

ECOLOGICAL ASSESSMENT OF THE OMAHA - TANIKO WETLAND COMPLEX, AT OMAHA



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ECOLOGICAL ASSESSMENT OF THE OMAHA-TANIKO WETLAND COMPLEX, AT OMAHA



Kahikatea forest within the Omaha-Taniko wetland complex. 9 January 2014.

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1. INTRODUCTION

Watercare commissioned Wildland Consultants Ltd to undertake an ecological assessment of the Omaha Taniko Wetlands.

This report is an ecological assessment that includes the following:

- Collation and review of relevant literature regarding the ecological values of the receiving environment, with a focus on the coastal swamp forest;
- A vegetation survey of forests and freshwater wetlands within the receiving environment;
- An assessment of aquatic animals and avifauna, with a particular focus on freshwater fish and wetland birds;
- Recommendations for ongoing monitoring to establish any trends in respect of any potentially significant long-term effects of the proposed discharge on the receiving environment.

2. BACKGROUND

The existing discharge sites within the golf course, which have been operating since 2002, are located on fairways on dunes to the east of the wetland complex. The discharge is via sub-surface irrigation and has the capacity to dispose up to *c.* 1,012 m³ per day of treated wastewater. Discharge capacity for the golf course discharge site is currently 732 m³ per day in the summer, and 294 m³ per day in the winter. Nutrients in the discharge are used to supplement fertiliser applied by the golf course, as part of course management.

Approximately 5,800 kg of nitrogen compounds, 1,360 kg of potassium compounds, and up to 500 kg of phosphorus, are applied to the southern nine holes on an annual basis. The discharge was predicted in 1999 to provide about 14% of the golf course's nitrogen requirements, and 70% of the phosphorus requirements, for the nine northern holes (Boffa Miskell and Woodward Clyde Consultants 1999).

High levels of discharge uptake by plants within the discharge sites during dry conditions means that, for most of the time, nutrients from the discharge are retained on the golf course (Diffuse Sources 2008). There is greater potential for nutrients to enter the groundwater during the wetter winter months, but typically discharge doesn't occur during the winter. From the golf course the groundwater primarily flows to the west, through coastal swamp forest and wetlands, into the Whangateau Estuary. Soil cross-sections from 1999, prior to the discharge, indicated the depth to groundwater under the forest and wetlands to be typically less than 1 m, but there is relatively little data prior to the discharge. A thorough understanding of groundwater depths and flows is essential to be able to evaluate potential ecological effects, as depth to groundwater will not only influence soil moisture levels, but will also determine the availability of nutrients in the groundwater to the overlying vegetation. Recent

monitoring data indicates that groundwater levels now average 0.7-0.8 m, but range from 0.1-1.4 m.

3. ECOLOGICAL CONTEXT

3.1 Location

The Omaha-Taniko wetlands complex lies on the eastern shoreline of Whangateau Harbour in the northeastern corner of Rodney Ecological District (c.200,250 ha), which is one of eight ecological districts that comprise Auckland Ecological Region. Rodney Ecological District lies to the north of Auckland City, between the Kaipara Harbour to the west and the Hauraki Gulf to the east. It adjoins Waipu Ecological District to the north, Otamatea and Kaipara Ecological Districts to the west, and the Tamaki and Waitakere Ecological Districts to the south.

Information below on Rodney Ecological District is derived from Mitchell *et al.* (1992).

3.2 Physical character

Rodney Ecological District is an area of relatively subdued lowland hill country. Hills extend to the coast which forms the eastern boundary in an intricate pattern of dunes, headlands and peninsulas, broad harbours and penetrating tidal inlets. Drowned valleys of the Kaipara Harbour extend to within a few kilometres of the east coast. The climate is generally warm and moist with high sunshine hours (2,000 per annum), high humidity, and a prevailing westerly wind, although the most destructive winds come from the east and northeast. Summer temperatures average 19°C and winter 10°C. Rainfall varies from 1,200 mm in the Kumeu rain shadow area to over 1,600 mm in the elevated hills of central Rodney. Generally, the District is sheltered in the east by the Hauraki Gulf islands and in the west by the Kaipara South Head dune barrier and Kaipara Harbour. The topography is characterised by steep south-facing escarpments and hill slopes, which tend to be cooler and wetter than elsewhere.

3.3 Pre-human natural areas

Prior to human settlement, Rodney Ecological District was extensively forested with mixed kauri (*Agathis australis*)-podocarp-broadleaved species forest (c.102,757 ha), inland kauri forest (c.12,417 ha), and coastal broadleaved forest (c.16,773 ha). Freshwater wetlands and swamp forests occupied dune slacks and alluvial valleys, originally covering approximately 24,614 ha. Extensive areas of dune vegetation (c.1,351 ha) were present between Mangawhai and the southern end of Pakiri.

3.4 Existing natural areas

Rodney Ecological District has a long history of human occupation and modification of the natural landscape. Natural areas are highly modified and most remaining indigenous vegetation is fragmented. There are, however, sizeable areas of regenerating forest, often dominated by kanuka (*Kunzea* sp.). There is very little original kauri forest left, except in a few small reserves. Totara (*Podocarpus totara*)-dominant remnants are a feature of the District, with characteristically distinctive

riverside forests. Kahikatea (*Dacrycarpus dacrydioides*) – dominant forest occurs locally away from the coast, including swamp forest in the Omaha-Taniko wetlands, and is associated with poorly-drained sites.

Freshwater wetlands and swamp forests have been reduced significantly from their original extent. Many former wetlands have been modified or destroyed by vegetation clearance and drainage, and wetland loss has been particularly rapid over the last 40 years. Existing wetlands are small and scattered and consist mainly of raupo (*Typha orientalis*) reedlands.

Most dunelands have been converted to farmland or radiata pine (*Pinus radiata*) plantation forest. There are, however, significant areas of spinifex (*Spinifex sericeus*) and pingao (*Ficinia spiralis*) in sand dune communities on the Mangawhai and Pakiri foredunes. These communities are threatened by human activities such as off-road vehicles and invasive weeds such as marram (*Ammophila arenaria*), brush wattle (*Paraserienthes lophantha*), lupin (*Lupinus arboreus*), and wilding pines.

Approximately 15% of the remaining indigenous vegetation remnants are in protected areas. The largest blocks are Atuanui/Mt Auckland, Moirs Hill, and Mt Tamahunga, all of which are administered by the Department of Conservation.

3.5 Omaha-Taniko Wetlands

The Omaha-Taniko wetlands form the eastern edge of the Waikokopu Creek arm of Whangateau Harbour. In general, the ecological sequence extends, in an east to west direction, from kahikatea swamp forest and manuka scrub on low-lying consolidated sand dunes, to manuka scrub, to saltmarsh, to mangroves, to open intertidal flats, seagrass (*Zostera muelleri* subsp. *novozelandica*) beds, and tidal channels (Appendix 4: Plate 1).

The kahikatea swamp forest is the largest and best remaining example of this habitat type in the Auckland Ecological Region. The wetland complex as a whole is also the best and most extensive example of an ecological sequence from terrestrial to estuarine habitats in both the Auckland Ecological Region and nationally.

4. METHODS

- A literature review was undertaken to identify relevant information relating to ecological values of the receiving site, including the ecological context of the site.
- A field survey was undertaken on 8-9 January 2015.
- Vegetation and habitat types at the site were identified, mapped, and described¹.
- A list of vascular plants recorded during the field visits was compiled and is provided in Appendix 2.
- Freshwater fish were surveyed using 3 mm metal mesh Gee minnow traps in the two ponds that held water at the time of survey (refer to Figure 1). The freshwater fish survey included trapping methods suitable for the detection of black mudfish

¹ Mapped vegetation types were derived using the methods proposed by Atkinson (1985).

(*Neochanna diversus*), as outlined in Appendix 1. Fourteen traps were deployed on 8 January 2015, and then checked the following day.

- All avifauna present at the impact sites were recorded. Records of avifauna species present in the wider catchment, including in the parts of the wetland, administered by the Department of Conservation, were collated and reviewed by Wildland Consultants (2015).

5. VEGETATION AND HABITATS

5.1 Overview

Twelve vegetation types, covering 95.40 ha, were identified and mapped within the discharge receiving environments (Figure 1). These habitats are bounded to the east and north by Omaha golf course and by Whangateau Harbour to the west.

5.2 Kahikatea forest (35.99 ha)

Kahikatea forest covers a large proportion of the low-lying flats between the golf course and the eastern shoreline of the Waikokopu Arm of Whangateau Harbour. Kahikatea prefers moist, fertile soils, and is relatively light-demanding, usually regenerating following large-scale canopy disturbance (Smale *et al.* 2005). Kahikatea typically has a life span of up to 450 years (Enright and Ogden 1995), but coring of old-growth trees has shown that ages in excess of 700 years can be attained (Burns *et al.* 1999). Based on tree diameters and heights, it is likely that most if not all of the trees have regenerated within the last 100-150 years, following forest clearance post-European settlement.

North of Broadlands Drive, the forest is dominated by mature kahikatea with frequent puriri (*Vitex lucens*), and occasional totara and tī kōuka (*Cordyline australis*). Along the eastern edge of the forest, the foliage on upper branches exposed to the east was often brown (Appendix 4: Plate 2). This foliage death was not seen on the western, inland edge of the forest, and is not adjacent to an area affected by the discharge or recent housing developments. As such the most likely cause of this foliage death is salt spray. In this area of the kahikatea forest, the sub-canopy comprises frequent nīkau (*Rhopalostylis sapida*), kiekie (*Freycinetia banksii*), and kaeao (supplejack: *Ripogonum scandens*), with kiekie and tupari-maunga (*Gahnia xanthocarpa*) in the understorey and scattered coastal karamū (*Coprosma macrocarpa* subsp. *minor*). Exotic plants are largely restricted to the forest margins.

Environmental pest plants present on the northern edge of Broadlands Drive include agapanthus (*Agapanthus praecox*) and tuber ladder fern (*Nephrolepis cordifolia*). On the western, northern, and eastern edges scattered exotic trees include sheoak (*Casuarina cunninghamiana*), Sydney golden wattle (*Acacia longifolia*), brush wattle (*Paraserianthes lophantha*), coastal banksia (*Banksia integrifolia*), Moreton Bay fig (*Ficus macrophylla*), and Norfolk Island hibiscus tree (*Lagunaria patersonia* subsp. *patersonia*).

To the south of Broadlands Drive, the forest floor is generally wetter, with frequent pukatea (*Laurelia novae-zelandiae*), tī kōuka, and kiekie in the canopy, and occasional supplejack (Appendix 4: Plate 3). Pukatea and tī kouka become increasingly common on the western, estuarine edge of the kahikatea forest. Ti kouka then becomes locally dominant in places, before the forest grades into to manuka scrub. The shrub tier comprises frequent hangehange (*Geniostoma ligustrifolium* var. *ligustrifolium*) and whekī (*Dicksonia squarrosa*) with scattered māhoe (*Melicytus ramiflorus* subsp. *ramiflorus*), *Coprosma areolata*, and putaputawētā (*Carpodetus serratus*). Kiekie and *Gahnia xanthacarpa* are common in the ground tier, with frequent kiokio (*Blechnum novae-zelandiae*), and occasional *Deparia petersenii* subsp. *congrua*, *Microtis* sp. and tutukiwi (*Pterostylis banksii*). Along the northern forest boundary, beside Broadlands Drive, piles of garden waste are common on the road edge, with the establishment of yucca (*Yucca gloriosa*), agapanthus, tradescantia (*Tradescantia fluminensis*), ivy (*Hedera helix*), and busy lizzie (*Impatiens walleriana*).

Ophioglossum petiolatum, a threatened fern ally, is present along the forest edge, at the foot of the road embankment.

5.3 Exotic grassland (9.37 ha)

Sweet vernal (*Anthoxanthum odoratum*) and kikuyu (*Cenchrus clandestinus*) dominate the exotic grassland in the forest margins adjacent to golf course. Damp depressions amongst the grassland areas support narrow-leaved carpet grass (*Axonopus fissifolius*) with scattered communities of indigenous spike sedge (*Eleocharis acuta*), *Machaerina* spp., and rushes such as *Juncus planifolius* (Appendix 4: Plate 4). Two species of indigenous sun orchids (*Thelymitra* sp.) are present in small numbers. On bare northeastern margins, where herbicides are regularly used, diminutive indigenous plants, such as *Centipeda minima*, are present. Further south, on the eastern margins of the forest, scattered tī kōuka, harakeke (*Phormium tenax*) and occasional totara occur within the grassland areas. Young manuka (*Leptospermum scoparium*) is beginning to establish. Exotic herbs are present, including swamp plantain (*Plantago australis*), creeping buttercup (*Ranunculus repens*), lotus (*Lotus pedunculatus*), and Australian fireweed (*Senecio bipinnatisectus*).

5.4 Manuka-Machaerina shrubland (0.14 ha)

On the eastern margin of the northern part of the kahikatea forest, there is a moist low-lying area south of the eastern pond. Permanently wet soils in this location provide suitable habitat for moisture-tolerant groundcover species such as *Centella uniflora* and *Sphagnum cristatum*, and the latter was not seen elsewhere during the site survey. *Machaerina rubiginosa* and manuka are abundant, with frequent harakeke; tangle fern (*Gleichenia dicarpa*) is locally abundant (Appendix 4: Plate 5). The presence of *Sphagnum cristatum*, in association with manuka and tangle fern, is indicative of lower fertility habitat.

5.5 Ponds (0.29 ha)

Ponds occur on both the eastern and western margins of the northern kahikatea forest.

The western pond is more open, with little shade on its western, southern, and northern margins. Aquatic vegetation includes abundant manihi (*Potamogeton cheesemanii*) and water purslane (*Ludwigia palustris*), with locally abundant raupo towards the eastern boundary. Indigenous spike sedge (*Eleocharis acuta*), *Machaerina juncea*, tutunawai (*Persicaria decipiens*), karearea *Lemna disperma*, and retoretore (*Azolla rubra*) are present throughout. Indigenous herb species, including punakura (*Lobelia anceps*), kawariki (*Ranunculus amphitrichus*), and *Centipeda minima* occur in open areas on the pond banks.

The eastern pond is more shaded, surrounded on all sides by taller vegetation, including some trees. The land surrounding this pond is generally moist and transitions into the manuka-*Machaerina* shrubland described above (Appendix 4: Plate 6). Aquatic vegetation is similar to the western pond, but with the additional presence of a stand of kāpūngāwhā (*Schoenoplectus tabernaemontani*).



- Legend**
- Exclusion fence
 - Vegetation and habitat types
 - KF. Kahikatea forest
 - EG. Exotic grassland
 - MMSh. Manuka - Machaerina shrubland
 - MSc. Manuka scrub
 - KANF. Kanuka forest
 - KTT. Kanuka - totara treeland
 - RR. Raupo reedland
 - MSEG. Machaerina sedgeland – exotic grassland mosaic
 - SOR. Sea rush – oioi rushland
 - SRR. Sea rush rushland
 - MgSh. Mangrove shrubland
 - P. Pond



Figure 1. Vegetation and habitat types of the receiving environment for the Omaha Wastewater Treatment Plant discharge, Omaha.
(Sheet 1 of 2)

Data Acknowledgment
 Maps contain data sourced from LINZ
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5.6 Manuka scrub (15.74 ha)

Manuka scrub comprises a significant part of the wetland complex, occurring along the western boundary of the southern kahikatea forest, and to the east of the saltmarsh habitat within the Waikokopu Arm of Whangateau Harbour. This vegetation type also occurs as a band through the southern kahikatea forest, which extends from the golf course in the east to the saltmarsh in the west. At this location, mature manuka 6-8 m tall dominates the canopy, with occasional tī kōuka and horoeka (lancewood; *Pseudopanax crassifolius*). The shrub tier is diverse and comprises young kahikatea and totara, with occasional nīkau, mapou (*Myrsine australis*), and kiekie, and lower-stature vegetation such as mingimingi (*Leucopogon fasciculatus*), hangehange, and maukoro (*Carmichaelia australis*). The ground tier is dominated by *Gahnia xanthocarpa*; kiokio is common (Appendix 4: Plate 7). A seasonally dry water channel within this area of manuka scrub is habitat for *Centella uniflora*, *Nertera scapanoides*, kawariki (*Ranunculus amphitrichus*) and swamp millet grass (*Isachne globosa*). Boffa Miskell (2000) recorded water depths up to 0.3 m within the wetland complex.

Manuka scrub also occurs along the eastern edge of the kahikatea forest, to the south of Broadlands Drive. Manuka 4-6 m tall forms the canopy, with occasional kanuka (*Kunzea robusta*) and kahikatea. The ground tier comprises several sedge species including *Machaerina teretifolia*, wīwī (*Schoenus tendo*) and *Isolepis prolifera*. Ferns are common, including occasional young mamaku (*Cyathea medullaris*), and locally abundant mātātā (water fern; *Histiopteris incisa*) and swamp kiokio (*Blechnum minus*).

5.7 Kanuka forest (0.18 ha)

On the eastern edge of the kahikatea forest there is a small area of forest dominated by kanuka 12-15 m tall, with occasional kahikatea and totara (Appendix 4: Plate 8). The subcanopy is dominated by nīkau, mapou, and totara. The shrub and ground tier comprises *Gahnia xanthocarpa*, mingimingi, *Coprosma aerolata* and occasional kiokio and ponga (*Cyathea dealbata*).

5.8 Kanuka-totara treeland (0.96 ha)

To the east of the exclusion fence within the golf course grounds, there are two areas of indigenous treeland on well-drained soils. Kanuka and totara are abundant, with occasional kahikatea. The ground tier is predominantly exotic grassland with patches of pātītī (*Microlaena stipoides*).

5.9 Raupo reedland (0.06 ha)

Raupo (*Typha orientalis*) reedland occurs in a freshwater wetland area on the eastern edge of the wetland complex. The raupo vegetation transitions into a mosaic of other indigenous wetland species including kāpūngāwhā (*Schoenoplectus pungens*), *Machaerina* spp., toetoe upoko-tangata (*Cyperus ustulatus*) and exotic plants, including sweet vernal, Yorkshire fog (*Holcus lanatus*), purple umbrella sedge (*Cyperus congestus*) and lotus. The indigenous bindweed, pōhue (*Calystegia sepium*)

subsp. *roseata*) is present, along with occasional scattered tī kōuka and mamaku (*Cyathea medullaris*).

5.10 Machaerina sedgeland-exotic grassland mosaic (1.92 ha)

Machaerina teretifolia on the southeastern edge of the wetland complex, within the exclusion fence, is abundant. It occurs in distinct patches alongside areas of locally abundant kikuyu and sweet vernal grassland, with less frequent paspalum (*Paspalum dilatatum*), and herbs including *Senecio esleri*. Young manuka (<2 m tall) is establishing throughout the grassland, along with occasional gorse (*Ulex europaeus*) and harakeke. A row of planted tī kōuka is present along the western side of the exclusion fence (Appendix 4: Plate 9).

5.11 Sea rush-oioi rushland (13.54 ha)

Sea rush-oioi rushland occurs along the western shoreline of the wetland complex, between the manuka scrub, and the more saline communities dominated by sea rush or mangroves. Oioi (*Apodasmia similis*) is abundant on the landward side and grades increasingly into sea rush (*Juncus kraussii* var. *australiensis*) towards the harbour. Areas of bare intertidal sands and muddy sands, with scattered mangrove seedlings, are present within this vegetation type.

5.12 Mangrove shrubland (15.95 ha)

Furthest to the west, the sandy intertidal flats are dominated by mangrove (mānawa; *Avicennia marina* subsp. *australasica*) (Appendix 4: Plate 10). There are few mature trees and young mangroves are sparse in places with locally abundant arrow grass (*Triglochin striata*).

5.13 Sea rush rushland (1.26 ha)

Within the mangrove shrubland, there is a narrow ridge that is raised *c.*1 m above mean high water. On this higher land there is a distinct vegetation community which includes frequent marsh ribbonwood (mākaka; *Plagianthus divaricatus*) with occasional young trees of pōhutukawa (*Metrosideros excelsa*) and sheoak. Grasses include *Austrostipa stipoides* and the exotic tall fescue (*Schedonorus arundinaceus*), with occasional wīwī (*Ficinia nodosa*), remuremu (*Selliera radicans*), and māakoako (*Samolus repens* var. *repens*).

6. FLORA

One hundred and seventeen indigenous vascular plant species and 57 naturalised vascular plant species (Appendix 2) were recorded during the survey within wetland habitats and the adjacent kahikatea forest.

Two “Nationally Threatened” species, as per de Lange *et al.* (2013), were recorded at the site: *Ophioglossum petiolatum*, classified as “Threatened-Nationally Critical (Appendix 4: Plate 11), and sneezeweed (*Centipeda minima* subsp. *minima*), classified as “Threatened-Nationally Endangered (Appendix 4: Plate 12). Sneezeweed

is a small annual daisy that requires bare ground to establish. This species was found on the edges of a golf course fairway, where the vegetation is periodically sprayed with herbicide.

The wetland complex, and in particular dune slacks dominated by manuka or sedges, provides potential habitat for a range of indigenous orchid species, including several that are listed as “Threatened” or “At Risk”. Orchids can be vulnerable to nutrient enrichment, as they typically occupy environments where ground tier vegetation is suppressed by low fertility and or fluctuating water levels. Two sun orchids species (*Thelymitra* spp.) were seen during the survey, but could not be identified as they were not flowering. An orchid survey should be undertaken in mid to late Spring (November) to determine if any species of conservation concern e.g. *Thelymitra ixioides*, are present, or if any areas support a high diversity of orchid species.

7. FAUNA

7.1 Overview

Fauna species recorded during the survey are listed in Appendix 3.

7.2 Freshwater fish

Trapping in January 2015 confirmed the presence of three fish species within the wetland complex and these are summarised in Table 1. Longfin eel (*Anguilla dieffenbachii*) is classified by Goodman *et al.* (2014) as “At Risk-Declining” (Appendix 4: Plate 13).

Table 1: Summary of fish trapping results for 14 trap nights, in the Omaha-Taniko wetland complex at Omaha 8 January 2015.

✓ indicates presence at site.

Species	Common Name	Western Pond	Eastern Pond
<i>Anguilla australis</i>	Shortfin eel	✓	✓
<i>Anguilla dieffenbachii</i>	Longfin eel		✓
<i>Gambusia affinis</i> ¹	Mosquitofish	✓	

¹ Exotic species.

7.3 Avifauna

Sixteen indigenous bird species were recorded at the site on 8-9 January 2015. Records are set out below, within relevant vegetation types:

Coastal swamp forest/scrub/grassland habitats

Pīwakawaka (North Island fantail: *Rhipidura fuliginosa placabilis*), riroriro (grey warbler: *Gerygone igata*), pūkeko (*Porphyrio melanotus melanotus*), tūī (*Prothemadera novaeseelandiae novaeseelandiae*), kāhu (swamp harrier: *Circus approximans*), and kereru (New Zealand pigeon: *Hemiphaga novaeseelandiae*) were seen at the time of survey.

Korimako (bellbird: *Anthornis melanura melanura*) were heard in the kahikatea forest south of Broadland Drive.

Saltmarsh/mangrove shrubland habitats

Karoro (southern black-backed gull: *Larus dominicanus dominicanus*), godwit (*Limosa* sp.), white-faced heron (*Ardea novaehollandiae*), huahou (lesser knot: *Calidris canutus*); poaka (pied stilt: *Himantopus himantopus leucocephalus*) classified as “At Risk-Declining”, tōrea (variable oystercatcher: *Haematopus unicolor*) classified as “At Risk-Recovering”, tarāpunga (red-billed gull: *Larus novaehollandiae scopulinus*) classified as “Threatened-Nationally Vulnerable”, and little black shag (*Phalacrocorax sulcirostris*) classified as “At Risk-Naturally Uncommon” were seen at the time of survey.

Mātātā (North Island fernbird: *Bowdleria punctata vealeae*) were heard calling in areas of saltmarsh south of the causeway. North Island fernbird is classified as “At Risk-Declining”.

Threat classifications for avifauna listed above are from Robertson *et al.* (2013).

7.4 Herpetofauna

A herpetofauna survey was not undertaken but several skinks were observed along the forest edge on the southern side of Broadlands Drive. One rainbow skink (*Lampropholis delicata*), a pest species introduced from Australia, was captured and identified. The forest is likely to be habitat for forest gecko (*Mokopirirakau granulatus*), classified as “At Risk-Declining” (Hitchmough *et al.* 2013).

8. MONITORING

If groundwater monitoring data shows that the wetland complex is no longer acting as a nutrient sink, or that nutrient levels are trending upwards at locations within the wetland complex, a long-term monitoring programme will be required to assess ecosystem health. Monitoring should include the following:

- Depth to water table within the wetland complex along an east-west gradient, including areas adjacent to existing and proposed discharge. Measurement should capture any seasonal changes between winter and summer;
- Foliar nitrogen content of key canopy species, i.e. kahikatea, totara, pukatea, nikau;
- Crown health of permanently marked individuals of key canopy species, including photopoints, foliage colour, and foliage density;
- Re-mapping of vegetation types, as done for this report, on a five-yearly basis.

This monitoring data can be analysed in conjunction with water quality data to determine if there are any linkages between the discharge and ecosystem health.

9. CONCLUSIONS

The Omaha-Taniko wetland complex is the best and most extensive example of a sequence from coastal wetland to estuarine habitats in the Auckland Region, and the largest area of kahikatea swamp forest in the Region. Aside from its value as an intact ecological sequence, its high fauna values are well recognised, particularly for wetland bird species. Plant species classified as nationally threatened were found at the site during this survey, and further add to the value of this wetland complex for the conservation of indigenous biodiversity.

The discharge of treated wastewater, by sub-surface irrigation to the adjacent golf course, has been operating since 2002. The nutrients within the discharge are used to supplement the fertiliser requirements of the golf course, and within the discharge sites, less fertiliser is applied. Whilst there is some baseline data for groundwater levels and nutrient concentrations within the existing discharge site, and for the eastern edge of the wetland complex, quantitative data is lacking for trends in groundwater and nutrient levels within the wetland complex. At present, there are no indications of poor vegetation health that can be attributed to the existing discharge. Kahikatea on the north-eastern edge of the wetlands had localised areas of foliage dieback but these trees were adjacent to non-irrigated areas, and poor tree health there is most likely due to salt spray. Except for constructed ponds on the golf course edge, no surface water was found within the wetlands. Based on vegetation health, and literature regarding the nitrogen uptake potential of forest and wetland systems, the most likely scenario is that the wetland complex is currently nutrient-limited, and acts as a nitrogen sink.

Long-term trends for both groundwater levels and nitrogen concentrations along an east-west gradient through the wetland complex are unknown, and monitoring has begun to rectify this information gap. As long as the wetland complex acts as a nutrient sink, the key ecological components of the wetland complex, including kahikatea swamp forest, and an extensive terrestrial to estuarine ecological sequence, the potential adverse ecological effects are likely to be no more than minor.

If future monitoring reveals increasing nutrient levels in the wetland complex, for either one monitoring point through time, or for multiple monitoring points along an east-west gradient, a comprehensive ecological monitoring programme should be designed and implemented. This monitoring will need to include groundwater levels, tree health, foliar nitrogen content, and vegetation mapping. Any assessment of the effects of nutrient enrichment needs to consider the relative roles of the wastewater discharge, fertiliser application within the golf course, and any other potential sources of nutrients within the wider catchment.

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REFERENCES

- Aber J.D., Nadelhoffer K.J., Steudler P., and Melillo J.M. 1989: Nitrogen Saturation in Northern Forest Ecosystems. *BioScience* 39(6): 378-386.
- Atkinson I.A.E. 1985: Derivation of vegetation mapping units for an ecological survey of Tongariro National Park, North Island, New Zealand. *New Zealand Journal of Botany* 23: 361-378.
- Boffa Miskell 2000: Baseline Biological Monitoring of Omaha South Kahikatea Forest: Vegetation assemblage and current condition Report 2: Summer Period. Prepared for Manapouri Developments Ltd.
- Boffa Miskell Ltd and Woodward Clyde Consultants Ltd 1999: Omaha Wastewater Golfcourse Irrigation. Application 3. Prepared for Rodney District Council and Manapouri Developments. 52 pp.
- Burns B.R., Smale M.C., and Merrett M.F. 1999: Dynamics of kahikatea forest remnants in middle North Island: implications for threatened and local plants. *Science for Conservation Series 113*. Department of Conservation, Wellington.
- Coats R.N., Leonard R.L., and Goldman C.R. 1976: Nitrogen Uptake and Release in a Forested Watershed, Lake Tahoe Basin, California. *Ecology* 57(5): 995-1004.
- Cooke J.G., Cooper B., and Clunie N.M.U. 1990: Changes in the water, soil, and vegetation of a wetland after a decade of receiving sewage effluent. *New Zealand Journal of Ecology* 14: 37-47.
- de Lange P., Rolfe J., Champion P., Courtney S., Heenan P., Barkla J., Cameron E., Norton D., and Hitchmough R. 2013: Conservation status of New Zealand indigenous vascular plants, 2012. *New Zealand Threat Classification Series 3*. Department of Conservation, Wellington. 70 pp.
- de Winton M., Bodmin K., and Champion P. 2010: Review of weed transfer risk associated with mudfish sampling and mitigation strategies. *NIWA Client Report: HAM2010-068*. National Institute for Water and Atmospheric Research Limited, Hamilton. Prepared for the Department of Conservation.
- Enright N.J. and Ogden J. 1995: The southern conifers - a synthesis. In: Enright N. J.; Hill R.S. (Editors) *Ecology of the southern conifers*. Melbourne. University Press, Melbourne. 341 pp.
- Eugster W. and Haeni M. 2013: Nutrients or pollutants? Nitrogen Deposition to European forests. In: R. Matyssek, N. Clarke, P. Cudlin, T. N. Mikkelsen, J.-P. Tuovinen G. Wieser, & E. Paoletti (Eds.), *Climate Change, Air Pollution and Global Challenges: Knowledge, Understanding and Perspectives from Forest Research*, Elsevier Physical Sciences Series "Developments in Environmental Science" 13: 37-56.

- Fenn M.E., Poth M.A., Aber J.D., Baron J.S., Bormann B.T., Johnson DW., Lemly A.D., McNulty S.G., Ryan D.F., and Stottlemeyer R. 1998: Nitrogen excess in North American ecosystems: predisposing factors, ecosystem responses, and management strategies. *Ecological Applications* 8(3): 706-733.
- Goodman J.M., Dunn N.R., Ravenscoft P.J., Allibone R.M., Boubée J.A.T., David B.O., Griffiths M., Ling N., Hitchmough R., and Rolfe J.R. 2014: Conservation status of New Zealand freshwater fish, 2013. *New Zealand Threat Classification Series 7*. Department of Conservation, Wellington. 12 pp.
- Heather B.D. and Robertson H.A. 1996: The field guide to birds of New Zealand. Penguin Books, Auckland. 440 pp.
- Hitchmough R., Anderson P., Barr B., Monks J., Lettink M., Reardon J., Tocher M., and Whitaker T. 2013: Conservation status of New Zealand reptiles, 2012. *New Zealand Threat Classification Series 2*. Department of Conservation, Wellington. 16 pp.
- Ling L., O'Brien L.K., Miller R., and Lake M. 2009: Methodology to survey and monitor New Zealand mudfish species. *CBER Contract Report 104*. Department of Conservation and University of Waikato, Hamilton. 60 pp.
- Mitchell N.D., Campbell G.H., Cutting M.L. Ayres B.D., Hilton M., and Slaven D. 1992: Rodney Ecological District Survey Report for the Protected Natural Areas Programme (1983-1984). Department of Conservation, Auckland.
- Robertson H.A., Dowding J.E., Elliot G.P., Hitchmough R.A., Miskelly C.M., O'Donnell C.F.J., Powlesland R.G., Sagar P.M., Scofield R.P., and Taylor G.A. 2013: *Conservation status of New Zealand birds*. *New Zealand Threat Classification Series 4*. Department of Conservation, Wellington.
- Smale M.C, Ross C.W., and Arnold G.C 2005: Vegetation recovery in rural kahikatea (*Dacrydium dacrydioides*) forest fragments in the Waikato region, New Zealand, following retirement from grazing. *New Zealand Journal of Ecology* 29(2): 261-269.
- Wildland Consultants 2015: Desktop review of wading bird diversity and abundance within the Waikokopu Creek Arm, Omaha. *Wildland Consultants Ltd Contract Report No. 3605*. Prepared for Watercare. Wildland Consultants, Auckland. 10 pp.

FRESHWATER FISH TRAPPING METHODS

Traps were set and baited according to best practice for mudfish monitoring (Ling *et al.* 2009). Key considerations were as follows:

- Traps were placed partly submerged, so that atmospheric air could be breathed by captured fish, and to increase capture of mudfish foraging on the surface at night.
- Traps were placed out of public view, to reduce the likelihood of theft and/or interference with monitoring.
- Traps were unbaited, as studies have shown that baiting has no effect on catch rates, and bait may increase the capture of mudfish predators, such as eels (*Anguilla* spp.).
- Unless there was an intervening high point or obstruction, traps were set at least 3 m apart, so that the presence of a trap did not unduly affect catch rates of any adjacent traps.
- Traps were cleaned before use, to ensure no transfer of invasive aquatic organisms between sites (as per Winton *et al.* 2010).
- Traps were counted prior to and post sampling, to ensure that all traps had been removed from the site at the end of each monitoring round.
- The location of each individual trap was recorded and mapped using a GPS unit.
- A strip of pink flagging tape was securely tied to the nearest branch immediately adjacent to each trap.
- Each fish caught was identified and released.
- Traps were cleaned thoroughly following removal from the field.

VASCULAR PLANT SPECIES LIST FOR THE OMAHA-TANIKO WETLANDS, OMAHA

INDIGENOUS SPECIES

Gymnosperms

<i>Dacrycarpus dacrydioides</i>	kahikatea
<i>Dacrydium cupressinum</i>	rimu
<i>Podocarpus totara</i> var. <i>totara</i>	totara

Monocot. trees and shrubs

<i>Cordyline australis</i>	tī kōuka, cabbage tree
<i>Rhopalostylis sapida</i>	nīkau

Dicot. trees and shrubs

<i>Avicennia marina</i> subsp. <i>australasica</i>	mānawa, mangrove
<i>Beilschmiedia tarairi</i>	taraire
<i>Beilschmiedia tawa</i>	tawa
<i>Carmichaelia australis</i>	maukoro, tainoka, taunoka
<i>Carpodetus serratus</i>	putaputawētā
<i>Coprosma areolata</i>	
<i>Coprosma lucida</i>	karamū, kāramuramu, glossy karamu
<i>Coprosma macrocarpa</i> subsp. <i>minor</i>	karamū, kāramuramu
<i>Coprosma rhamnoides</i>	
<i>Coprosma robusta</i>	karamū, kāramuramu
<i>Coprosma spathulata</i> subsp. <i>spathulata</i>	
<i>Corynocarpus laevigatus</i>	karaka
<i>Geniostoma ligustrifolium</i> var. <i>ligustrifolium</i>	hangehange
<i>Hedycarya arborea</i>	porokaiwhiri; pigeonwood
<i>Kunzea robusta</i>	
<i>Laurelia novae-zelandiae</i>	pukatea
<i>Leptospermum scoparium</i> agg.	mānuka
<i>Leucopogon fasciculatus</i>	mingimingi
<i>Melicytus ramiflorus</i> subsp. <i>ramiflorus</i>	māhoe
<i>Myrsine australis</i>	māpou, matipou, māpau
<i>Pittosporum crassifolium</i>	karo
<i>Pittosporum tenuifolium</i>	kōhūhū, rautāhiri, rautāwhiri
<i>Plagianthus divaricatus</i>	marsh ribbonwood mākaka
<i>Pseudopanax crassifolius</i>	horoeaka, lancewood
<i>Pseudopanax crassifolius</i> × <i>P. lessonii</i>	
<i>Pseudopanax lessonii</i>	houpara
<i>Vitex lucens</i>	pūriri

Monocot. lianes

Freycinetia banksii
Ripogonum scandens

kiekie
supplejack, kareao

Dicot. lianes

Calystegia sepium subsp. *roseata*
Metrosideros perforata
Muehlenbeckia complexa
Rubus australis

pōhue
aka
pōhuehue
tātārāmoa

Ferns

Asplenium flaccidum
Asplenium oblongifolium
Azolla filiculoides
Blechnum filiforme
Blechnum minus
Blechnum novae-zelandiae
Cyathea dealbata
Cyathea medullaris
Deparia petersenii subsp. *congrua*
Dicksonia squarrosa
Doodia australis
Gleichenia dicarpa
Histiopteris incisa
Hypolepis ambigua
Lastreopsis microsora subsp. *pentangularis*
Microsorium pustulatum

Microsorium scandens
Ophioglossum petiolatum
Paesia scaberula
Pteridium esculentum
Pteris tremula
Pyrrosia eleagnifolia

makawe, ngā makawe o Raukatauri
huruhuru whenua
retoretore
pānako
swamp kiokio
kiokio
ponga, silver fern
mamaku

whekī
pukupuku
tangle fern, swamp umbrella fern
mātātā, water fern

kōwaowao, pāraharaha, hound's
tongue fern
mokimoki

mātātā
rārahu, bracken
turawera, shaking brake
leather-leaf fern

Orchids

Microtis unifolia agg.
Pterostylis banksii
Thelymitra spp.

tutukiwi

Grasses

Austrostipa stipoides
Isachne globosa
Microlaena stipoides

swamp millet
pāfīfī, meadow rice grass

Oplismenus hirtellus subsp. *imbecillis*

Sedges

<i>Carex dissita</i>	
<i>Carex lambertiana</i>	
<i>Carex maorica</i>	
<i>Carex virgata</i>	pūrei
<i>Cyperus ustulatus</i> f. <i>ustulatus</i>	toetoe upoko-tangata
<i>Eleocharis acuta</i>	spike sedge
<i>Eleocharis gracilis</i>	
<i>Ficinia nodosa</i>	wīwī
<i>Gahnia xanthocarpa</i>	tupari-maunga
<i>Isolepis cernua</i>	
<i>Isolepis prolifera</i>	
<i>Machaerina juncea</i>	
<i>Machaerina rubiginosa</i>	
<i>Machaerina teretifolia</i>	
<i>Schoenoplectus tabernaemontani</i>	kāpūngāwhā
<i>Schoenus tendo</i>	wīwī
<i>Uncinia uncinata</i>	kamu matau a Maui, kamu

Rushes

<i>Apodasmia similis</i>	oioi
<i>Juncus kraussii</i> var. <i>australiensis</i>	wī, wīwī sea rush
<i>Juncus pallidus</i>	wī, wīwī
<i>Juncus planifolius</i>	
<i>Juncus sarophorus</i>	wī, wīwī

Monocot. herbs (other than orchids, grasses, sedges, and rushes)

<i>Collospermum hastatum</i>	kahakaha
<i>Dianella nigra</i>	tūrutu
<i>Lemna disperma</i>	karearea
<i>Phormium tenax</i>	harakeke, flax
<i>Potamogeton cheesemanii</i>	manihi
<i>Potamogeton ochreatus</i>	
<i>Triglochin striata</i>	arrow grass
<i>Typha orientalis</i>	raupō

Composite herbs

<i>Centipeda minima</i> subsp. <i>minima</i>	
<i>Cotula coronopifolia</i>	bachelor's button
<i>Senecio esleri</i>	

Dicot. herbs (other than composites)

Centella uniflora

<i>Epilobium pallidiflorum</i>	tawarewa
<i>Galium propinquum</i>	mawe
<i>Gonocarpus micranthus</i>	piripiri
<i>Hydrocotyle novae-zeelandiae</i> var. <i>novae-zeelandiae</i>	
<i>Lobelia anceps</i>	punakura
<i>Nertera dichondrifolia</i>	
<i>Nertera scapanioides</i>	
<i>Persicaria decipiens</i>	tutunawai
<i>Ranunculus amphitrichus</i>	kawariki
<i>Samolus repens</i> var. <i>repens</i>	māakoako
<i>Selliera radicans</i>	remuremu, rekoreko, raumangu

NATURALISED AND EXOTIC SPECIES

Gymnosperms

<i>Cupressus macrocarpa</i>	macrocarpa
<i>Pinus radiata</i>	radiata pine

Monocot. trees and shrubs

<i>Archontophoenix cunninghamiana</i>	bangalow palm
<i>Yucca gloriosa</i>	yucca

Dicot. trees and shrubs

<i>Acacia longifolia</i>	Sydney golden wattle
<i>Banksia integrifolia</i>	banksia
<i>Casuarina</i> sp.	sheoak
<i>Eriobotrya japonica</i>	loquat
<i>Ficus macrophylla</i>	Moreton Bay fig
<i>Lagunaria patersonia</i> subsp. <i>patersonia</i>	Norfolk Island hibiscus tree
<i>Paraserianthes lophantha</i>	brush wattle
<i>Salix babylonica</i>	weeping willow
<i>Solanum mauritianum</i>	woolly nightshade
<i>Syzygium smithii</i>	lillypilly, monkey apple
<i>Ulex europaeus</i>	gorse

Ferns

<i>Nephrolepis cordifolia</i>	tuber ladder fern
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Grasses

<i>Anthoxanthum odoratum</i>	sweet vernal
<i>Axonopus fissifolius</i>	narrow-leaved carpet grass
<i>Briza maxima</i>	large quaking grass
<i>Cenchrus clandestinus</i>	kikuyu grass
<i>Cortaderia selloana</i>	pampas
<i>Holcus lanatus</i>	Yorkshire fog

<i>Paspalum dilatatum</i>	paspalum
<i>Rytidosperma racemosum</i>	danthonia
<i>Schedonorus arundinaceus</i>	tall fescue

Sedges

<i>Cyperus brevifolius</i>	globe sedge
<i>Cyperus congestus</i>	purple umbrella sedge
<i>Cyperus eragrostis</i>	umbrella sedge

Rushes

<i>Juncus acuminatus</i>	sharp-fruited rush
<i>Juncus effusus</i> var. <i>effusus</i>	soft rush, leafless rush
<i>Juncus tenuis</i> var. <i>tenuis</i>	track rush

Monocot. herbs (other than orchids, grasses, sedges, and rushes)

<i>Agapanthus praecox</i>	agapanthus
<i>Tradescantia fluminensis</i>	tradescantia

Composite herbs

<i>Aster subulatus</i>	sea aster
<i>Cirsium vulgare</i>	Scotch thistle
<i>Conyza sumatrensis</i>	broad-leaved fleabane
<i>Hypochaeris radicata</i>	catsear
<i>Leontodon taraxacoides</i>	hawkbit
<i>Senecio bipinnatisectus</i>	Australian fireweed
<i>Taraxacum officinale</i>	dandelion

Dicot. herbs (other than composites)

<i>Anagallis arvensis</i>	scarlet pimpernel
<i>Crassula multicava</i>	fairly crassula
<i>Daucus carota</i>	wild carrot
<i>Impatiens walleriana</i>	busy lizzie
<i>Lotus pedunculatus</i>	lotus
<i>Lotus suaveolens</i>	hairy birdsfoot trefoil
<i>Ludwigia palustris</i>	water purslane
<i>Lythrum hyssopifolia</i>	hyssop loosestrife
<i>Myosotis laxa</i> subsp. <i>caespitosa</i>	water forget-me-not
<i>Phytolacca octandra</i>	inkweed
<i>Plantago australis</i>	swamp plantain
<i>Plantago lanceolata</i>	narrow-leaved plantain
<i>Prunella vulgaris</i>	selfheal
<i>Ranunculus repens</i>	creeping buttercup
<i>Rumex acetosella</i>	sheep's sorrel
<i>Solanum nodiflorum</i>	
<i>Verbena bonariensis</i>	purple-top

FAUNA SPECIES LIST FOR THE OMAHA-TANIKO WETLANDS, OMAHA

BIRDS

Indigenous

<i>Anthornis melanura melanura</i>	korimako; makomako; bellbird
<i>Ardea novaehollandiae</i>	white-faced heron, blue heron
<i>Bowdleria punctata vealeae</i>	mātātā; North Island fernbird
<i>Calidris canutus</i>	huahou, lesser knot
<i>Circus approximans</i>	kāhu; swamp harrier
<i>Gerygone igata</i>	riroriro; grey warbler
<i>Haematopus unicolor</i>	tōrea, tōrea pango, variable oystercatcher
<i>Hemiphaga novaeseelandiae</i>	kererū; kūkupa; New Zealand pigeon
<i>Himantopus himantopus leucocephalus</i>	poaka; pied stilt
<i>Larus dominicanus dominicanus</i>	karoro; southern black-backed gull
<i>Larus novaehollandiae scopulinus</i>	tarāpunga; red-billed gull
<i>Limosa</i> sp.	godwit
<i>Phalacrocorax sulcirostris</i>	little black shag
<i>Porphyrio melanotus melanotus</i>	pūkeko
<i>Prothemadera novaeseelandiae novaeseelandiae</i>	tūī
<i>Rhipidura fuliginosa placabilis</i>	pīwakawaka; North Island fantail

Introduced

<i>Anas platyrhynchos platyrhynchos</i>	mallard
<i>Gymnorhina tibicen</i>	Australian magpie
<i>Passer domesticus domesticus</i>	house sparrow
<i>Phasianus colchicus</i>	common pheasant
<i>Platycercus eximius</i>	eastern rosella
<i>Turdus merula merula</i>	Eurasian blackbird
<i>Turdus philomelos</i>	song thrush

REPTILES MOKOMOKO

Mokomoko is the general Māori name for skink and gecko

Lampropholis delicata rainbow skink

FISH

Indigenous

Anguilla dieffenbachii longfin eel
Anguilla australis shortfin eel
Gambusia affinis mosquitofish

SITE PHOTOGRAPHS



Plate 1: Ecological sequence from sea rush-oioi rushland (foreground) to manuka scrub and kahikatea forest (distance), south of Broadlands Drive. . 8 January 2015.



Plate 2: Eastern edge of kahikatea forest to the north of Broadlands Drive. Death of canopy foliage is evident on the eastern edge of the trees and is most likely due to damage from salt spray. 8 January 2015.



Plate 3: Kahikatea forest to the south of Broadlands Drive. 9 January 2015.



Plate 4: Exotic grassland between fairway and kahikatea forest to the north of Broadlands Drive. Vegetation in shallow depressions is dominated by species such as narrow-leaved carpet grass and sedge species (foreground). Better drained soils within this vegetation type are dominated by kikuyu grass (upper left). Manuka is frequent throughout. 8 January 2015.



Plate 5: Manuka-*Machaerina rubiginosa* shrubland on eastern edge of kahikatea forest, to the north of Broadlands Drive. Tangle fern (photograph centre) is locally abundant. 9 January 2015.



Plate 6: Pond on eastern edge of kahikatea forest, to the north of Broadlands Drive. Aquatic vegetation includes tutunawai (*Persicaria decipiens*), *Isolepis prolifer*, and k p ng wh  (*Schoenoplectus tabernaemontani*).



Plate 7: Interior of manuka scrub to the south of Broadlands Drive. The understorey is dominated by *Gahnia xanthocarpa* and kiokio, with *Ranunculus amphitricus* common in seasonally dry pools 9 January 2015.



Plate 8: Kanuka forest on central eastern edge of wetland complex. Kanuka are dominant in the canopy, over a shrub tier of mingimingi (*Leucopogon fasciculatus*) and *Gahnia xanthocarpa*. Sedgeland dominated by *Machaerina* spp. in foreground. 9 January 2015.



Plate 9: Exotic grassland dominated by sweet vernal (foreground) with patches of *Machaerina* sedgeland in low-lying depressions (centre). Manuka saplings and shrubs are frequent throughout. Exclusion fence and planted ti kouka are visible (photograph top left).



Plate 10: Mangrove shrubland in estuary to the south of Broadlands Drive. Mangroves to c.1 m tall form a broken cover over sandy intertidal flats. Patches of sea rush (centre left) occur along the landward edge. 9 January 2015.



Plate 11: *Ophioglossum petiolatum*, listed as “Threatened-Nationally Critical”, in kahikatea forest on the southern edge of Broadlands Drive. 9 January 2015.



Plate 12: Sneezeweed (*Centipeda minima*) (light green with small spherical seed heads) on the margins of the fairway to the north of Broadlands Drive. This species is dependent on disturbed habitats and is listed as “Threatened-Nationally Endangered”. 8 January 2015.



Plate 13: Juvenile shortfin eels and longfin eels captured in the eastern pond. 9 January 2015.



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