Appendix F. Ecological Assessment Report

PUHOI STOUR

Aratapu Water Storage Reservoir

Assessment of Ecological Effects

12 August 2020

puhoistour.co.nz

Aratapu Water Storage Reservoir – Assessment of Ecological Effects

Prepared by Puhoi Stour Ltd in association with Tonkin & Taylor Ltd.

Sam Heggie-Grace,

Alicia Wong,

Justine Quinn,

Josh Markham,

Trevor Connolly,

Martin Neale.

Document History

PSL Report Number 2020/10

Version	Date	Reviewed by
Draft for PSL review	04/08/2020	Martin Neale
Final	12/08/2020	Martin Neale

Table of Contents

Table of Contents 4
1. Introduction 6
2. Site description 6
3. Methods 7
3.1 Desktop assessment 7
3.2 Freshwater values assessment 8
3.2.1 Stream classifications 8
3.2.2 Macroinvertebrates 8
3.2.3 Fish 9
3.2.4 Stream ecological valuation 9
3.3 Terrestrial values assessment 10
3.3.1 Ecosystem types 10
3.3.2 Bats 11
3.3.3 Birds 11
3.3.4 Herpetofauna 11
3.3.5 Invertebrates 12
3.4 Assessment of effects 12
4. Freshwater ecological assessment 12
4.1 Freshwater values 12
4.1.1 Stream classification and values 12
4.1.2 Macroinvertebrates 13
4.1.3 Freshwater fauna 13
4.2 Assessment of ecological effects - freshwater 14
4.2.1 Sedimentation during construction 14
4.2.2 Injury or mortality of freshwater fauna 15
4.2.3 Fish passage 15
4.2.4 Permanent modification of stream habitat 16
4.2.5 Downstream water quality effects 18
4.2.6 Downstream habitat effects 19

5. Terrestrial and wetland ecological assessment 19
5.1 Terrestrial ecological values 19
5.1.1 Mamaku treeland 20
5.1.2 Pine forest 20
5.1.3 Mānuka, gumland, *Machaerina* scrub sedgeland (WL1) 21
5.1.4 *Machaerina*-dominated wetland 21
5.1.4 Kutakuta-*Isolepis* wetland 21
5.1.5 Raupō reedland (WL19) 22
5.1.6 *Isolepis*-dominated turf wetland 22
5.1.7 Pampas-dominated wetland 22
5.1.8 Exotic-dominated pasture wetland 22
5.1.9 Bats 22
5.1.10 Avifauna 23
5.1.11 Herpetofauna 23
5.1.12 Invertebrates 24
5.2 Assessment of ecological effects - terrestrial 24
5.2.1 Vegetation effects 24
5.2.2 Fauna effects 26
6. Recommendations to manage effects 30
7. Report applicability 32
8. Appendices 33
Appendix A Ecological values and sampling locations across K13 34
Appendix B EIANZ ecological impact assessment guidelines 36
Appendix C SEV cross-section photographs 40
Appendix D Macroinvertebrate sample results 43
Appendix E SEV modelling assumptions 44
Appendix F Species lists 46
Appendix G BOAM justifications table 48
Appendix H Terrestrial and wetland ecosystem photographs 56

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 (Aratapu Creek Water Supply Reservoir) off West Coast Road, Te Kopuru, Dargaville 0371, in the Kaipara District.

In brief, the applicant proposes to construct a new water supply reservoir, by constructing a dam across the Aratapu Creek, and inundating a section of the Aratapu Creek, including headwaters, and surrounding land. The construction and ongoing operation of the water supply dam is anticipated to have the following effects on ecological values:

- Construction effects relating to earthworks and works within the bed of a stream or wetland.
- Direct and indirect effects on freshwater fauna.
- Ongoing effects on fish passage.
- Downstream effects on water quality and quantity.
- Loss of 2,317 m permanent stream (~2,939 m2 streambed area) and 677 m intermittent stream (~366 m2 streambed area).
- Loss of 3.8 ha wetland habitat comprising mānuka, gumland *Machaerina* scrub/sedgeland (WL1), *Machaerina,* Eleocharis wetland, raupō reedlands (WL19), *Isolepis*-dominated wetlands, pampas-dominated wetland and an additional 1.44 ha of exotic dominated pasture wetlands and 0.075 ha of open water.
- Removal of 0.62 ha mamaku treeland and a further 0.82 ha pine and wattle forest.
- Direct and indirect effects on terrestrial fauna, potentially including bats, birds, and 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. Recommendations are made to further offset or compensate residual adverse effects that cannot be otherwise avoided, remedied, or mitigated.

This report builds on work previously undertaken by PSL and T+T to inform the development of an ecological opportunities and constraints report and findings from that assessment are included within this assessment where appropriate.

2. Site description

The proposed Aratapu Water Supply Reservoir site is located off West Coast Road, between Te Kopuru and Glinks Gully in the Kaipara District, Northland (Figure 1). Located in the Kaipara Ecological District (ED) (Northland Conservancy), the proposed reservoir is approximately 2 km from the west coast and 5 km from Wairoa River to the east. There are no mapped areas of significance in the site, however, the site is located in close proximity to Pouto Priority 1 Waiora Northland Priority Catchment Area, a shallow water wetland (PNAP P08/212) within 1 km to the west, the Upper Aratapu Creek shrubland (PNAP P08/062), located 2 km north of the site, and fragments of WF10 Kauri forest, WF11 Kauri, podocarp, broadleaved forest, and WL1 Manuka, gumland, *Machaerina* scrub/sedgeland. Historically, vegetative cover in the area would have consisted of kauri, podocarp, broadleaved forest, and dune forest comprised of tōtara, kānuka, broadleaf forest intermixed with areas of mānuka gumland. Much of the indigenous forest in the ED has been cleared for the purposes of farming and forestry, resulting in a fragmented landscape.

The site is dominated by perch-gley (UP) utlic soils that is characteristic of strong weathering, leaching, and is typically acidic. The site is classified as a lowland area. Currently, the site is an operational dairy farm and current modification of the landscape is typical of agricultural land use. The site is in the headwaters of the Aratapu Creek, which discharges into the Wairoa River approximately 5 km to the east of the site, and the Kaipara Harbour.

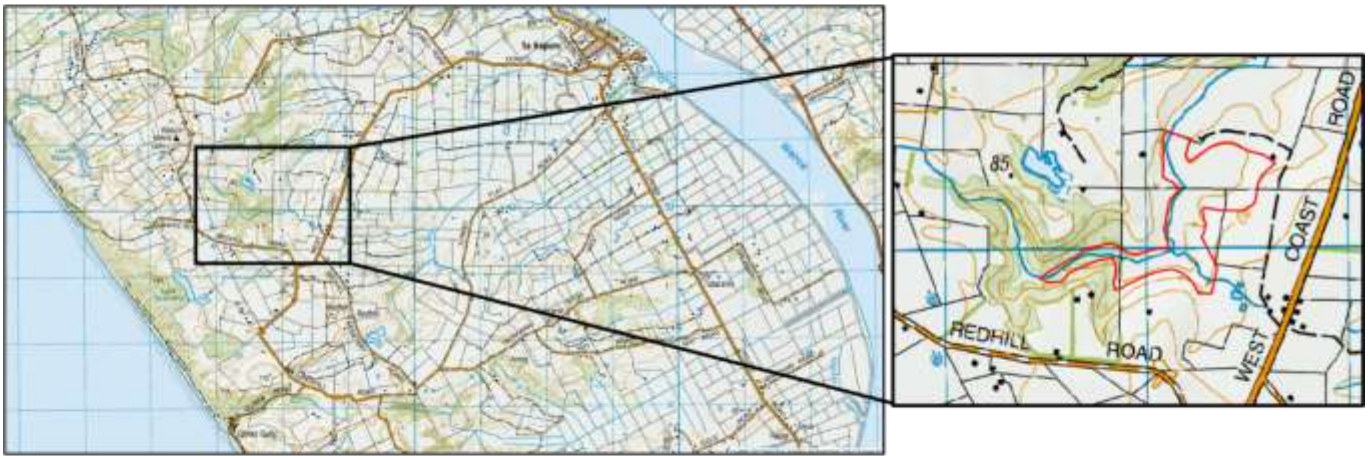


Figure 1: Location of proposed reservoir (in red outline) off West Coast Road, Te Kopuru.

3. Methods

An assessment of this site (referred to as K13) has been undertaken in two stages.

The first was a site visit on 27 and 28 May 2020 to assess the presence of any threatened freshwater and terrestrial species and/or habitats in the proposed reservoir development. This assessment was limited to the proposed reservoir footprint and informed the development of an opportunity and constraints assessment report. Two additional nearby sites, K10 and K17 were also investigated at this time.

A second site visit to K13 was undertaken on 13, 14 and 15 July 2020 to inform a more detailed assessment of ecological effects including a more comprehensive terrestrial assessment.

The details of both site assessments are included in the following sections and all sampling sites are shown in Appendix A.

3.1 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 the wider Aratapu Creek and lower Wairoa River catchment;
- Proposed Regional Plan for Northland, Appeals Version – June 2020;
- Northland Regional Council biodiversity wetlands online map;
- Natural areas of Kaipara Ecological District (Northland Conservancy), Reconnaissance survey report for the Protected Natural Areas Programme, dated 2009;
- Department of Conservation, a classification of New Zealand's terrestrial ecosystems, dated 2014;
- Department of Conservation (2004). Wetland Types in New Zealand.
- Manaaki Whenua Landcare Research Soil Portal;

- NIWA, New Zealand fish passage guidelines, dated 2018; and
- Other primary literature sources.

3.2 Freshwater values assessment

3.2.1 Stream classifications

An initial site walkover was conducted in May 2020 to assess the presence of any At Risk or Threatened freshwater species according the current threat rankings published by DOC and habitats within the proposed reservoir development. At this time, the stream tributaries were walked to assess the presence and extent of aquatic habitat.

During the July 2020 site visit, all streams on site were classified in accordance with the definitions of intermittently/flowing river or stream set out in the Proposed Regional Plan for Northland. Heavy rain had fallen in the 48 hours prior to our site visit.

3.2.2 Macroinvertebrates

A single standard macroinvertebrate (kick net) sample was collected in May 2020 in the mid reaches of the site upstream of an existing farm race in accordance with a soft-bottom semi-quantitative protocol (C2). The habitat sampled included macrophytes and a small amount of overhanging vegetation. A small amount of woody debris was also sampled. There was no riparian vegetation at the sample location.

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[1].

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

[1] 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.

3.2.3 Fish

Trapping was undertaken on two separate occasions, initially in May 2020 in the mid reaches of the site then followed by another survey in July 2020 in the headwaters.

In May 2020, un-baited gee minnow traps (GMT) (*n* = 6) were deployed around in the main channels in the footprint of the proposed reservoir and fyke nets (*n* = 3) were placed in the channels in the lower reaches of the proposed reservoir. Traps were left overnight on 27 May and retrieved during the morning of 28 May.

Further fish surveys were undertaken in July 2020, un-baited GMT (*n* = 8) were deployed in the headwaters of the main channel and tributaries; 5 of which were left overnight on 13 July and retrieved during the morning of 14 July, while 3 were left overnight on 14 July and collected on 15 July. Un-baited fyke nets (*n* = 2) were deployed in the mid reaches of the site, left overnight on 13 July, and retrieved during the morning of 14 July. Stream survey locations were selected based on presence of suitable stream habitat and sufficient water depth.

3.2.4 Stream ecological valuation

The stream ecological valuation (SEV) method was used to assess the aquatic ecological function of streams in the proposed reservoir using the methods described in Storey et al. (2011), Neale et al. (2011), and Neale et al. (2016)[2].

Two representative SEV reaches were selected based on the expected impact location (along the main channel [Watercourse 1] and a side tributary [Watercourse 1A]). Both SEV reaches assessed were ~100 m in length.

The method involves assessing physical characteristics at a reach scale, involving transects and whole of reach parameters. These data are supplemented with 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.

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

[2] 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.

› Fish spawning habitat
› Habitat for aquatic fauna
Biodiversity Provision Functions
› Fish fauna intact
› Invertebrate fauna intact
› Riparian vegetation intact

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 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.

3.3 Terrestrial values assessment

3.3.1 Ecosystem types

A site walkover was undertaken on 13, 14 and 15 July 2020 to survey and describe terrestrial ecological 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 DOC[3]. Terrestrial and wetland ecosystems were assessed and classified according to Singers & Rogers (2014)[4] where the habitat remained intact, and in accordance with the Proposed Regional Plan definitions[5] and criteria set out in Appendix 5 of the Regional Policy Statement for Northland.

Modified 10 x 10 m RECCE[6] plots were undertaken to measure vegetation characteristics to inform offset modelling. RECCE plots involved delineating a 10 x 10 m area in each habitat type and recording:

- Canopy height (m)
- Canopy cover (%)
- Diameter at Breast Height (DBH) for all woody vegetation over 2.5 cm DBH
- Indigenous plant diversity (no. of species per 100 m2)

The RECCE plots were undertaken in distinct ecosystem types listed below:

- Mānuka, gumland, Machaerina scrub/sedgeland (WL1);
- Machaerina-dominated wetland;

[3] 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/
[4] Singers, N. J., & Rogers, G. M. (2014). *A classification of New Zealand's terrestrial ecosystems*. Department of Conservation.
[5] The definitions relating to wetlands are currently under appeal, however considered appropriate for this assessment.
[6] Hurst, J. M., & Allen, R. B. (2007). *The recce method for describing New Zealand vegetation – field protocols*. Landcare Research.

- Kutakuta-*Isolepis* wetland; and
- *Isolepis*-dominated turf wetland.

Furthermore, offset model parameters for raupō reedland and pampas wetland were developed through site visit observations as these ecosystems effectively constituted monocultures of raupō and pampas, respectively. Attributes measured to use in biodiversity offset models included indigenous species cover, indigenous species richness, vegetation height, and basal area where woody vegetation was present.

3.3.2 Bats

Long-tailed bats (*Chalinolobus tuberculatus*; 'Threatened – Nationally Critical'[7]) are highly mobile and utilise a variety of ecosystems for foraging and roosting, including exotic vegetation such as pine and wattle. Long-tailed bats have previously been detected within 50 km of the Project footprint[8].

Potential bat foraging, commuting and roosting habitat was assessed across the proposed footprint during a site visit in May 2020. Potential bat roost habitat comprised trees greater than 15 cm diameter at breast height (DBH) and with any of the following characteristics:

- Cavities, cracks and crevices;
- Epiphytes, especially perching epiphytes; and/or
- Flaky and peeling bark.

Acoustic survey using Automated Bat Monitors (ABMs) would ordinarily be undertaken in order to detect the presence of long-tailed bats on site. However acoustic survey should only be undertaken during warmer months (October to April inclusive) when bats are more mobile. The site visit took place outside this period, and therefore acoustic survey was not undertaken.

3.3.3 Birds

To assess avifauna composition across the site, all incidental bird observations (seen or heard) were recorded during site visits on 13, 14, and 15 July.

Targeted wetland bird surveys were not undertaken due to seasonal constraints, as surveying for wetland birds should be undertaken during peak wetland bird breeding season when birds are more active and detectable due to increased call rates (October to February inclusive).

It is unlikely that North Island brown kiwi (*Apteryx mantelli*) would be present on site, as determined through a review of Northland kiwi distributions[9]. Therefore no further surveys were undertaken.

3.3.4 Herpetofauna

Potential herpetofauna (gecko and skink) habitat was identified and mapped, with potential lizard characteristics assessed as any of the following:

- Rank grass;
- Coarse woody debris;
- Deep leaf litter;
- Exotic vegetation, particularly pampas present on dry ground; and
- Native vegetation (including potential mature, secondary, and regenerating vegetation).

---

[7] 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.
[8] Sourced from Department of Conservation National Bat Database
[9] Kiwis for Kiwi (2016). North Island Brown Kiwi Estimated distribution 2016.

Due to the site visit being undertaken during winter, spotlighting for geckos and manual searching for skinks was not undertaken. Lizard searches are best undertaken between October and April (inclusive).

3.3.5 Invertebrates

Kauri snails, which are protected by the Wildlife Act 1953, have been considered to potentially occur in Kaipara ED, although to date none have been found. Potential kauri snail (*Powelliphanta* spp.) habitat was assessed by identifying potential areas of deep leaf litter, fern skirts and logs, particularly where indigenous forest is present.

3.4 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)[10].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;
- 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,
- 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.

4. Freshwater ecological assessment

4.1 Freshwater values

4.1.1 Stream classification and values

The site is in the Aratapu Creek catchment and characterised by highly modified deepened and straightened channels along paddock edges and base of slopes.

Two main stems are classified as continuously flowing permanent streams situated along the centre of the proposed reservoir. There are several small tributaries from the main stems throughout the site (shown in Appendix A). Most of the tributaries are located fully within the proposed reservoir or are fed by farm ponds just outside the proposed reservoir footprint. Shallow water was present in the narrow tributaries, therefore these were classified as intermittent given the likelihood of becoming periodically dry over summer.

The main permanent channels were on average 1.3 m wide and had a depth of 0.2 m. The intermittent tributaries were on average 0.54 m wide and had a depth of 0.04 m. For both permanent and intermittent tributaries, the streambed was dominated

[10] 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.

by fine sediments and instream habitat was limited to macrophytes. Large clumps of green filamentous algae were collected in the fish nets and traps in May, which is an indication of nutrient enrichment in the channels.

Stream channels traversed through paddocks and intact vegetation was absent along most of the stream margins. Some channels in the upper catchment had dense pampas clusters growing on the streambed and banks. Where pampas dominated, the stream channel was shaded but often became moist or dry. While most of the channels were fenced from stock by a single hot-wire, the fences were erected <1 m setback from the edge of the channel which is a very small setback. The main permanent channels flow out of a large wetland complex and reappears as an online channel in the wetland in two short sections upstream of where farm access tracks intersect. The culverts upstream and in the mid-section of the wetland complex are not perched and therefore do not appear to be barriers to fish passage.

Stream ecological valuations were undertaken on stream reaches considered to be representative of the remainder of the reaches on site. The main permanent stream channel (Watercourse 1) and the intermittent tributary (Watercourse 1A) have low current ecological value, with SEV scores of 0.31 and 0.31, respectively. 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, and low fish and macroinvertebrate biodiversity.

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

4.1.2 Macroinvertebrates

Eleven invertebrate taxa were recorded from a kick sample collected from the main permanent stream channel (Watercourse 1). The invertebrate community sample indicate poor quality class with a MCI-sb value of 63 and a QMCI-sb value of 2.4. No sensitive EPT taxa were recorded, and the sample was dominated (85%) by *Potamopyrgus* snails which have high tolerance to polluted waters.

The summary statistics for the sample collected in this survey are provided in Table 3, with full taxa list provided in Appendix D.

Table 3: Summary statistics for macroinvertebrates collected from Watercourse 1, in the proposed K13 reservoir footprint (May 2020).

Site name	Taxa richness	EPT richness	Number of individuals	MCI-sb value	MCI-sb class	QMCI-sb value	QMCI-sb class
Watercourse 1	11	0	1052	68	Poor	2.4	Poor

4.1.3 Freshwater fauna

During the initial fish survey in May 2020, six shortfin eels ranging in size from 200 mm to 700 mm were recorded from one fyke net in the eastern arm of the proposed reservoir (Table 4). The channel had been cleared at this location and in-stream habitat features were minimal. Gambusia (*Gambusia affinis*), an introduced pest fish species, were abundant in this same location, and less prevalent in the remainder of the sites.

Two elver and one adult inanga (*Galaxias maculatus*, At Risk - Declining) were recorded in the channels near the propose dam face. Inanga are a migratory species but they are poor swimmers, meaning their distribution is often affected by the presence of in-stream barriers such as waterfalls, perched culverts, weirs, or tide gates. Their presence at the site indicates that there are no substantial barriers to fish passage in the reaches downstream. When including these species in the index of biological integrity (IBI), a score of 22 is returned, indicative of 'poor' IBI.

No fish were caught across all fykes (n = 2) and GMT (n = 8) deployed during the second fish survey in July 2020.

A desktop review, using the NZFFD, of streams in the Aratapu catchment and the Wairoa River was carried out. In addition to the fish species caught during our fish survey, catfish (*Ameiurus nebulosus*) (introduced pest fish species) had also been recorded downstream and outside the proposed reservoir footprint. A diverse range of fish species have been recorded in the Wairoa River, including banded kōkopu (*Galaxias fasciatus*), common bullies (*Gobiomorphus cotidianus*), and redfin bullies (*Gobiomorphus huttoni*). It is likely that these species may use the stream network on site.

The presence of 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 habits of indigenous fauna'.

Table 4: Freshwater fauna recorded within the proposed K13 reservoir footprint, survey methods, and threat statutes (including sampling undertaken in May and July 2020).

Common name	Scientific name	Gee-minnow (GMT)	Fyke net	Threat status[10, 11]	Ecological value[12]
Shortfin eel	*Anguilla australis*		6	Not threatened	Moderate
Inanga	*Galaxias maculatus*	1		At Risk - Declining	High
Elver	-	2		-	-
Gambusia	*Gambusia affinis*		abundant	Pest	-

4.2 Assessment of ecological effects - freshwater

4.2.1 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 shortfin eels) are tolerant of elevated suspended sediment, measured either by turbid water or high concentrations of total suspended solids ("TSS")[13].

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 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 affected streams are highly modified and degraded by historical and ongoing agricultural land-use. Bubbling and odours were present when streambed substrates were disturbed. This indicates streams on site were heavily laden with fine anaerobic sediment.

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. 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.

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).

[11] Dunn, N. R., Allibone, R. M., Clos, 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.
[12] 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.
[13] 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.

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 a moderate ecological value due to the existing high sediment loading on the streambed and macroinvertebrate fauna present. However, inanga are present on site and because they are classified as At Risk – Declining the activity is considered to have a potential effect on freshwater fauna with a **high** ecological value. The magnitude of effects of 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 a **low** level.

4.2.2 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 without salvage. Provided the reservoir is not filled too rapidly we expect fauna within the site to find suitable habitat unaided but should be considered further in the Freshwater Fauna Relocation Plan (FFRP). Eels and inanga are also known to inhabit lakes and inanga can often be seen shoaling in open water. The creation of a reservoir is likely to result in an increase in the area of aquatic habitat.

We recommend a Freshwater Fauna Relocation Plan (FFRP) is prepared as part of the reservoir construction methodology to minimise losses during streamworks and reservoir filling.

Inanga 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 were 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 FFRP 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**.

4.2.3 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[14]. 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. Providing passage is important to realising the compensatory replacement of stream habitat for eels with lake habitat in the reservoir.

[14] 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.

Eels and inanga are present in the streams on site, however other native fish species recorded in the Wairoa River may also inhabit the stream network on site. Eels and inanga are catadromous in that they live in freshwater but migrate to sea (or estuarine waters) to spawn, with juveniles returning to freshwater. Shortfin eels are accomplished climbers and are well adapted to negotiating barriers to reach catchment headwaters, therefore will be mostly unaffected by the construction of the dam. Other native fish species (banded kōkopu and redfin bullies) that may inhabit the site are also considered good climbers. Inanga, however, cannot climb and instead burst swim to overcome small barriers. Their presence in the downstream extent of the site suggests that there are currently no significant fish barriers downstream.

Neither eels or inanga were observed in the upper headwater reaches on site suggesting the online wetlands may be natural barriers to their upstream movements. The provision of fish passage (upstream and downstream) into the proposed reservoir is recommended for eels to enable eels to access the habitat within the reservoir. An elver pass could be constructed up the face of the dam. If this was 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.

We recommend 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. We do not recommend fish passage is 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.

While the fauna present, or expected to be present, are typically not threatened, inanga are classified as At Risk – Declining, meaning that the potentially affected fauna are of **high** ecological value. Inanga are naturally lowland species that inhabit gentle streams near the coast and were only found in the downstream extent of the site. That is, modification of access to the headwaters will not affect their lifecycle. In respect of eels, only a small section of Watercourse 1 will remain upstream of the reservoir, therefore, the magnitude of the effect caused by impeding fish passage is considered **low**. This would result in an overall level of effect of **low,** but further dam design to incorporate eel passage is recommended to contribute to the compensation package resulting from stream habitat loss.

4.2.4 Permanent modification of stream habitat

The proposed reservoir will inundate the gully system resulting in modification of 2,317 m (~2,939 m^2 streambed area) continually flowing permanent stream and 677 m (~366 m^2 streambed area) of intermittently flowing stream. This will impact the main stems and tributaries across the site, as well as connected wetland complexes online of the main stem; assessed in further detail in section 5.

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 **moderate** ecological value based on a combination of the highly modified nature, poor macroinvertebrate community (MCI-sb) scores, poor fish community (IBI scores) even with the presence of inanga, and stream function SEV scores. 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**.

4.2.4.1 Restoration length 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 the SEV scores.

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 4 presents the summary SEV scores for the current (SEVi-C) and potential (SEVi-P) values for the impact permanent and intermittent reaches, Watercourse 1 and Watercourse 1A, respectively. All other streams on site are similar in their characteristics, and so the SEV data collected for Watercourse 1 is representative of permanent channels and Watercourse 1A is representative of 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 models for potential SEV scores for both Watercourse 1 and Watercourse 1A is 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 all of the fish and macroinvertebrate species observed in Watercourse 1 and so it provides some functional value.

Table 4: Actual and modelled stream ecological valuation results used to determine the estimated ECR.

Stream ID	SEVi-C	SEVi-P	SEVi-I	SEVm-C[15]	SEVm-P[15]
Watercourse 1 (permanent reach)	0.31	0.68	0.2	0.31	0.68
Watercourse 1A (intermittent reach)	0.31	0.65	0.2	0.31	0.65

A total area of 3,304 m^2 streambed area will be impacted by the reservoir along 2,317 m of permanent and 677 m of intermittent stream. While an offset planting location(s) has not yet been identified and confirmed, hypothetical SEVm-C and SEVm-P scores (being the actual measured SEV scores from site) have been used to estimate the quantum of stream offset required to achieve no net loss of ecological function. Based on the hypothetical SEV values in Table 5, an estimated ECR of 1.95 for permanent channels and 1.98 for intermittent channels is calculated, which means approximately 5,717 m^2 and 725 m^2 (collectively 6,443 m^2) of similar permanent and intermittent streambed area habitat enhancement in nearby catchments in Te Kopuru is required to achieve no net loss of ecological function. The ECR could be closer to 3 to 5 if streams in nearby catchments differ in stream functions from that surveyed-on site and SEV gains are less. Consequently, the quantum of streambed area required will increase accordingly to achieve no net loss of ecological function.

Once offset stream locations have been identified, the SEV scores from the offset streams and ECR calculations will need to be updated to determine the quantum of riparian enhancement required to achieve no net loss ecological function, it is considered that the effects associated with habitat modification can be offset using the SEV and ECR methodology. While the offset

[15] SEVm-C and SEVm-P scores are hypothetical scores as offset locations have yet to be identified and the impact reaches are assumed to be same in nearby streams in the Aratapu catchment.

quantum are currently estimations, we would expect similar SEV scores for streams in the same catchment due to similar modification and agricultural land-use practices observed on satellite imagery, therefore similar offset requirements.

The recommended offset requirements are considered positive effects but cannot contribute to reducing the magnitude of adverse effect, and so the magnitude of effects remains the same and subsequently the overall level of effects remain **high**. Notwithstanding, the proposed offset package measures outlined above are recommended to be consistent with biodiversity offsetting principles.

A Stream Offset and Compensation Enhancement Planting Plan (SOCEP) is recommended to identify the location(s) of the proposed planting, updated offset SEV scores and ECR calculations, species list, size, spacing, and weed maintenance programme to support the establishment of plantings.

Table 5: Estimated ECR's and offset areas required to achieve no net loss of ecological function for the reclamation of permanent and intermittent channels across the proposed K13 reservoir footprint.

Impact Sites Stream ID	SEVi-C	SEVi-P	Average width (m)	Length (m)	Streambed area (m2)	Stream ID	ECR	Streambed area compensation required (m2)
Permanent channels	0.31	0.20	1.27	2,317	**2938.0**	**Similar permanent channels**	1.95	**5717.1**
Intermittent channels	0.31	0.20	0.54	677	**365.6**	**Similar intermittent channels**	1.98	**725.5**
Totals				**2,994**	**3,303.5**			**6442.6**

4.2.5 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. Native fauna downstream of the reservoir are likely to be more impacted by increases in water temperatures than decreases, and warmer stream temperatures will likely benefit the introduced gambusia recorded in the downstream sections of the proposed reservoir footprint. Subject to the reservoir outlet being from deeper water, we consider the effect on 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.

The stream habitat is considered to have a **moderate** ecological value due to the highly modified nature, heavy loading of fine sediment, and dominance of macrophytes. 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.

4.2.6 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[16]. The magnitude of this effect is difficult to predict, but due to the relatively small size of the catchment, may be relatively small. To minimise these impacts, it is recommended that the design of the reservoir consider facilities to allow sediment flushing to occur.

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, but minimum flows will be maintained through the dam outflow. However, flushing flows will be reduced. 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 gentle flow, given that the channels are highly modified and predominately uniform in depth and width. The freshwater community downstream of the reservoir is generally tolerant of changes in flow regimes, but environmental flow investigations are recommended to fully assess the effects of changes in flow regime.

The habitat downstream of the proposed reservoir was observed to be similar to that observed on site, characterised by modification, straightened and deepened channels, heavy loading of fine sediment, lack of riparian vegetation, and dominance of macrophytes. Therefore, the downstream habitat is considered to have a **moderate** ecological value. The magnitude of this impact and the overall level of effects is likely to be **low**, but further assessment will be required to determine the magnitude and therefore the overall level of effect.

5. Terrestrial and wetland ecological assessment

5.1 Terrestrial ecological values

The Project footprint primarily consists of pasture grass and pugged and grazed wet pasture, however natural high-value wetland habitat is present in the south-western corner of the proposed footprint. In this area terrestrial ecosystems are also present, consisting of native mamaku treeland and exotic pine forest.

Stock have access to all areas of the Project footprint, and therefore all habitats have been affected by grazing and/or pugging. Furthermore, substantial areas of pampas and to a lesser extent, gorse and Spanish heath have invaded areas of the south-western area of the footprint.

A 2.5 ha wetland complex is present at the south-western corner and upstream end of the proposed reservoir footprint. Due to the historic landforms (kauri forest) and topography of the area acidic soils and poor drainage have resulted in the formation of mānuka, gumland, *Machaerina* scrub sedgeland in the headwaters, which transitions to raupō reedland downstream. Areas of *Machaerina, Eleocharis* wetland are present downstream of the raupō reedland before a defined channel forms the main tributary which draws water into the main farm area. Some areas of this wetland complex have been severely compromised by invasion of pampas.

Despite formed channels increasing drainage on hill slopes around the main tributary in the headwaters of the Project footprint, drainage is poor, particularly on the south side of the main tributary, and areas of *Machaerina*, *Eleocharis-Isolepis* wetlands remain.

Outside of the south-west arm the proposed reservoir footprint has been heavily grazed, with the land cover consisting of pasture grasses and some grazed *Isolepis* in wetter areas.

[16] 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

Wetlands, regardless of ecological condition, are a nationally threatened ecosystem type, with 10% of the original wetland extent remaining nationally[17] and with freshwater wetlands compromising 7% of all indigenous habitats remaining in the Kaipara ED. Furthermore, mānuka gumlands are also considered a nationally critical ecosystem[18,19].

To be considered 'Significant' under the Proposed Regional Plan, 'wet heathland' must be greater than 0.2 ha, 'swamp' greater than 0.4 ha and 'marsh, fen, ephemeral wetland or seepage' greater than 0.05 ha. The ecological site comprises a wetland complex of 3.8 ha, including the south-western arm which is 2.5 ha. The wetland complex is comprised of connected sequences of the following wetland types, which collectively meet the 'Significant' criteria (Appendix A Figure 1):

- 'Wet heathland': mānuka, gumland, *Machaerina* scrub sedgeland (0.59 ha in Project footprint)
- 'Swamp': *Machaerina*, kutakuta-*Isolepis* and raupō complex (0.93 ha in Project footprint)
- 'Marsh, fen, ephemeral wetland or seepage': *Isolepis*-dominated turf wetland (1.42 ha in Project footprint;)

In regard to Threatened or At Risk plant species, only mānuka was observed which is classified as At Risk – declining[20] due to the potential threat of myrtle rust.

Species lists and photographs of each ecosystem type are presented in Appendix F and Appendix H respectively.

5.1.1 Mamaku treeland

Small areas of mamaku treeland border wetland areas at the south-western end of the Project footprint with a total extent of approximately 0.62 ha. Mamaku treelands are dominated by a mamaku canopy, with degraded understorey due to stock access, and weed invasion by pampas (*Cortaderia selloana*), gorse and pasture grass. Occasional mānuka (*Leptospermum scoparium*), hangehange (*Geniostomum ligustrifolium*), sword sedge (*Lepidosperma laterale*), and whekī (*Dicksonia squarrosa*) are present in the understorey, with basket grass (*Oplismenus hirtellus subsp. Hirtellus*) groundcover.

Overall, mamaku treelands are of **low** ecological value due to impacts from stock, pest plants and the low diversity of plants present.

5.1.2 Pine forest

Approximately 30 ha of pine forest borders the south-western boundary of the site, which surrounds the wetland complex in the gully floor (Appendix A Figure 1). Of this, approximately 0.82 ha of pine forest is within the Project footprint. Pine forest is dominated by mature exotic pine and is bordered by planted exotic wattle (*Acacia spp.*), with weeds and occasional native shrubs present within the understorey. The pine trees have an average DBH of 40 cm and a large proportion of trees assessed exhibit cracks, crevices and breakouts which may provide suitable roosting sites for long-tailed bats. Mature exotic wattle is also within the footprint, with DBH of approximately 30 cm, however with less flaky bark and cavities than the pine and of moderate quality for long-tailed bat roosting. An additional three individual pine trees are also present in the middle of the proposed footprint (Appendix A Figure 1) which also provide similar potential bat roost features.

Native species in the understorey of the pine forest include kumarahou (*Pomaderris kumarahou*), tauhinu (*Pomaderris amoena*), hangehange, and sword sedge.

For the purposes of this assessment we have conservatively assumed that long-tailed bats are present and therefore pine forest is classified as having **moderate** ecological value.

---

[17] Belliss, S, Shepherd, J, Newsome, P, & Dymond, J (2017). *An analysis of wetland loss between 2001/02 and 2015/16*. Landcare Research Contract Report LC2798 for the Ministry for the Environment

[18] 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.

[19] Wiser, S. K., Buxton, R. P., Clarkson, B. R., Hoare, R. J., Holdaway, R. J., Richardson, S. J., ... & Williams, P. A. (2013). New Zealand's naturally uncommon ecosystems. *Ecosystem services in New Zealand: conditions and trends. Manaaki Whenua Press, Lincoln*, 49-61.

[20] 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.

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 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 common native birds, provides some buffering to wetlands, and is of a relatively large size).

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

5.1.3 Mānuka, gumland, *Machaerina* scrub sedgeland (WL1)

Mānuka, gumland, *Machaerina* scrub sedgeland surrounds wetland extents at the south-western end of the Project footprint, on moderately drained substrates, forming a buffer between the pine forest and *Isolepis*-dominated wetland. This ecosystem type was wet during the site visit and is likely inundated during floods and constitutes 0.59 ha of the proposed reservoir footprint.

Mānuka is the dominant canopy species, with abundant tangle fern (*Gleichenia dicarpa*) in the understorey which is indicative of moderate rainfall and nutrient levels[21]. Occasional sword sedge, hangehange, karamu (*Coprosma robusta*), tussock swamp twig rush (*Machaerina* juncea), New Zealand lobelia (*Lobelia anceps*) and swamp kiokio (*Parablechnum minus*) are also present, however stock browse has reduced overall understorey species richness and abundance in this ecosystem.

Mānuka shrublands comprise 6% of remaining indigenous habitat in the ED[22] and are also considered a wetland system. Furthermore, gumlands are classified as a Critically Endangered ecosystem nationally, therefore this ecosystem is considered as having **very high** ecological value.

5.1.4 *Machaerina*-dominated wetland

Tussock swamp twig rush forms the dominant canopy species both downstream of the raupō reedland and on the southern banks of the main tributary present in the headwaters where drainage is moderate. It forms 0.62 ha of wetland habitat within the proposed reservoir footprint.

Isolepis prolifera and sharp spike sedge (*Eloecharis acuta*), are the predominant understorey species in this ecosystem type. Other species observed in these wetland areas include native swamp kiokio and swamp millet (*Isachne globosa*) and exotic Spansih heath (*Erica lusitanica*), pampas and grasses (*Paspallum urvillei* and *Anthoxanthum odoratum*).

All areas of this ecosystem type have been compromised by stock browse and trampling, and to a lesser extent, pest plants, primarily rank grass and pampas. No Threatened or At Risk plants were present in this habitat type.

Due to the indigenous dominance of this ecosystem, and as wetlands are a threatened ecosystem, this wetland extent is considered of **high** ecological value.

5.1.4 Kutakuta-*Isolepis* wetland

Kutakuta (*Eleocharis sphacelata*) is present south of the raupō reedland where drainage is poor. *Isolepis prolifera* forms the main understorey species, while occasional *Juncus effusus* and *Juncus prismatocarpus* are also present. This wetland area constitutes 0.14 ha of wetland habitat within the proposed reservoir footprint and has been damaged by minor stock browse and trampling.

[21] 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.

[22] Smale, M., Clarkson, B., Clarkson, B., Floyd, C., Cornes, T., Clarkson, F., ... & Briggs, C. (2009). Natural areas of Kaipara ecological district (Northland conservancy). *Reconnaissance Survey Report for the Protected Natural Areas Programme. Report prepared by Landcare Research New Zealand and The University of Waikato for Department of Conservation, Northland Conservancy*.

Kutakuta reedlands form just 0.2% of indigenous ecosystems in the ED, therefore due to the low proportion of this habitat type remaining, this area is considered to have **very high** ecological value.

5.1.5 Raupō reedland (WL19)

Approximately 0.17 ha of raupō reedland is present in the south-western wetland complex which is being severely impacted by pampas invasion. The raupō reedland consists of stands of raupō (*Thypha orientalis*), with *Isolepis prolifera* forming an understorey at the margins with overall low species richness. The raupō reedland is partially protected from stock impacts due to its dense form and propensity to establish in relatively deep water.

Raupō reedlands comprise 3% of indigenous ecosystems in the ED and therefore are considered as having **high** ecological value.

5.1.6 *Isolepis*-dominated turf wetland

A number of wetland seepages are present across the Project footprint, dominated by *Isolepis prolifera*, the largest of which sits in the south-western gully of the site, immediately surrounded by mānuka, gumland, *Machaerina*, scrub sedgeland and by pine forest on higher slopes. Additional species observed in these turfs include sharp spike sedge, slender clubrush (*Isolepis cernua* var. *cernua*), and *Juncus prismatocarpus*. Overall *Isolepis*-dominated turf wetlands constitute 1.42 ha of the proposed reservoir footprint.

These wetlands are compromised by stock browse and some pest plant invasion, primarily rank grass as well as water starwort (*Callitriche stagnalis*) and watercress (*Nasturtium officinale*).

Due to their degraded nature, these wetlands are considered of **moderate** ecological value.

5.1.7 Pampas-dominated wetland

The south-western wetland complex has been severely compromised by pampas, which now forms extensive monoculture stands over wetland areas covering approximately 0.86 ha of wetland ecosystem.

Wetlands, regardless of condition, are a nationally threatened ecosystem type, therefore pampas-dominated wetland is considered to have **moderate** ecological value, despite its degraded state.

5.1.8 Exotic-dominated pasture wetland

Exotic-dominated pasture wetlands are common throughout the proposed reservoir footprint and primarily consist of rank grass and soft rush (*Juncus effusus*). Occasional native giant rush (*Juncus pallidus*) is also present. This ecosystem type constitutes 1.44 ha of the overall footprint.

Under the Proposed Regional Plan for Northland pasture wetlands dominated by rushes are not considered a 'Natural Wetland' under Appendix H.6 of the proposed Regional Plan for Northland. Therefore, this ecosystem type is of **low** ecological value.

5.1.9 Bats

Potential roost habitat for long-tailed bats is present within the Project footprint within the pine forest, which includes many large trees with cracks and crevices suitable for roosting. Furthermore, linear features and a wetland gully corridor provide a suitable potential flyway of approximately 500 m within the pine, which may be used by bats for foraging. Pine forest is distributed patchily across the outlying landscape, and these patches may provide a series of stepping-stones of roosting and foraging habitat for long-tailed bats. Little mature indigenous vegetation remains however, and overall landscape connectivity is poor.

No acoustic long-tailed bat surveys have been undertaken within the footprint, and acoustic surveys are required to determine whether bats are present at this site. However for the purposes of this assessment we have conservatively assumed they are

PUHOI STOUR

present. Due to long-tailed bats having a conservation threat status of Threatened – Nationally Critical[23], this species is considered as having **very high** ecological value.

5.1.10 Avifauna

Overall, 22 bird species were identified during the site walkover and bird counts which included 10 native species (Appendix F). In general, the avifauna community was typical of farmland and pine forestry habitats. Indigenous birds included tūī (*Prosthemadera novaeseelandiae*), riroriro (*Gerygone igata*), pīwakawaka (*Rhipidura fuliginosa*), white-faced heron (*Egretta novaehollandiae*), welcome swallow (*Hirundo neoxena*), paradise shelduck (*Tadorna variegata*), spur-winged plover (*Vanellus miles novaehollandiae*), swamp harrier (*Circus approximans*), sacred kingfisher (*Todiramphus sanctus*), and silvereye (*Zosterops lateralis*). Of these, 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 throughout the area.

No Threatened or At Risk birds were observed during the site visit, however wetland habitats on site provide potential habitat for wetland birds including:

- Fernbird (Bowdleria punctata; At Risk – Declining[24])
- Spotless crake (Porzana tabuensis; At Risk - Declining);
- Marsh crake (Porzana pusilla; At Risk - Declining); and,
- Australasian bittern (Botaurus poiciloptilus; Threatened - Nationally Critical).

The site walkover was undertaken outside of peak wetland bird breeding season during which wetland birds are more conspicuous, and it is possible any of the above-listed birds were present but not detected. Wetland birds may also utilise the site intermittently, as part of a larger network of connected wetlands.

Australasian bittern were observed at potential water reservoir site K17 on 28 May 2020, approximately 6 km away from K13 and it is therefore assumed that Australasian bittern may intermittently forage along the farm drains and wetlands of the site. New Zealand pipit (Anthus novaeseelandiae; At Risk - Declining) may also intermittently access areas of pasture grass for foraging but were not observed during the site visit.

At Risk and Threatened avifauna are considered as having **high** and **very high** ecological value, respectively.

5.1.11 Herpetofauna

No herpetofauna were observed during the site visit; lizards are normally active during warmer months, October – April.

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[25] 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*). At Risk – Declining, At Risk – relict and Not Threatened herpetofauna are considered as having **high**, **moderate,** and **low** ecological values, respectively.

Skink habitat on site is considered marginal as coarse woody debris and leaf litter was sparsely distributed and of low quality, due to stock access to sites. Potential skink habitat on site is described as follows:

- Pampas skirts in drier areas provide moderate value potential copper skink habitat; and,
- Small areas of rank grass may be providing habitat for copper skinks.

---

[23] 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.
[24] 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
[25] 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.

In general, there was moderate-quality habitat for indigenous geckos. Identified gecko habitat includes the mānuka, gumland, *Machaerina* scrub sedgeland, where geckos may utilise the thick tangle fern wrapped around the trunks of mānuka trees for habitat.

The fragmented habitat with poor connectivity to large contiguous areas of forest and the presence of pest mammals on site reduces the likelihood of herpetofauna presence on site. If present, it is expected that herpetofauna will be in low abundance and are remnant populations.

5.1.12 Invertebrates

No habitat was identified as suitable for kauri snails.

5.2 Assessment of ecological effects - terrestrial

5.2.1 Vegetation effects

It is expected that all vegetation within the reservoir footprint will be removed. The total quantity of indigenous vegetation loss is 3.56 ha, with an additional 0.82 ha of pine forest, 0.86 ha of pampas-dominated wetland and 1.44 ha of wet pasture removal.

This includes a total of:

- 0.62 ha of mamaku treeland;
- 0.82 ha of exotic pine forestry, including 3 standalone trees on the farm;
- 0.59 ha of Mānuka, gumland, Machaerina scrub sedgeland (WL1);
- 0.62 ha of Machaerina– dominated wetland;
- 0.14 ha of kutakuta-*Isolepis*-dominated wetland;
- 0.17 ha of raupō reedland (WL19);
- 1.42 ha of *Isolepis* – dominated pasture wetland;
- 0.86 ha of pampas-dominated wetland removal; and,
- Rank grass and pasture removal, including 1.44 ha of exotic dominated wet pasture grass.

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

5.2.1.1 Magnitude and overall level of effect

Removal of 0.62 ha mamaku treeland is considered a **moderate** magnitude of effect for this habitat, as mamaku is a relatively common species and the quantum of this ecosystem being removed is small, however permanent removal of this vegetation is proposed. A **low** ecological value combined with a **moderate** magnitude of effect results in an overall **low** ecological effect.

Removal of 0.82 ha pine forest and standalone pine trees is considered a **moderate** magnitude of effect for this ecosystem, as pine is common in the wider landscape, however permanent removal of vegetation is proposed. A **moderate** ecological value with a **moderate** magnitude of effect results in an overall **moderate** ecological effect.

Removal of 0.59 ha mānuka, gumland, *Machaerina* scrub sedgeland wetland is considered a **high** magnitude effect due to the quantity of permanent wetland loss, and the rarity of this ecosystem type in the ED. A **very high** ecological value combined with **high** magnitude of effect results in a **very high** ecological effect.

Removal of 0.62 ha *Machaerina*-dominated wetland is considered a **high** magnitude effect due to the quantity of permanent wetland loss. A **high** ecological value combined with **high** magnitude of effect results in a **very high** ecological effect.

Removal of 0.17 ha of raupō reedland is considered a **high** magnitude effect due to the quantity of permanent wetland loss and the rarity of this ecosystem type in the ED. A **high** ecological value combined with **high** magnitude of effect results in a **very high** ecological effect.

Removal of 1.42 ha of *Isolepis*-dominated turf wetland is considered a **high** magnitude effect due to the quantity of permanent wetland loss. A **moderate** ecological value combined with **high** magnitude of effect results in a **moderate** ecological effect.

Removal of 0.86 ha of pampas-dominated wetland is considered a **high** magnitude effect due to the quantity of permanent wetland loss. A **moderate** ecological value combined with **high** magnitude of effect results in a **moderate** ecological effect.

Removal of 1.44 ha of exotic-dominated pasture wetland is considered a **high** magnitude effect due to the quantity of permanent wetland loss. A **low** ecological value combined with **high** magnitude of effect results in a **low** ecological effect.

5.2.1.2 Vegetation effects management

Ecosystem impacts resulting from vegetation removal can be offset and compensated through planting and enhancement of existing ecosystems which may be degraded. Such enhancement might include planting, pest control, and the provision of large coarse woody debris for indigenous fauna.

The construction of the reservoir will result in the creation of edge wetland habitat for wetland birds including Australasian bittern, fernbird, spotless crake, marsh crake and other native waterfowl.

Management plans will be required prior to construction in order to remedy, offset and compensate impacts to vegetation and habitats. The following management plans are recommended:

- Final terrestrial offset and compensation package, outlining the quantum of planting or other compensation measures required to account for the loss of terrestrial and wetland habitats, including the use of offsetting guidance (see Section 5.2.1.3). Offset and compensation is recommended to include restoration planting and habitat enhancement.
- The magnitude of offsetting and compensation required will include approximately 12.24 ha of wetland plantings as outlined in Section 5.2.1.3.
- Development of a Restoration Management Plan detailing the extents and areas for replanting, planting proportions and densities, planting specifications and maintenance regime.

5.2.1.3 Biodiversity accountancy offsetting model

The Biodiversity Offset Accounting Model[26] (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';
- 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 have used 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 model 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.

The biodiversity attributes and justifications for benchmark data inputs and expected offset biodiversity value has been used to determine terrestrial offsetting quantities. Data has been collected from the impact areas which enables the calculation of the impact values, however until an offset site has been identified, the offset model cannot be finalised. It is recommended that an offset site is identified which provides opportunity to enhance like for like habitat to those being impacted is used to inform BOAM parameters.

Biodiversity offsetting and compensation preliminary results

Offset models have been run using results from RECCE plots and the models have incorporated the attributes of vegetation height, canopy cover, Diameter at Breast Height (for woody ecosystem types, e.g. mānuka gumland) and native plant diversity

[26] 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

(no. of species per 100 m²). Benchmark values have been derived from the literature and are outlined in Appendix G. It was assumed plantings will be planted into damaged wetland systems, such as those browse by stock or affected by weeds.

Preliminary offset modelling suggests a total of 12.26 ha of wetland offset planting is required to achieve net gain for the offset model attributes, with associated fencing, weed control and pest control to ensure growth of new plantings (e.g. rabbits and hares) (Table 1). BOAMs were undertaken to ensure net positive values for each of the measured attributes.

Table 1 outlines the proposed offset and compensation amounts determined through preliminary modelling, which may change slightly subject to an assessment of potential offset areas. Offset areas for each ecosystem type will be replaced with like-for-like wetland revegetation or enhancement. For the pampas-dominated wetland, a trade-up in wetland condition is proposed, whereby offset and compensation wetland areas will be planted with mānuka gumland *Macaherina* scrub/sedgeland or raupō depending on water depth. All plantings will be set out in a manner that provides landscape connectivity and be undertaken in close proximity to the impact site.

Table 1: Table showing Net Present Biodiversity value (in green) for all attributes input into BOAMs, as well as the overall offset and compensation area required for Net Gain for each ecosystem type.

Ecosystem type / Biodiversity attribute	Mānuka gumland	Kutakuta	*Machaerina*	Raupō	*Isolepis*	Pampas wetland	**Total**
Indigenous canopy cover (%)	0.87	0.01	0.84	0.16	0.01	0.6	
Height (m)	0.01	0.02	0.02	0.01	0.12	0.04	
Basal area (m²/ha)	0.01						
Species richness	0.12	0.14	0.74	0.11	0.03	0.4	
Impact area (ha)	*0.59*	*0.14*	*0.62*	*0.17*	*1.42*	*0.86*	**3.8**
Offset area required for Net Gain (ha)	**5.25**	**0.26**	**2.7**	**0.45**	**1.8**	**1.8**	**12.26**

It may be possible to undertake benching around the proposed water reservoir to create suitable areas for wetland plantings. However, further site visits will be used to determine additional potential offsetting areas for each of the wetland types being affected. Once additional site visits have been undertaken, further RECCE plots at offset sites will provide additional data that will be used to update the assumptions in the offset models.

To offset and compensate for loss of mānuka gumland *Machaerina* scrub sedgeland, it is recommended that habitat upstream of the proposed footprint is enhanced and planted to restore existing habitat. This will potentially include stock-proof fencing, pest control and planting. Other potential offset and compensation areas will be explored in order to successfully offset this Critically Threatened ecosystem type.

5.2.1.4 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 values can be achieved.

5.2.2 Fauna effects

Without mitigation, vegetation removal can result in the injury or mortality of nesting birds, eggs and fledglings, roosting long-tailed bats and lizards. Injury and mortality can be minimised through following set vegetation removal protocols, particularly regarding seasonal constraints. Fauna Management Plans will be utilised to mitigate impacts to fauna on site and will be implemented prior to construction commencing.

Without mitigation, vegetation removal can result in the injury or mortality of nesting birds, eggs and fledglings, roosting long-tailed bats and lizards. Injury and mortality can be minimised through following set vegetation removal protocols, particularly regarding seasonal constraints. Fauna Management Plans will be utilised to mitigate impacts to fauna on site and will be implemented prior to construction commencing.

5.2.2.1 Magnitude and overall level of effect without management recommendations

The magnitude of effect of vegetation removal on long-tailed bats is considered **high** due to the extent of potential high value roost habitat loss and the potential for injury and mortality of bats during vegetation clearance. 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 other wetland birds of wetland removal is considered **high** due to the potential of injury or mortality to breeding birds, as well as habitat loss. A possible **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 more common in the landscape than wetland birds therefore the magnitude of effect is considered to be moderate. A **moderate** ecological value combined with a **moderate** magnitude of effect results in a **moderate** ecological effect on tūī. A **low** ecological value combined with a **moderate** magnitude of effect results in a **low** ecological effect on other native forest birds.

The magnitude of effect on New Zealand pipit of pasture grass removal is considered **low**, due to the loss of otherwise common pasture grass in the wider landscape. A **high** ecological value combined with a **low** magnitude of effect results in a **low** 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, as well as habitat loss. A **high** magnitude of effect combined with **high** ecological values results in a **very high** ecological effect.

5.2.2.2 Fauna effects management

5.2.2.3 Bat management

Long-tailed bat acoustic monitoring has not been undertaken at the Project site and bat surveys using Automatic Bat Monitors are required between October and April to determine their presence.

It is possible that potential roost habitat within the footprint is at least intermittently used as part of a wider roost network. Considering this, the possibility exists that individual bats (or in the worst case, an active communal maternity roost) may be harmed or killed during site clearance. The implementation of a Bat Management Plan (BMP) will avoid, minimise and/or mitigate potential impacts to long-tailed bats. Depending on the findings of acoustic survey/s, a range of suitable management options may be recommended. These may include some or all of:

- Best-practice vegetation removal protocols to avoid injury or death during vegetation clearance, potentially involving further acoustic survey immediately prior to clearance, and/or climbing of trees to confirm bats are currently absent;
- Planting of tree species which may form roost habitat over time, to address the loss of potential roost habitat in the affected area;
- Planting of suitable species to replace the loss of foraging/commuting habitat within the affected area; and/or
- Pest control to protect roost habitat off site, over an appropriate area, for an appropriate length of time, to off-set the loss of potential roost habitat in the affected area.

5.2.2.4 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 timing, wetland bird management 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 is to be removed during the bird breeding season. Wetland vegetation should be removed outside of the wetland bird breeding season (September to February inclusive) to avoid impacts to indigenous wetland birds.

Construction can result in noise, vibration and dust effects which can disturb wildlife. Wetland birds can be especially sensitive to such effects. Noise and vibration impacts to wetland birds should be avoided during the wetland bird breeding season via a 30 m buffer zone of high value wetland areas, within which no construction is to be undertaken.

Furthermore, wetland offset and compensation planting will replace wetland bird habitat lost as a result of the proposed reservoir.

5.2.2.5 Herpetofauna management

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

Construction-assisted salvaging is recommended for native skinks potentially on site within pampas. This can be undertaken using a scrub cutter removing vegetation (pampas) approximately 30 cm above the ground. The area can then be searched by an ecologist for skinks. Spotlighting for geckos is recommended prior to the clearance of mānuka.

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.

Wetland offset planting (particularly mānuka gumland *Machaerina* scrub sedgeland offsetting) will replace lizard habitat lost as a result of the proposed reservoir.

5.2.2.6 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.

More data is required to accurately estimate the potential level of effect on native bats. If bats are found to be using the site for roosting, or there is high bat activity, then further measures may be required to compensate for the loss of habitat within the site. The extent of this will not be known until bat monitoring is undertaken and data analysis completed.

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**	The BMP will include vegetation removal protocols (including seasonal clearance constraints) which will avoid impacts to potentially roosting bats. The results of acoustic monitoring will also guide appropriate measures to address the loss of potential roost, foraging and commuting habitat if required.

Tūī	Moderate	**Low**	Offset and compensation will provide additional habitat. AMP will involve seasonal clearance constraints and bird nest checks, further reducing the magnitude of effect.
Other Not Threatened avifauna	Very low	**Very low**	
Wetland birds	Very high	**Low**	
New Zealand pipit	Low	**Low**	Seasonal clearance constraints and bird nest checks as outlined in AMP.
Herpetofauna	High	**Low**	LMP includes seasonal vegetation clearance and salvaging protocols. Salvaging protocols will include construction-assisted habitat searches and gecko spotlighting.

6. 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 range 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.

The following recommendations are 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.

- Develop and implement a Freshwater Fauna Salvage and Relocation Plan (FFRP) 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 native 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 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 abstraction associated with the reservoir.
- Undertake acoustic survey for long-tailed bats during warmer months (October – April inclusive). This will provide further detail on the likelihood of long-tailed bats utilising the site, determine the need for further survey and inform appropriate measures to address residual effects, if required.
- Exploration of suitable offset sites near to the proposed reservoir.
- 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
  - Bat Management Plan
  - Avifauna Management Plan
  - Lizard Management Plan

If the above management recommendations are implemented in full, and subject to further site visits to confirm potential offset and compensation areas, it is considered that effects to terrestrial and wetland ecosystems can be mitigated, offset and compensated for sufficiently, primarily through wetland planting and enhancement, 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 fish passage	High	High	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	Potentially High	Unknown	Unknown	Unknown
Removal of threatened trees and vegetation (refer section 5.3.2 for detail)	Low to Very High	Low to High	Low to High	Low to Very High (can be offset)
Direct and indirect effects on native terrestrial fauna	As described in Table 10			

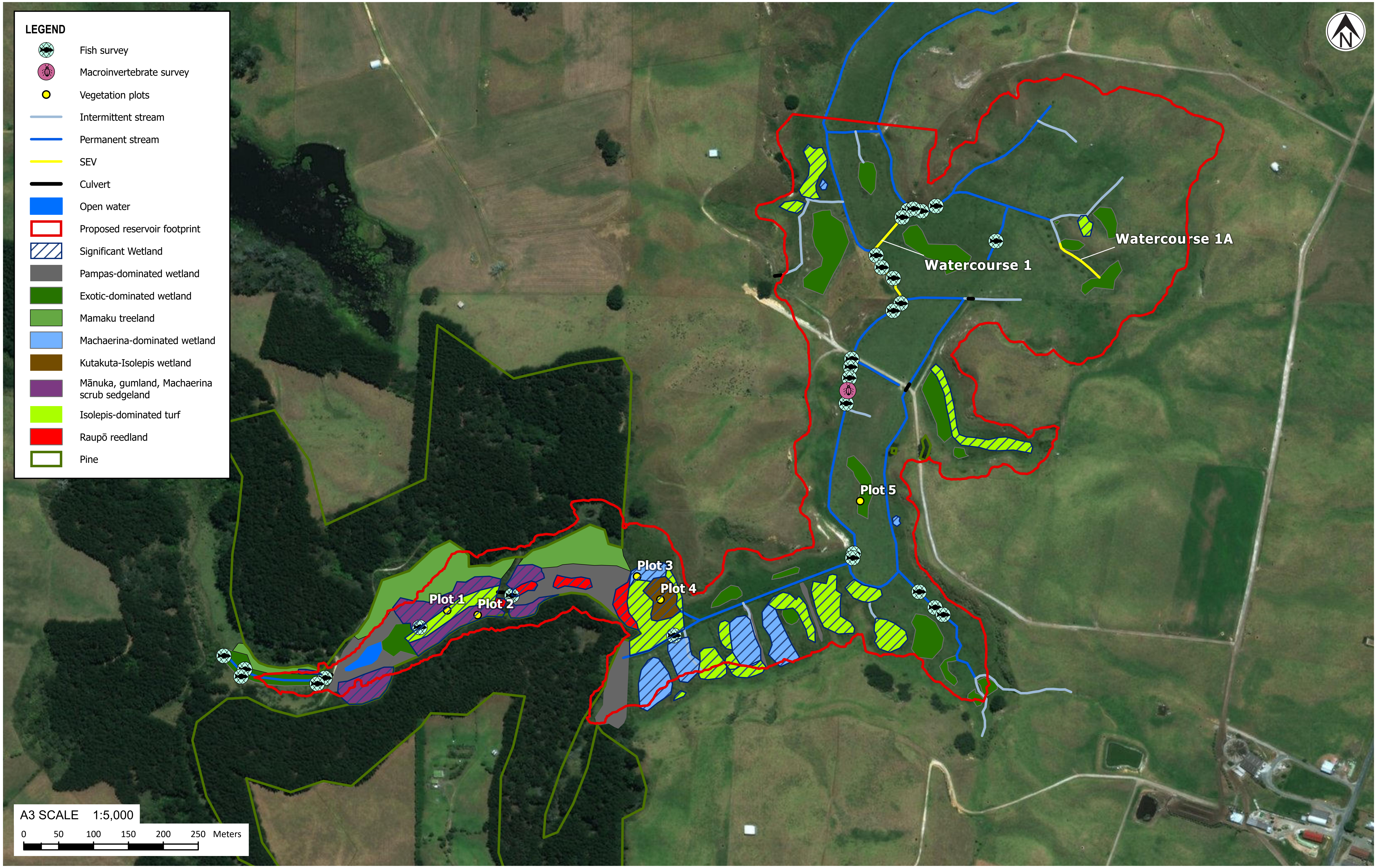
7. Report applicability

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.

8. Appendices

Appendix A Ecological values and sampling locations across K13

\\ttgroup.local\files\AKLProjects\1013835\1013835.1000\WorkingMaterial\03 - GIS\Working material\Kaipara 1013458 20200729.aprx Layout: Kaipara Water Reservoir Map Layout 2020-Aug-11 4:04 pm Drawn by ANDO



Tonkin+Taylor

Exceptional thinking together www.tonkintaylor.co.nz

NOTES:
Basemap World Boundaries and Places: LINZ, Stats NZ, Esri, HERE, Garmin. World Imagery: Maxar

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	SHEG	ANDO	30/07/20

LOCATION PLAN

PROJECT No.	1013835.1000	
DESIGNED	SHEG	AUG.20
DRAWN	SHEG	AUG.20
CHECKED	ANDO	AUG.20
APPROVED		DATE

CLIENT PUHOI STOUR LIMITED

PROJECT SITE K13 ASSESSMENT OF ECOLOGICAL EFFECTS

TITLE TERRESTRIAL AND FRESHWATER SURVEYS

SCALE (A3) 1:5,000 FIG No. FIGURE 1. REV 0

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-high	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-high	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 SEV cross-section photographs

Watercourse 1 (permanent channel)

Watercourse 1A (intermittent channel)




Appendix D Macroinvertebrate sample results

Taxa	Group	K13
Oxyethira	Caddisfly	4
Xanthocnemis	Damselfly	
Hydrophilidae	Beetle	
Chironomus	True Fly	
Orthocladiinae	True Fly	
Tanytarsini	True Fly	
Zelandotipula	True Fly	1
Collembola	Springtails	
Copepoda	Crustacea	
Ostracoda	Crustacea	15
Paracalliope	Crustacea	18
Paraleptamphopus	Crustacea	88
Tanaidacea	Crustacea	1
Mites	Water mite	1
Dolomedes	Spider	
Lymnaeidae	Mollusc	2
Physella	Mollusc	
Potamopyrgus	Mollusc	900
Oligochaetes	Worms	14
Nemerteans	Flatworms	8

Appendix E SEV modelling assumptions

Function Category	Variable	ID: Watercourse 1 (permanent channel) SEV: SEVm-P Offset: max 20 m riparian margin enhancement on both banks	ID: Watercourse 1A (intermittent channel) SEV: SEVm-P Offset: max 20 m riparian margin enhancement on both banks
Hydraulic	Vchann	Assumes no change to stream channel – no instream enhancement.	Assumes no change to stream channel – no instream enhancement.
	Vlining	Assumes slight reduction in fine silt from riparian margin.	Assumes slight reduction in fine silt from riparian margin.
	Vpipe	Assumes no pipe.	Assumes one pipe.
	Vbank	Assumes no change to current deepened channel incision.	Assumes no change to current deepened channel incision.
	Vrough	Assumes dominated by native regenerating vegetation in late stage of succession, some low diversity regenerating and stock exclusion (to 20 m on each bank).	Assumes dominated by native regenerating vegetation in late stage of succession, some low diversity regenerating and stock exclusion (to 20 m on each bank).
	Vbarr	Assumes no physical barriers.	Assumes no physical barriers.
	Vchanshape	Autopopulated.	Autopopulated.
Biogeochemical	Vshade	Assumes very high and high shading from 20 m riparian margin enhancement along entire length.	Assumes very high and high shading from 20 m riparian margin enhancement along entire length.
	Vdod	Assumes improvements to optimal dissolved oxygen.	Assumes improvements to optimal dissolved oxygen.
	Vveloc	Assumes no change to measured velocities	Assumes no change to measured velocities
	Vdepth	Assumes no change to measured depths	Assumes no change to measured depths
	Vripar	Assumes a full 20 m riparian margin.	Assumes a full 20 m riparian margin.
	Vdecid	Assumes no change from no deciduous.	Assumes no change from no deciduous.
	Vmacro	Assumes reduction in macrophytes following shading.	Assumes reduction in macrophytes following shading.
	Vretain	Autopopulated.	Autopopulated.
	Vsurf	Assumes slight changes in substrates from reduced fine sediment loading from 20 m riparian margin.	Assumes slight changes in substrates from reduced fine sediment loading from 20 m riparian margin.
	Vripfilt	Assumes slight improvement to filtering following planting	Assumes slight improvement to filtering following planting
Habitat Provision	Vgalspwn	Assumes no change to existing lack of near-flat slope due to incision.	Assumes no change to existing lack of near-flat slope due to incision.
	Vgalqual	Assumes no change – no near-flat slope so its unsuitable.	Assumes no change – no near-flat slope so its unsuitable.
	Vgobspawn	Autopopulated.	Autopopulated.
	Vphyshab	Assumes slight increase in aquatic habitat diversity including wood, undercut banks,	Assumes slight increase in aquatic habitat diversity including wood, undercut banks, and

		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.	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	No change from minimal due to similar landuse in catchment.	No change from minimal due to similar landuse in catchment.
	Vimperv	Assumes no change to existing 0% impervious above site	Assumes no change to existing 0% impervious above site
Biodiversity	**Vfish**	-	-
	Vmci	-	-
	Vept	-	-
	Vinvert	-	-
	Vripcond	Autopopulated.	Autopopulated.
	Vripconn	Assumes improvements to riparian connection.	Assumes improvements to riparian connection.

Appendix F Species lists

Table 2: Incidental bird identifications during site visits at the water reservoir proposed footprint.

Common name	Species name	Threat status	Observed during site visit
Myna	*Acridotheres tristis*	Introduced	x
Skylark	*Alauda arvensis*	Introduced	x
NZ pipit	*Anthus novaeseelandiae*	At Risk - Declining	May be intermittently present
Australasian bittern	*Botaurus poiciloptilus*	Threatened - Nationally Critical	May be intermittently present
Fernbird	*Bowdleria punctata*	At Risk - Declining	Cryptic - may be present
Goldfinch	*Carduelis carduelis*	Introduced	x
Greenfinch	*Carduelis chloris*	Introduced	x
Australian harrier	*Circus approximans*	Not Threatened	x
White-faced heron	*Egretta novaehollandiae*	Not Threatened	x
Yellowhammer	*Emberiza citrinella*	Introduced	x
Riroriro/Grey warbler	*Gerygone igata*	Not Threatened	x
Australian magpie	*Gymnorhina tibicen*	Introduced	x
Welcome swallow	*Hirundo neoxena*	Not Threatened	x
Feral turkey	*Meleagris gallopavo*	Introduced	x
House sparrow	*Passer domesticus*	Introduced	x
Ring-necked pheasant	*Phasianus colchicus*	Introduced	x
Marsh crake	*Porzana pusilla*	At Risk - Declining	Cryptic - may be present
Spotless crake	*Porzana tabuensis*	At Risk - Declining	Cryptic - may be present
Tūī	*Prosthemadera novaeseelandiae*	Not Threatened	x
Pīwakawaka/New Zealand fantail	*Rhipidura fuliginosa*	Not Threatened	x
Starling	*Sturnus vulgaris*	Introduced	x
Paradise shelduck	*Tadorna variegata*	Not Threatened	x
New Zealand kingfisher	*Todiramphus sanctus*	Not Threatened	x
Blackbird	*Turdus merula*	Introduced	x
Song thrush	*Turdus philomelos*	Introduced	x
Spur-winged plover	*Vanellus miles novaehollandiae*	Not Threatened	x
Silvereye	*Zosterops lateralis*	Not Threatened	x

Table 3: Vascular plant species list developed from site walkover and RECCE plots.

Common name	Species name	Threat classification	Mamaku treeland	Pine	WL1	*Machaerina*-dominated	Kutakuta-Isolepis	WL19	*Isolepis*	Pampas wetland
Wattle	*Acacia spp.*	Introduced		x						
Sweet vernal grass	*Anthoxanthum odoratum*	Introduced				x				
Water starwort	*Callitriche stagnalis*	Introduced							x	
Kikuyu	*Cenchrus clandestinus*	Introduced			x		x		x	
Boneseed	*Chrysanthemoides monilifera*	Introduced	x							
Boradleaved fleabane	*Conyza sumatrensis*	Introduced							x	
Karamu	*Coprosma robusta*	Not Threatened			x					
Pampas	*Cortaderia selloana*	Introduced	x		x			x		x
Mamaku	*Cyathea medullaris*	Not Threatened	x		x					
Shortleaf spikesedge	*Cyperus brevifolius*	Introduced							x	
Bunchy flat-sedge	*Cyperus polystachyos*	Introduced							x	
Sharp spike sedge	*Eleocharis acuta*	Not Threatened				x			x	
Kutakuta	*Eleocharis sphacelata*	Not Threatened				x	x			
Spanish heath	*Erica lusitanica*	Introduced	x		x					
	Isolepis cernua var. cernua	Not Threatened			x				x	
	Isolepis prolifera	Not Threatened	x		x	x	x	x	x	x
Hangehange	*Geniostoma ligustrifolium*	Not Threatened			x					
Tanglefern	*Gleichenia dicarpa*	Not Threatened			x					
Swamp millet	*Isachne globosa*	Not Threatened				x		x		
Soft rush	*Juncus effusus*	Introduced							x	
Great soft-rush	*Juncus pallidus*	Not Threatened							x	
Juncus	*Juncus prismatocarpus*	Not Threatened				x	x			
Manuka	*Leptospermum scoparium*	At Risk - Declining			x					
Angled lobelia	*Lobelia anceps*	Not Threatened			x					
Scarlet pimpernel	*Lysimachia arvensis*	Introduced			x					
Swamp twig rush	*Machaerina juncea*	Not Threatened				x				
Water cress	*Nasturtium officianale*	Introduced			x				x	
Basket grass	*Oplismenus hirtillus*	Not Threatened			x	x				
Swamp kiokio	*Parablechnum minus*	Not Threatened			x					
Kiokio	*Parablechnum novae-zelandiae*	Not Threatened			x					
Pine	*Pinus radiata*	Introduced		x						
Tauhinu	*Pomaderris amoena*	Not Threatened		x						
Kumarahou	*Pomaderris kumarahou*	Not Threatened		x						
Jersey cudweed	*Pseudognaphalium luteoalbum*	Not Threatened								
White clover	*Trifolium repens*	Introduced							x	
Raupo	*Typha orientalis*	Not Threatened						x		x
Gorse	*Ulex erupaeus*	Introduced			x				x	

Appendix G BOAM justifications table

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of mānuka gumland *Machaerina* scrub sedegland

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)	Reference
Canopy	Indigenous canopy cover (%)	90	Assume an almost full canopy. Stock impacts have likely reduced canopy cover in the impact mānuka gumland.	90 (20)	It is assumed indigenous mānuka will dominate canopy after 20 years.	70	Restoration planting and fencing to exclude livestock.	0.59/5.25	
	Average height (m)	5	NZPCN height of mānuka.	1 (20 years)	Mean annual height growth rate of mānuka in gumlands of 11.90 cm per year (Clarkson et al. 2011). Halved to 5 cm per year to be conservative. Therefore in 20 years it is expected that mānuka will be at least 1 m tall.	4	Restoration planting and fencing to exclude livestock.		Clarkson et al. (2011) NZPCN
	Basal area (m^2/ha)	25	Assumed that site represents a state close to a benchmark value. Increased slightly due to the current stock access which is likely reducing expected basal area.	5 (20)	As basal area is a quarter of the impact value of growth rate, basal area estimated to be a quarter of the measure after offset after 20 years.	19.7	Restoration planting and fencing to exclude livestock.		
Diversity	Diversity of native species (no. per 100 m^2)	15	Average of 12.4 species per 100 m^2 in Leptospermum–*Gleichenia* shrubland. Increased to 15 to account for the fact it is to be a 'pristine' ecosystem.	5 (20)	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.	11	Restoration planting and fencing to exclude livestock.		

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of kutakuta-*Isolepis* wetland

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)	Reference
Canopy	Percentage (%) cover indigenous	99	Benchmark taken from impact value.	80 (5)	Native plantings undertaken and the control of pest plants is assumed to result in a full canopy cover of native species. Reduced to 80% as conservative estimate.	99	Restoration planting and fencing to exclude livestock.	0.14/0.26	Estimate based on plots undertaken on site.
	Average height (m)	1.2	Kutakuta height from NZPCN.	0.5 (5)	Half a meter of growth in 5 years is assumed to be a conservative growth rate for a fast-growing wetland species. Can grow 29 cm in a year, at least as a seedling (Kapa, 2009)	0.4	Restoration planting and fencing to exclude livestock.		Kapa (2009)
Diversity	Diversity of native species (no. per 100 m^2)	5	Benchmark of 5 arbitrary, but often kutakuta forms monotypic stands, therefore 5 is considered a conservative benchmark.	6 (5)	At least 6 species of wetland plants will be planted into this habitat type and protected from weeds.	3	Restoration planting and fencing to exclude livestock.		

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

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)	Reference
Canopy	Percentage (%) cover indigenous	99	Estimate based on plots undertaken for the Manawatū bypass in a high value raupō wetland. Raupō typically forms a dominant wetland canopy.	90 (5 years)	Five years is considered an appropriate time to establish a closed canopy, as raupō is a fast-growing species (McK Pegman & Ogden, 2005).	85 (some invasion by pampas reduces its canopy cover value).	Restoration planting and fencing to exclude livestock.	0.17/0.45	Estimate based on plots undertaken on site McK Pegman and Ogden (2005)
	Average height (m)	3	Estimate based on NZPCN plant description of raupō.	1.5 (5 years)	Raupō is a fast-growing species (McK Pegman & Ogden, 2005). Five years is considered a conservative amount of time for raupō to reach 1.5 m in height.	2.5	Restoration planting and fencing to exclude livestock.		NZPCN
Diversity	Diversity of native species (no. per 100 m^2)	9	Estimate based on monotypic raupō reedland with some additional native species.	6 (5)	At least 6 species are proposed to be planted into this ecosystem type.	3	Restoration planting and fencing to exclude livestock		

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of *Isolepis* – dominated wetland

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)	Reference
Canopy	Percentage (%) cover indigenous	100	*Isolepis prolifera* can form dense swards creating a full cover.	95 (5)	Fast-growing species and ecosystem type. With protection will quickly smother. Known to be an aggressive weed on farms (NZPCN).	85	Restoration planting and fencing to exclude livestock	1.42/1.8	NZPCN
	Average height (m)	0.9	NZPCN maximum height.	0.25 (5)	0.25 m is considered a highly conservative measure given the fast-growing nature of this species.	0.15	Restoration planting and fencing to exclude livestock		NZPCN
Diversity	Diversity of native species (no. per 100 m^2)	6	Often forms monotypic swards. More species assumed to be present where stock browse has not affected overall species richness.	5	At least 5 wetland species are proposed to be planted into this wetland type.	3	Restoration planting and fencing to exclude livestock		

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of *Machaerina* – dominated wetland

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)	Reference
Canopy	Percentage (%) cover indigenous	100	*Machaerina juncea* can form dense swards creating a full cover.	80 (5)	Fast-growing species and ecosystem type.	99	Restoration planting and fencing to exclude livestock	0.62/2.7	NZPCN
	Average height (m)	1.35	NZPCN maximum height.	0.5 (5)	0.5 m is considered a highly conservative measure given the fast-growing nature of this species. *M. juncea* grows to a maximum height each summer after which shoots die with new spring shoots growing through this fallen vegetation (McK. Et al., 2006)	1.2	Restoration planting and fencing to exclude livestock		NZPCN (McK. Et al., 2006)
Diversity	Diversity of native species (no. per 100 m^2)	10	Often forms monotypic swards. Additional species above that found in impact plots assumed to be present where stock browse has not affected overall species richness.	5	At least 5 wetland species are proposed to be planted into this wetland type.	8	Restoration planting and fencing to exclude livestock		

Biodiversity component, attribute, benchmark, measure after offset, overall impact area and offset area values and justifications for offset models of pampas wetland. Pampas wetland assumed to be replaced by raupō reedland.

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)	Reference
Canopy	Percentage (%) cover indigenous	90	Assumed that without pampas, indigenous dominance would be very high and approximately 90%.	90 (5 years)	Five years is considered an appropriate time to establish a closed canopy, as raupō is a fast-growing species (McK Pegman & Ogden, 2005).	10	Restoration planting and fencing to exclude livestock.	0.86/1.8	Estimate based on plots undertaken on site McK Pegman and Ogden (2005)
	Average height (m)	3	Estimate based on NZPCN plant description of raupō.	1.5 (5 years)	Raupō is a fast-growing species (McK Pegman & Ogden, 2005). Five years is considered a conservative amount of time for raupō to reach 1.5 m in height.	2	Restoration planting and fencing to exclude livestock.		Estimate based on plots undertaken on site
Diversity	Diversity of native species (no. per 100 m^2)	9	Estimate based on monotypic raupō reedland with some additional native species.	6 (5)	At least 6 species are proposed to be planted into this ecosystem type.	3	Restoration planting and fencing to exclude livestock.		

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.

Kapa, M. M. (2009). *Ethnobotany, germination and growth of eleocharis sphacelata* (Doctoral dissertation, The University of Waikato).

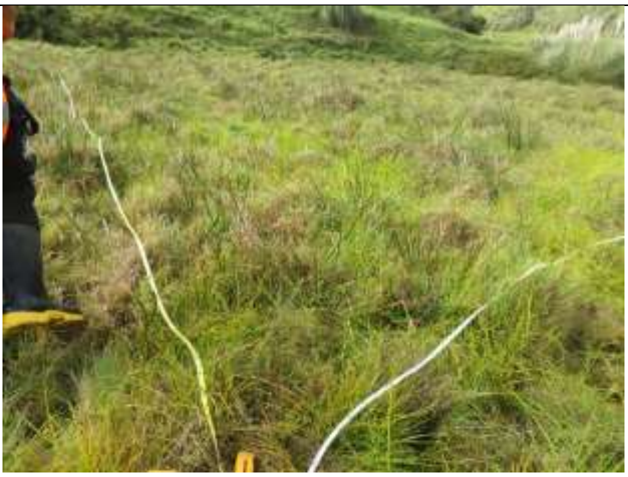
McK. Pegman, A. P., & Ogden, J. (2005). Productivity-decomposition dynamics of *Typha orientalis* at Kaitoke Swamp, Great Barrier Island, New Zealand. *New Zealand Journal of Botany*, *43*(4), 779-789.

McK. Pegman, A. P., & Ogden, J. (2006). Productivity-decomposition dynamics of *Baumea juncea* and *Gleichenia dicarpa* at Kaitoke Swamp, Great Barrier Island, New Zealand. *New Zealand Journal of Botany*, *44*(3), 261-271.

NZPCN (n.d.) New Zealand Plant Conservation Network. https://www.nzpcn.org.nz/

Appendix H Terrestrial and wetland ecosystem photographs


Photograph 1: Mānuka gumland *Machaerina* scrub sedgeland (WL1) with dense tanglefern


Photograph 2: Kutakuta-*Isolepis* wetland.


Photograph 3: *Machaerina*-dominated wetland


Photograph 4: Raupō wetland


Photograph 5: *Isolepis*-dominated wetland


Photograph 6: Mamaku treeland with degraded understorey due to stock damage.

Photograph 7: Wet pasture dominated by *Juncus effusus*

Photograph 8: Exotic pine (background), pampas wetland (right) and mānuka gumland (left) with stock track crossing.