value of 23. Increased to 25 as a conservative 'pristine' kānuka mānuka gumland.		Assumes a conservative basal area growth of 0.6 m2/ha per annum.				
Diversity	Diversity of native species (no. per 100 m²)	15	Average of 12.4 species per 100 m² in Leptospermum–Gleichenia shrubland (Clarkson et al., 2011). Increased to 15 to account for the fact it is to be a 'pristine' ecosystem.	10 (10)	At least 5 additional native species will be planted to achieve the species richness target. It is expected seed rain will increase this total number in time. Assumes planting into wetland with some (up to 5) existing native plants.	2	Restoration planting and fencing to exclude livestock.		0.27
Understorey	% cover of understorey species	80	High understorey cover assumed due to species associated with gumlands capable of forming dense swathes of high-cover vegetation such as Macaherina juncea.	30 (10)	30% understorey cover a conservative estimate, given planting of Macaherina spp. which can form dense understorey areas.	10	Restoration planting and fencing to exclude livestock.		0.23
Fauna habitat and food provision	Litter depth (mm)	0	Litter from mānuka and kānuka not expected.	0 (10)	No litter expected.	0	Restoration planting and fencing to exclude livestock.		-
	Flaky bark trees (no./ha)	2000	The number of flaky bark trees is expected to decrease in time due to self-thinning (Smale, 1994). Therefore a pristine ecosystem has less flaky bark trees than measured at the impact site. The value of 2000 estimated from Smale (1994).	500 (10)	After 10 years mānuka are expected to be at approximately 5000 stems /ha assuming 1.5 m spacing. However, only a few of these plantings are expected to have flaky bark due to their young age. 500 of these trees (i.e. 10%) have been	6000	Restoration planting and fencing to exclude livestock. Where flaky bark tree measure after offsets are not being met, closed		0.01

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
					conservatively estimated as having flaky bark which will support fauna.		cell foam covers, hole drilling or weta motels may be used to provide similar fauna habitat values.		
	Coarse woody debris (m^3/ha)	56	Median value in New Zealand forests (not including standing dead trees; Richardson et al., 2009). Potentially appropriate CWD measure for a benchmark mānuka gumland which does not have large trees.	10 (10)	Woody debris from felled vegetation as part of construction will be salvaged and used in restoration plantings to provide habitat for indigenous fauna.	0	Restoration planting and fencing to exclude livestock. Salvaged logs and log discs deployed in restoration areas.		0.14
	Habitat richness (count)	6	Indigenous turf tier, rush tier, tree tier, open water, indigenous buffer plantings, and stock exclusion.	4 (10)	Assumes turf tier, rush tier, fencing, buffer planting.	2	Restoration planting and fencing to exclude livestock.		0.20

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of mānuka-kiokio-Machaerina wetland.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
Canopy	Indigenous canopy cover (%)	90	Assume an almost full canopy.	80 (10)	80% canopy cover a standard and achievable goal for offset planting after 10 years.	20	Restoration planting and fencing to exclude livestock.	0.06/0.2	0.11
	Average height (m)	5	NZPCN height of mānuka (de Lange, 2020b).	1.3 (10 years)	Mean annual height growth rate of mānuka in gumlands of 11.90 cm per year (Clarkson et al. 2011). Note these gumlands all contained mānuka less than 2 m in height and therefore highly infertile. Reduced to 10 cm per year as a conservative estimate. Assumes planted mānuka will be 40 cm high when established. Height of other wetland plants also expected to be approximately 1.3 m after 10 years (e.g. Machaerina articulata).	2	Restoration planting and fencing to exclude livestock.		0.01
	Basal area (m^2/ha)	5	Assumed that basal area would be lower than the pure 'mānuka wetland', but higher than its current stock-degraded state.	0.46 (10)	Assumes growth of 1.5 cm DBH per mānuka planted after 10 years, and planting of area with 50% mānuka at 1.5 m spacings.	0.3	Restoration planting and fencing to exclude livestock.		0.01

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
			Assumed to be a wetland complex with occasional scattered mature mānuka.		An estimate of 1.5 cm per year is conservative, with studies showing mean growth of mānuka of between 4 and 6 cm after 10 years (Bergin et al., 1997), and between 5 mm and over 10 mm per year (Harrington et al., 2005).				
Diversity	Diversity of native species (no. per 100 m^2)	15	Average of 12.4 species per 100 m^2 in Leptospermum–Gleichenia shrubland (Clarkson et al., 2011). Increased to 15 to account for the fact it is to be a 'pristine' ecosystem.	10 (10)	At least 5 additional native species will be planted to achieve the species richness target. It is expected seed rain will increase this total number in time. Assumes planting into wetland with some (up to 5) existing native plants.	7	Restoration planting and fencing to exclude livestock.		0.02
Understorey	% cover of understorey species	80	High understorey cover assumed due to species associated with gumlands capable of forming dense swathes of high-cover vegetation such as Macaherina juncea.	70 (10)	70% understorey cover a conservative estimate, given planting of Macaherina spp. which can form dense understorey areas. Differs from other mānuka treeland restoration on site due to a lower proportion of mānuka in this ecosystem. Wetland plants expected to form dense cover within the understorey tier.	60	Restoration planting and fencing to exclude livestock.		0.06
Fauna habitat and food provision	Litter depth (mm)	0	Litter from mānuka and kānuka not expected.	0 (10)	No litter expected.	0	Restoration planting and fencing to exclude livestock.		-
	Flaky bark trees (no./ha)	500	Assumes some mature flaky bark trees (mānuka) in a wetland complex (5 per 100 m^2).	250 (10)	After 10 years mānuka are expected to be at approximately 2500 stems	0	Restoration planting and fencing to exclude		0.02

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
					/ha assuming 1.5 m spacing and 50% coverage. However, only a few of these mānuka are expected to have flaky bark due to their young age. 250 of these trees (i.e. 10%) have been conservatively estimated as having flaky bark which will support fauna.		livestock. Where flaky bark tree measure after offsets are not being met, closed cell foam covers, hole drilling or weta motels may be used to provide similar fauna habitat values.		
	Coarse woody debris (m^3/ha)	10	A relatively low CWD assumed for this ecosystem type considering occasional mānuka present as woody plants.	5 (10)	Woody debris from felled vegetation as part of construction will be salvaged and used in restoration plantings to provide habitat for indigenous fauna.	0	Restoration planting and fencing to exclude livestock. Salvaged logs and log discs deployed in restoration areas.		0.06
	Habitat richness (count)	6	Indigenous turf tier, rush tier, tree tier, open water, indigenous buffer plantings, and stock exclusion.	4 (10)	Assumes turf tier, rush tier, fencing, buffer planting.	3	Restoration planting and fencing to exclude livestock.		0.01

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of tōtara forest.

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
Canopy	Indigenous canopy cover (%)	90	Assume an almost full canopy.	80 (10)	80% canopy cover a standard and achievable goal for offset planting after 10 years.	90	Restoration planting and fencing to exclude livestock.	0.17/1.4	0.59
	Average height (m)	30	NZPCN height of tōtara (de Lange, 2020c).	3.5 (10 years)	Tōtara on good sites grows to 2 m in 5 years. Reduced to 1.5 m per 5 years, so 3 m after 10 years (Bergin, D., 2003). Seedlings presumed to be 40 cm high when planted.	12	Restoration planting and fencing to exclude livestock.		0.03
	Basal area (m^2/ha)	130	100 year tōtara plantation at puhipuhi had a basal area of 128.3 (Bergin & Kimberly, 2003).	20 (30)	Tōtara plantation in Tapapakanga reached basal area of 13.4 after 10 years (Bergin & Kimberly, 2003). Furthermore, table 6 of Bergin & Kimberly (2003) show an average basal area of planted tōtara of 25.4 after 30 years. Reduced to 20 as conservative measure.	29.32	Restoration planting and fencing to exclude livestock.		0.01
Diversity	Diversity of native species (no. per 100 m^2)	25	A total of 25 species found in a 2.3 ha fragment of tōtara forest (Young & Norton, 2017).	10 (10)	At least 10 native species to be planted. Natural colonisation of indigenous species expected to increase this estimate.	9	Restoration planting and fencing to exclude livestock.		0.34

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
Understorey	% cover of understorey species	50	Average understorey cover observed in New Zealand hill country forest fragments is 40% (Smale et al., 2008). 50 used as a conservative estimate of a more 'pristine' ecosystem.	20 (30)	Enrichment planting proposed at year 5 which is conservatively expected to result in at least 20% understorey cover by year 30.	20	Restoration planting, enrichment planting and fencing to exclude livestock.		0.10
Fauna habitat and food provision	Litter depth (mm)	63	Estimate derived from 10 x 10 m^2 RECCE plot undertaken in fenced secondary broadleaf forest nearby as part of Te Ruaotehauhau Stream Water Storage Reservoir Assessment of Ecological Effects. This leaf litter number is the highest result found in any of the collective water reservoir RECCE plots.	5 (10)	A small amount of litter expected after 10 years. Logs and log discs proposed to provide additional habitat for invertebrates and other fauna.	11	Restoration planting and fencing to exclude livestock. Logs and log discs translocated.		0.03
	Flaky bark trees (no./ha)	500	Assumes mature tōtara trees at a density of 5 per 100 m^2 which have flaky bark habitat.	150 (30)	At least 300 tōtara to be planted per ha. After 30 years half of these have been assumed to provide flaky bark for fauna.	300	Restoration planting and fencing to exclude livestock. Where flaky bark tree measure after offsets are not being met, closed cell foam covers, hole drilling or weta motels may be used to provide similar fauna habitat values.		0.03

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time until	Measure after offset justification	Impact value	Management regime to achieve measure after offset.	Overall Impact Area/Offset Area (ha)	Attribute Net Present Biodiversity
	Coarse woody debris (m³/ha)	19.6	Estimate derived from 10 x 10 m² RECCE plot undertaken in fenced old-growth pūriri forest nearby as part of Te Ruaotehauhau Stream Water Storage Reservoir Assessment of Ecological Effects.	5 (10)	Woody debris from felled vegetation as part of construction will be salvaged and used in restoration plantings to provide habitat for indigenous fauna.	0	Restoration planting and fencing to exclude livestock. Salvaged logs and log discs deployed in restoration areas.		0.03

References

Bergin, D. O., Kimberley, M. O., & Marden, M. (1995). Protective value of regenerating tea tree stands on erosion-prone hill country, East Coast, North Island, New Zealand. New Zealand Journal of Forestry Science, 25(1), 3-19.

Bergin, D. O., (2003). Totara establishment, growth and management. New Zealand Indigenous Tree Bulletin 1176-2632; No.1.

Bergin, D. O., & Kimberley, M. O. (2003). Growth and yield of totara in planted stands. New Zealand Journal of Forestry Science, 33(2), 244-264.

Clarkson, B. R., Smale, M. C., Williams, P. A., Wiser, S. K., & Buxton, R. P. (2011). Drainage, soil fertility and fire frequency determine composition and structure of gumland heaths in northern New Zealand. New Zealand Journal of Ecology, 96-113.

de Lange, P.J. (2020a): Kunzea robusta Fact Sheet (content continuously updated). New Zealand Plant Conservation Network. https://www.nzpcn.org.nz/flora/species/kunzea-robusta/ (13 November 2020).

de Lange, P.J. (2020b): Leptospermum scoparium var. scoparium Fact Sheet (content continuously updated). New Zealand Plant Conservation Network. https://www.nzpcn.org.nz/flora/species/leptospermum-scoparium-var-scoparium/ (16 November 2020)

de Lange, P.J. (2020c): Podocarpus totara var. totara Fact Sheet (content continuously updated). New Zealand Plant Conservation Network. https://www.nzpcn.org.nz/flora/species/podocarpus-totara-var-totara/ (17 November 2020)

Harrington, K. C., Nurhayati, R. H., & Millner, J. P. (2015). Field assessment of herbicides to aid establishment of manuka (Leptospermum scoparium). New Zealand Plant Protection, 68, 132-138.

Young, L. M., & Norton, D. A. (2017). Sustainable totara management and biodiversity conservation in Northland. NZ Journal of Forestry, 62(2), 23.

Richardson, S. J., Peltzer, D. A., Hurst, J. M., Allen, R. B., Bellingham, P. J., Carswell, F. E., ... & Wright, E. F. (2009). Deadwood in New Zealand's indigenous forests. Forest Ecology and Management, 258(11), 2456-2466.

Scott, N. A., White, J. D., Townsend, J. A., Whitehead, D., Leathwick, J. R., Hall, G. M., ... & Whaley, P. T. (2000). Carbon and nitrogen distribution and accumulation in a New Zealand scrubland ecosystem. Canadian Journal of Forest Research, 30(8), 1246-1255.

Smale, M. C., Dodd, M. B., Burns, B. R., & Power, I. L. (2008). Long-term impacts of grazing on indigenous forest remnants on North Island hill country, New Zealand. New Zealand Journal of Ecology, 57-66.

Smale, M.C. 1994. Ecology of kanuka (Kunzea ericoides var. ericoides) heaths on sand dunes in the Bay of Plenty, North Island, New Zealand. New Zealand Journal of Botany 32: 441-452.

Tane's Tree Trust (n.d.). Kanuka (Kunzea ericoides). Accessed from https://www.tanestrees.org.nz/species-profiles/kanuka/#:~:text=Growth%20is%20quite%20fast%2C%20up,initially%20and%20pruned%20if%20required on 13 November 2020.

MN02 Biodiversity Offset Accounting Model for wetland ecosystems requiring offset and compensation.

1. Eleocharis – Schoenoplectus – Machaerina wetland complex

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time till endpoint)	Measure after offset justification	Measure prior to and after Offset + impact value	Management regime to achieve measure after offset	Overall impact area/Offset area (ha)	Attribute Net Present Biodiversity Value
Canopy	Canopy vegetation percentage indigenous cover (%)	90	Wetland is assumed to have high indigenous canopy cover with some gaps.	80 (after 10 years)	80% canopy cover after 5 years is a standard and achievable performance target for new plantings. Assumes 10% cover of indigenous plants at offset sites.	Prior = 10% After offset = 80% Impact value = 10%	Planting, weed control and fencing.	Impact area = 0.09 Offset area = 0.24	0.03
Canopy height	Indigenous vegetation canopy height	3	Schoenoplectus tabermontanei reaches up to 3 m in height (de Lange, 2020).	1.5 (after 10 years)	Wetland plants such as Schoenoplectus tabernaemontani are fast-growing and 1.5 m after 10 years is a conservative estimate (studies show it can reach 1.5 m in one year; Nicol et al., 2015).	Prior = 0.3 cm After offset = 1.5 m Impact value = 1.5 m			0.01
Diversity	Species richness of vascular plants	10	Assumed to have a diverse assemblage of wetland plants.	6 (after 10 years)	Assuming planting into wetland with two indigenous species already present (e.g. Juncus edgariae and Isolepis cernua).	Prior = 2	Planting, weed control and fencing.		0.01

					Conservatively assumes planting 4 wetland species.	After offset = 4 Impact value = 6			
	Habitat intactness	6	Benchmark richness includes a full suite of wetland habitat characteristics. Intactness includes an indigenous turf, rush and tree tier, stock exclusion, open water and wetland buffer planting.	4 (after 10 years)	Fenced from stock, turf tier, rush tier and buffer plantings.	Prior = 2 After offset = 4 Impact value = 2	Planting, weed control and fencing.		0.02

2. Indigenous-dominated Juncus wetland

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time till endpoint)	Measure after offset justification	Measure prior to and after Offset + impact value	Management regime to achieve measure after offset	Overall impact area/Offset area (ha)	Attribute Net Present Biodiversity Value

Canopy	Canopy vegetation percentage indigenous cover (%)	99	Wetland is assumed to have high indigenous canopy cover with some gaps.	80 (after 10 years)	80% canopy cover after 5 years is a standard and achievable performance target for new plantings. Assumes 10% cover of indigenous plants at offset sites.	Prior = 10% After offset = 80% Impact value = 50%	Planting, weed control and fencing.	Impact area = 4.05 Offset area = 6.0	0.28
Canopy height	Indigenous vegetation canopy height	30	Kahikatea typically reach up to 30 m in height (Tane's Tree Trust, n.d.).	2 (after 10 years)	Kahikatea grows between 10 and 70 cm per annum (Tane's Tree Trust, n.d.). Conservative estimate of 2 m after 10 years used. Other wetland species planted are also expected to reach 2 m after 10 years such as Juncus edgariae and Machaerina juncea.	Prior = 0.3 cm After offset = 2 m Impact value = 1.5 m	Planting, weed control and fencing.		0.01
Diversity	Species richness of vascular plants	44	Miller (2004) found 37 to 44 species per 500 m^2 in floodplain kahikatea forest plots in south Westland, New Zealand.	10 (after 10 years)	Assuming planting into wetland with five indigenous species already present (e.g. Juncus edgariae and Isolepis cernua). Conservatively assumes planting 5 wetland species.	Prior = 5 After offset = 10 Impact value = 2	Planting, weed control and fencing.		0.23
	Habitat intactness	6	Benchmark richness includes a full suite of wetland habitat characteristics. Complexity includes an indigenous turf, rush and tree tier, stock exclusion, open water and wetland buffer planting.	4 (after 10 years)	Fenced from stock, turf tier, rush tier and buffer plantings.	Prior = 2 After offset = 4	Planting, weed control and fencing.		0.55

						Impact value = 2			

3. Exotic-dominated Juncus wetland

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time till endpoint)	Measure after offset justification	Measure prior to and after Offset + impact value	Management regime to achieve measure after offset	Overall impact area/Offset area (ha)	Attribute Net Present Biodiversity Value
Canopy	Canopy vegetation percentage indigenous cover (%)	99	Wetland is assumed to have high indigenous canopy cover with some gaps.	80 (after 10 years)	80% canopy cover after 5 years is a standard and achievable performance target for new plantings. Assumes 10% cover of indigenous plants at offset sites.	Prior = 10% After offset = 80% Impact value = 20%	Planting, weed control and fencing.	Impact area = 0.13 Offset area = 0.2	0.07

Canopy height	Indigenous vegetation canopy height	30	Kahikatea typically reach up to 30 m in height (Tane's Tree Trust, n.d.).	2 (after 10 years)	Kahikatea grows between 10 and 70 cm per annum (Tane's Tree Trust, n.d.). Conservative estimate of 2 m after 10 years used. Other wetland species planted are also expected to reach 2 m after 10 years such as Juncus edgariae and Machaerina juncea.	Prior = 0.3 cm After offset = 2 m Impact value = 0.4 m	Planting, weed control and fencing.		0.01
Diversity	Species richness of vascular plants	44	Miller (2004) found 37 to 44 species per 500 m^2 in floodplain kahikatea forest plots in south Westland, New Zealand.	10 (after 10 years)	Assuming planting into wetland with five indigenous species already present (e.g. Juncus edgariae and Isolepis cernua). Conservatively assumes planting 5 wetland species.	Prior = 5 After offset = 10 Impact value = 1	Planting, weed control and fencing.		0.01
	Habitat intactness	6	Benchmark richness includes a full suite of wetland habitat characteristics. Complexity includes an indigenous turf, rush and tree tier, stock exclusion, open water and wetland buffer planting.	4 (after 10 years)	Fenced from stock, turf tier, rush tier and buffer plantings.	Prior = 2 After offset = 4 Impact value = 1	Planting, weed control and fencing.		0.02

4. Isolepis turf wetland

Biodiversity Component	Biodiversity Attribute	Benchmark	Benchmark justification	Measure after offset (time till endpoint)	Measure after offset justification	Measure prior to and after Offset + impact value	Management regime to achieve measure after offset	Overall impact area/Offset area (ha)	Attribute Net Present Biodiversity Value
Canopy	Canopy vegetation percentage indigenous cover (%)	99	Wetland is assumed to have high indigenous canopy cover with some gaps.	80 (after 10 years)	80% canopy cover after 5 years is a standard and achievable performance target for new plantings. Assumes 10% cover of indigenous plants at offset sites.	Prior = 10% After offset = 80% Impact value = 60%	Planting, weed control and fencing.	Impact area = 0.005 Offset area = 0.03	0.01
Canopy height	Indigenous vegetation canopy height	30	Kahikatea typically reach up to 30 m in height (Tane's Tree Trust, n.d.).	2 (after 10 years)	Kahikatea grows between 10 and 70 cm per annum (Tane's Tree Trust, n.d.). Conservative estimate of 2 m after 10 years used. Other wetland species planted are also expected to reach 2 m after 10 years such as Juncus edgariae and Machaerina juncea.	Prior = 0.3 m After offset = 2 m Impact value = 0.1 m	Planting, weed control and fencing.		0.00
Diversity	Species richness of vascular plants	44	Miller (2004) found 37 to 44 species per 500 m^2 in floodplain kahikatea forest plots in south Westland, New Zealand.	10 (after 10 years)	Assuming planting into wetland with five indigenous species already present (e.g. Juncus edgariae and Isolepis cernua). Conservatively assumes planting 5 wetland species.	Prior = 5 After offset = 10	Planting, weed control and fencing.		0.00

						Impact value = 1			
	Habitat intactness	6	Benchmark richness includes a full suite of wetland habitat characteristics. Complexity includes an indigenous turf, rush and tree tier, stock exclusion, open water and wetland buffer planting.	4 (after 10 years)	Fenced from stock, turf tier, rush tier and buffer plantings.	Prior = 2 After offset = 4 Impact value = 1	Planting, weed control and fencing.		0.01

References

de Lange, P.J. (2020). Schoenoplectus tabernaemontani. Fact Sheet (content continuously updated). New Zealand Plant Conservation Network. https://www.nzpcn.org.nz/flora/species/Schoenoplectus-tabernaemontani/ (accessed on 16 November 2020)

Miller, C. J., Norton, D. A., & Miller, T. K. (2004). Kahikatea and totara-matai forest patches in the agricultural landscape, Westland, New Zealand: representatives of a past and future condition. Pacific Conservation Biology, 9, 278-293.

Nicol, J., Gehrig, S., Frahn, K (2015). Establishment success and benefits to the aquatic plant community of planting Schoenoplectus tabernaemontani around the shorelines of lakes Alexandria and Albert – 2015. South Australian Research & Development. PIRSA.

Tane’s Tree Trust (n.d.). Kahikatea (Dacrycarpus dacrydioides). https://www.tanestrees.org.nz/species-profiles/kahikatea/ (accessed on 24 November 2020)