Bay of Plenty Regional Council

Kaituna River Rediversion & Ongatoro/Maketū Estuary Enhancement Project

Terrestrial, Avian and Wetland Restoration Ecology

Assessment of Environmental Effects

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Assessment of Environmental Effects

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Executive Summary

The Kaituna River Re-diversion and Ongatoro - Maketū Estuary Enhancement Project proposes to re-divert an additional 16% (for a total of 20%) of the Kaituna River's flow back into Ongatoro - Maketū Estuary to improve the health and restore some of the mauri of the area by allowing salt marsh and freshwater wetlands to recover creating more suitable habitat for a range of species, and to reduce the rate at which sand fills in the estuary and possibly set in motion a process of gradual sand erosion. In addition, up to 27.5 ha of wetland will be created around the estuary margins on land that was largely wetland prior to development for farming.

A new channel to draw increased Kaituna River flow into Ford's Cut and then into the Ongatoro - Maketū Estuary will be constructed and the section of Ford's Loop Channel that currently feeds water into Ford's Cut will be filled in and established as a wetland area.

Stopbanks surrounding the Brain block of land and causeways linking the Brain land to Papahikahawai Island will be removed (assuming purchase of the land from the Brain family), and the stopbanks along the southern edge of Papahikahawai Island may be removed (at the owners' discretion) if it can be shown that the island is not at risk of further loss due to erosion.

This report provides an assessment of the environmental effects of the proposed project on three aspects of the area's ecology:

1. The potential effects of re-diversion on the terrestrial and wetland vegetation including the estuarine margins and areas of salt marsh, Maketū Spit and Wildlife Management Reserve and lower Kaituna River margins;
2. The potential effects of re-diversion on the avifauna and avian habitat on and around the margins of the estuary;
3. The potential effects of establishment of up to 27.5 ha of wetland on the ecology of the estuary and its surrounds. Consideration is also given to the likely effects of revegetation of Papahikahawai Island, including both the southern wetland portion and the remaining terrestrial portion of the island.

<u>Potential ecological effects on vegetation:</u>

- None of the physical and chemical changes likely to occur as a result of the river re-diversion are expected to have significant adverse effects on the remaining salt marsh areas within Maketū estuary.
- It is likely that there will be some changes in species composition of the vegetation in parts of the Titchmarsh wetland in response to the predicted increase in salinity in the lower Kaituna River. However, vegetation collapse within the Titchmarsh wetland area is not considered likely as a result of the re-diversion because of the existing predominance of salt tolerant species along the margins that are likely to be exposed to the increased salinity. A monitoring programme has been recommended to track any vegetative changes and contingency mitigation measures proposed should they be necessary.
- The vegetation on Ford Island is not expected to change greatly.
- Maketu Spit vegetation is also not expected to change significantly as a result of the re-diversion.

- There is a low risk of accelerated erosion along parts of the southern edge of Papahikahawai Island if the stopbanks are removed. From an ecological perspective, removal of the stopbanks and creation of a natural ecotone from estuarine sand flats through estuarine wetland, palustrine wetland and into terrestrial vegetation would maximise the benefits of the project. However, due to the uncertainty about the risk of accelerated erosion, postponement of the removal of the stopbanks on the island is recommended until a better understanding of the impact of re-diversion on erosion is obtained.
- There has been a reduction in ground level of up to 600mm on the Brain land over the last 30 years (R.Waugh pers comm) as a result of land drainage, peat mineralisation and compaction, consequently, most of the Brain land is likely now to be predominantly suitable for salt marsh species rather than the freshwater species that once grew there.
- Changes to salinity and removal of the stopbanks in the north-western corner of the estuary may create conditions suitable for salt marsh species to establish naturally or be replanted.
- Predicted increases in current flow may make the estuarine conditions in the area of the large salt marsh that has since disappeared unsuitable for the re-establishment of salt marsh.

<u>Potential ecological effects on avian ecology:</u>

- No significant adverse effects are expected on the shorebird and wader avifauna currently using the estuary.
- The potential increase in estuarine benthic invertebrate fauna may lead to increased and improved feeding grounds for waders.
- Birds inhabiting the remaining salt marsh areas are unlikely to be negatively affected by the re-diversion because the existing salt marsh areas are expected to remain intact (and some may enlarge naturally).
- There is some risk of a small decline in the size of the Titchmarsh wetland which may have an effect on the wetland bird species inhabiting this area but this is likely to be more than compensated for by a substantial increase in wetland habitat that will occur with the proposed restoration of up to 27.5 ha of wetland on the Brain land and Papahikahawai Island.

<u>Potential ecological effects of wetland restoration:</u>

No adverse effects are expected on the existing ecology as a result of the restoration of the proposed 27.5 ha of wetland. On the contrary, substantial beneficial effects are anticipated. The diversity and abundance of indigenous plants and animals will increase substantially as a result of the increased area of high value habitat and increased biological productivity. Aspects of water quality may also improve as a result of the removal of grazing livestock from the estuary margins and the nutrient trapping and extraction capacity of healthy functioning wetlands.

1 Introduction

The Kaituna River Re-diversion and Ongatoro - Maketū Estuary Enhancement Project was set up to implement part of the Kaituna River and Ongatoro - Maketū Estuary Strategy (BOPRC 2009) in response to long-standing tangata whenua and community concerns about environmental degradation in the estuary.

The Applicant (Bay of Plenty Tegional Council) proposes to re-divert an additional 16% (for a total of 21%) of the Kaituna River's flow back into Ongatoro - Maketū Estuary to improve the health and restore some of the mauri of the area by allowing salt marsh and freshwater wetlands to recover creating more suitable habitat for a range of species, and possibly reducing the rate at which sand fills in the estuary. In addition, up to 27.5 ha of wetland will be created around the estuary margins on land that was largely wetland prior to development for farming.

The goal of the Kaituna River Re-diversion and Ongatoro - Maketū Estuary Enhancement Project is:

> *'To significantly increase the volume of water (particularly freshwater) flowing from the Kaituna River through Ongatoro - Maketū Estuary by 2018 in a way that maximises the ecological and cultural benefits (particularly wetlands and kaimoana), while limiting the economic cost and adverse environmental effects to acceptable levels.'*

Opus International Consultants (Opus) and River Lake Ltd were commissioned by Bay of Plenty Regional Council (BOPRC) to provide ecological advice to identify wetland creating opportunities and to assess the potential effects of the project prior to applying for resource consents.

This report provides an assessment of the environmental effects of the proposed project on three aspects of the area's ecology:

1. The potential effects of re-diversion on the terrestrial vegetation including the estuarine margins and areas of salt marsh, Maketū Spit and Wildlife Management Reserve and lower Kaituna River margins;
2. The potential effects of re-diversion on the avifauna and avian habitat on and around the margins of the estuary;
3. The potential effects of establishment of up to 27.5 ha of wetland on the ecology of the estuary and its surrounds. Consideration is also given to the likely effects of revegetation of Papahikahawai Island, including both the southern wetland portion and the remaining terrestrial portion of the island.

Each aspect is considered in separate sections in the report that follows.

The assessment of effects on other aspects of the ecology, including fish, benthic organisms, macroinvertebrates, and algae, as well as consideration of the influences of changes in salinity, water quality and water flow, are covered in a separate report prepared by K. Hamill (2014).

Information about the nature and extent of the physical changes that will occur with the re-diversion of Kaituna River flow into the estuary have been provided by other specialists (Dahm 2014; DHI 2014; Everitt, 2014; Park, 2014). In particular, comprehensive modelling of potential outcomes has been undertaken by DHI and I have used this information as the basis for assessing likely ecological changes. The nature of the changes predicted by modelling is detailed below.

2 Project Description

2.1 Proposed Works

Visual representation of the re-diversion works can be seen in Figure 1 and 2. Detailed description of the physical work that will be undertaken is provided in other reports.

In summary, the proposal is to create a new channel to draw more flow from the Kaituna River into Ford's Cut and then into the Ongatoro - Maketū Estuary. The new channel will link with the Kaituna River channel approximately 1000 metres west (upstream) of the current Ford's Cut inlet. The Ford's Loop Channel that currently feeds water into Ford's Cut from beside Ford Road will be filled in and established as a wetland area.

The proposal also includes the removal of stopbanks along the east – north east edge of the low-lying grazed land to the east of Ford Road (referred to as the Brain land), the removal of the causeways linking the Brain land with Papahikahawai Island, the removal of the stopbanks between Papahikahawai Island and Maketū Spit, and potentially, the removal of all of the stopbanks along the southern edge of Papahikahawai Island. It is likely that some of the major drains on the Brain land will be filled with stopbank / causeway material to restore a more natural hydrology to the area. The removal of the stopbanks will result in the re-flooding of most of the Brain land and a portion of the southern side of Papahikahawai Island.

In conjunction with the re-diversion of Kaituna River water into the estuary, the intention is to re-establish freshwater and salt marsh wetlands wherever each is possible by restoring indigenous plants into up to 27.5 ha of estuarine margin. These areas can be seen in Figure 1 and 2 and include the area known as the Brain land (19 ha), the southern low-lying flats of Papahikahawai Island (8 ha), and the portion of Ford's Loop Channel (0.5 ha) that is to be filled. All of these areas were wetland (a mix of salt marsh and palustrine) habitat prior to drainage and development for farming. It has been assumed for the purposes of writing this report that the land owned by the Brain family will become available for restoration back to wetland, however it is acknowledged that, at this time, no agreement regarding sale and purchase of the land has been reached between the Brain family and Bay of Plenty Regional Council.

Figure 1: Graphic representation of the proposed re-diversion works and wetland restoration

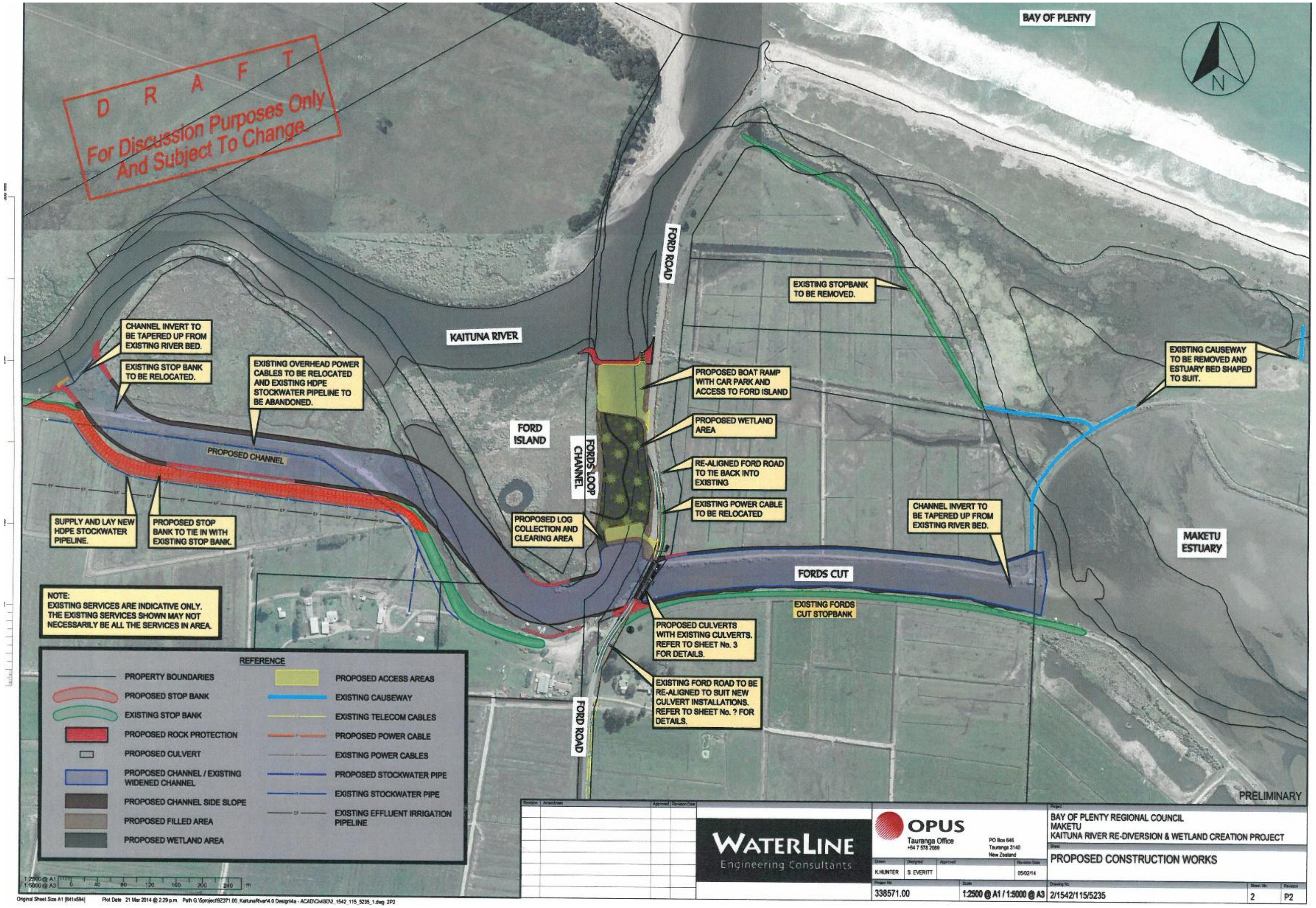


Figure 2: Details of the proposed physical re-diversion works.

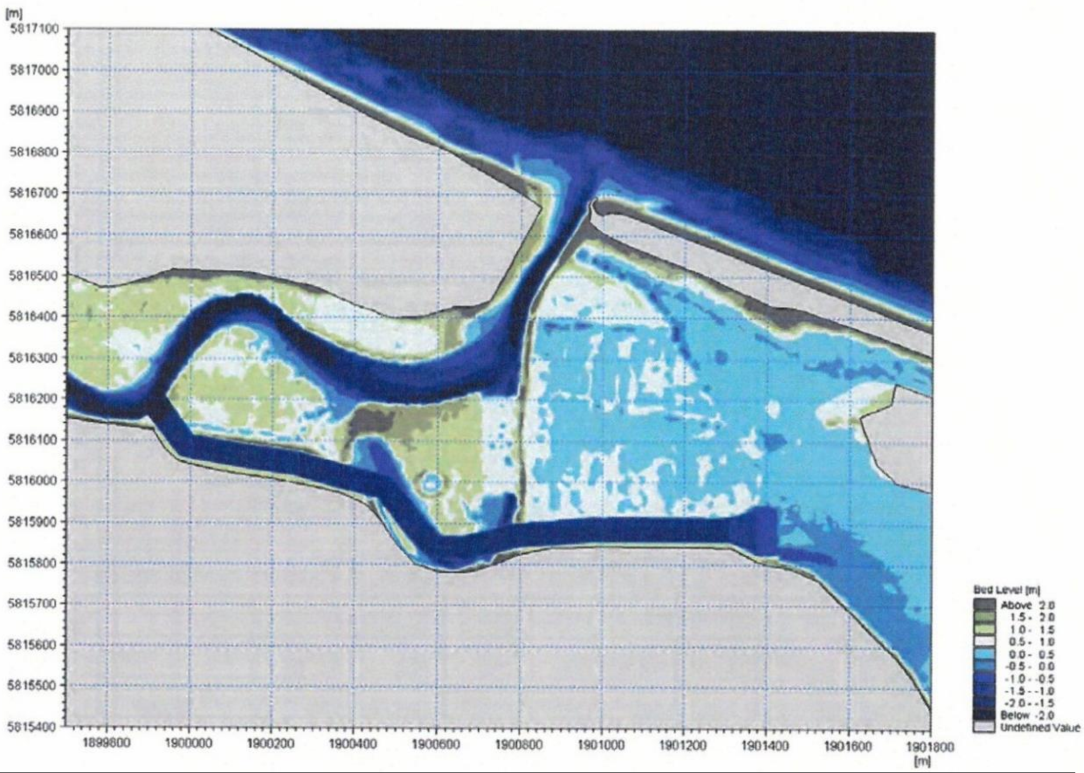


Figure 3: Representation of upper estuary and lower Kaituna River areas likely to be inundated with river and/or tidal water following re-diversion and removal of the stopbanks and causeway, as modelled by DHI (2014).

3 Terrestrial and Riparian Vegetation

3.1 Ecological Description

3.1.1 Historical vegetation

Prior to significant clearance by Maori and Europeans, the landscape around the Maketū estuary and Lower Kaituna River would have been clothed with a mix of swamp forest dominated by kahikatea (*Dacrycarpus dacrydioides*) with swamp maire (*Syzygium maire*) and large areas of kiekie (*Freycinetia banksii*) present, and extensive freshwater wetlands dominated by flax (*Phormium tenax*), raupo (*Typha orientalis*), wiwi (*Ficinia nodosa*) and a variety of reed species (Wildland 2005, Goodhue 2007). Extensive areas of "tea tree", likely to be manuka (*Leptospermum scoparium*) rather than kanuka (*Kunzea ericoides*), were also reported around the estuary area (Goodhue 2007).

The Ongatoro - Maketū estuary contained extensive areas of saltmarsh in the tidal zone (approx. 170 ha compared to little more than 5 ha remaining today; KRTA 1986), with sea rush (*Juncus kraussii var. australiensis*) dominant at the tidal edge and oioi (*Apodasmia similis*) and saltmarsh ribbonwood (*Plagianthus divaricatus*) common behind the sea rush in the slightly more elevated areas. Extensive eelgrass beds (*Zostera muelleri)* occurred above the mid-tide zone in the central portions of the estuary and large stands of *Bolboschoenus caldwellii* were also reported in the western areas of the estuary (Donovan et al 1976). When compared to more northern estuaries (such as Tauranga), mangroves (*Avicennia marina*) appear never to have been particularly abundant nor to have grown particularly large within Ongatoro - Maketū estuary. However, a photograph taken in 1865 (Murray 1978) shows them to be considerably more numerous than the nine reported by Murray and a similar number reported by Bergin (1991) adjacent to Maketū Road. Ongatoro - Maketū is reasonably close to the natural southern limit for mangroves, which may explain their limited occurrence.

Very little information exists regarding the vegetation that grew on Papahikahawai Island before it was cleared, other than an extensive area of salt marsh (approx. 70 ha) existed on its southern edge which extended well out into the estuary channel (see more information below). Salt marsh species including sea rush, oioi, saltmarsh ribbonwood, *Bolboschoenus caldwellii* and a selection of saltmarsh / salt meadow species such as bachelor's button (*Cotula coronopifolia*), remuremu (*Selliera radicans*) and glasswort (*Sarcocornia quinqueflora*) would have occurred on the most low-lying sections of the island exposed to tidal sea water intrusion (Donovan et al 1976). The island flats above the high tide mark would have been freshwater wetlands, probably dominated by flax with stands of raupo (*Typha orientalis*), wetland rushes and sedges, mingimingi (*Coprosma propinqua*) and possibly scattered cabbage trees (*Cordyline australis*).

The top of the island and northern, coastal-facing slopes are likely to have had a cover of hardy, salt tolerant mid-dune species such as pohuehue (*Muehlenbeckia complexa*), tauhinu (*Ozothamnus leptophylla*) and taupata (*Coprosma repens*) Interestingly, matagouri (*Discaria toumatou*), a plant better known in the South Island high country, used to occur on the dunes in this area (last reported by Murray 1978). Manuka (*Leptospermum scoparium*) and other "scrub" species such as *Pomaderris phlicifolia var. ericifolia* are known to have been common in the area and would have occupied the wetland margins and exposed south-facing slopes and are likely to have been interspersed with tree species such as ti kouka (cabbage tree, *Cordyline australis*), ngaio (*Myoporum laetum),* houpara (*Pseudopanax lessonii*) and karo (*Pittosporum crassiflolium*). It is possible that some larger coastal trees, such as karaka (*Corynocarpus laevigatus*), puriri (*Vitex lucens*) and possibly whau (*Entelea arborescens)* may have grown in the more sheltered depressions that run south to the estuary.

The Maketū spit would originally have had a typical cover of fore- and mid-dune species. Pingao (*Ficinia spiralis*) and spinifex (*Spinifex sericeus*) would have anchored the seaward side of the dune (spinifex predominates there today) and spinifex, pohuehue, shore bindweed (*Calystegia soldanella*), sand coprosma (*Coprosma acerosa*), coastal flax (*Phormium cookianum*), and toe toe (*Cortaderia toetoe*) would have dominated the landward side of the dunes. Taupata, ngaio, karo and cabbage tree probably occurred in small numbers only because the spit has a history of being breached. It is unlikely that the dune ever remained sufficiently stable to enable small stands of coast trees to establish. A 1992 survey, and subsequent surveys, recorded the threatened sand tussock hinarepe (*Poa billiardierei*) on the spit. This species is likely to have been more prevalent prior to the introduction of rabbits and the unconfined grazing of livestock.

3.1.2 Changes since the early 1900's

Extensive man-made changes have been made to the environment around the Ongatoro - Maketū estuary since 1900, and within the estuary itself (especially since the 1950's). These have directly or indirectly lead to changes to the vegetation (and faunal habitat) of the estuary, estuarine margins and surrounding wetland and terrestrial areas. Likely changes in the location and extent of vegetation in Ongatoro - Maketū Estuary over the period 1939 – 2011 were assessed using a Geographic Information System (GIS) (Park 2014). KRTA (1986) also undertook their own estimation of areas lost. The areas calculated by Park and KRTA vary by a small margin but the general extent of decline is consistent. The results of the GIS assessment are presented in Figure 5 A-E, and the KRTA summation in Figure 4. Major changes that have occurred since 1900 include (largely extrapolated from KRTA (1986):

1. *Drainage of Kaituna system wetlands.*
   14,000 ha of wetland have been drained, cleared of vegetation and converted to farmland in the early 1900's.

2. *Stopbanking.*
   Stopbanking of the southern edge of the estuary from Ford's Cut to Maketū Road between 1948 and 1959 to safeguard a large area of farmland against flooding resulted in the isolation of 46 ha of salt marsh. Once cut off from daily tidal cycles the salt marsh species would have declined rapidly.

   A stopbank and causeway was built in 1961 to provide a link between the farmland near Ford's Cut and Papahikahawai Island and an additional causeway was built to link the island to the spit. The consequence was the isolation of another 45 ha of salt marsh.

   By 1977 a stopbank had been built along the southern edge of Papahikahawai Island which cut off a further 10 ha of salt marsh.

   More stopbanking and drainage occurred near Maketū Road in 1979 effectively removing another 7 ha of salt marsh.

3. *Kaituna River Diversion*
   The Kaituna River was diverted to sea through the Te Tumu cut early in 1957, significantly reducing the volume of freshwater entering the estuary.

The drainage of 14,000 ha of wetland and the isolation of 108 ha of the 170 ha (64%) of salt marsh wetland that existed in the Ongatoro - Maketū estuary prior to 1948 would have significantly reduced the habitat for a wide range of vertebrate and invertebrate animal species that depend directly and indirectly on wetlands to sustain them. The likely ecological implications are discussed in the next section.

Subsequent to the diversion of the Kaituna River out through Te Tumu in 1957, a further 53 ha of salt marsh and palustrine wetland has 'disappeared' from the main body of the estuary immediately south of the Papahikahawai Island stopbanks (Figure 4; Figure 5 A-E). A sequence of aerial photographs show this area of salt marsh/wetland to be largely intact in 1959; by 1963/64 there is evidence of some decline in the area of salt marsh/wetland; by 1977 most of the salt marsh/wetland area has reverted to tidal mudflats; and by 1979, salt marsh on the estuary side of the stopbanks was limited to a 5 ha area alongside Maketū Road, most of which remains today, and small remnants (totalling 2 ha) scattered across the rest of the estuary).

In total, between 92 and 95% of the salt marsh / palustrine wetland area has been lost between 1939 and today. KRTA (1986) conclude that 161 ha (95%) of the 170 ha salt marsh and palustrine wetland area present in 1939 has disappeared, while Park (Table 2) calculated a larger area of wetland (205 ha) in 1939 and a 92% (16 ha remaining) loss by 2011.

From his GIS analysis, Park noted a significant shift in wetland species composition between 1948 and 1961 with a mix of freshwater (palustrine) species and salt water tolerant (estuarine) species in 1948 but a predominance of salt tolerant estuarine wetland species by 1961, 4 years after the river diversion. Landowner Alan Brain has confirmed that, pre-1960, his block of land and that on the western end of Papahikahawai Island were both freshwater wetland areas and not salt marsh (P. de Monchy pers comm). Park's analysis also noted that a significant portion of the vegetation visible in the 1961 aerial photograph in the marsh area to the immediate south of Papahikahawai Island appears to be dead or dying.

Table 2: Historic wetland extents (ha) in Ongatoro - Maketū Estuary from 1939 to 2011 with breakdown into hydroclass and plant form. Also given is area lost by drainage. (Park 2014)

		Rushland		Rush/reed/shrub	
Year	Total Area	Estuarine	Palustrine	Palustrine	Drained
1939	205.304	60.519	124.128	15.8733	-
1948	196.645	61.099	105.785	16.569	24.205
1961	115.897	98.353	0.231	15.14	47.101
2011	16.288	7.219	0.368	3.593	95.223

Bergin (1991 and 1994) monitored the rate of retreat or expansion of the remnant salt marsh stand beside Maketū Road. Over a four year period, 11 of 14 marked sites showed retreat of the salt marsh edge by between 70 and 150 cm. One site expanded by 60 cm. The author's conclusion was that the salt marsh was still retreating at a significant rate and was likely to "be reduced to discontinuous patches of salt marsh vegetation within 50 years …". However, the retreat in this area of salt marsh has been much less than further up the estuary, and has occurred at a considerably reduced rate from that observed by Bergin, as evidenced by the sequence of aerial photos (Figure 5 A-E). Analysis of 2011 aerial photos and field observation in 2014 (Figure 7; T. Connolly pers comm) suggest that limited decline has occurred since 1994 (no more than 15 to 20 m retreat in selected areas only; and this has been represented graphically in Figure 6. It is reasonable to conclude that the factors that led to the elimination of the salt marsh in the upper reaches of the estuary have not been as prevalent in this area.

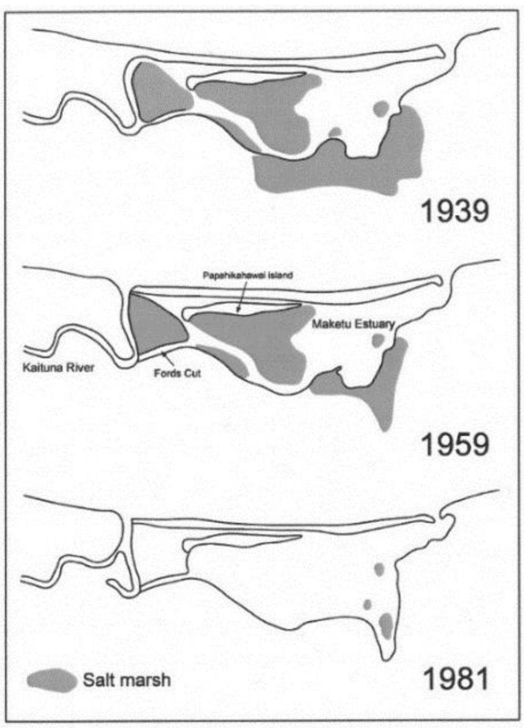


Figure 4: Decline in salt marsh in the Ongatoro - Maketū estuary from 1939 to 1981. (Sourced from Goodhue 2007, adapted from KRTA 1986). The larger shaded area of salt marsh in the bottom right of the 1981 diagram is the area studied by Bergin (1991

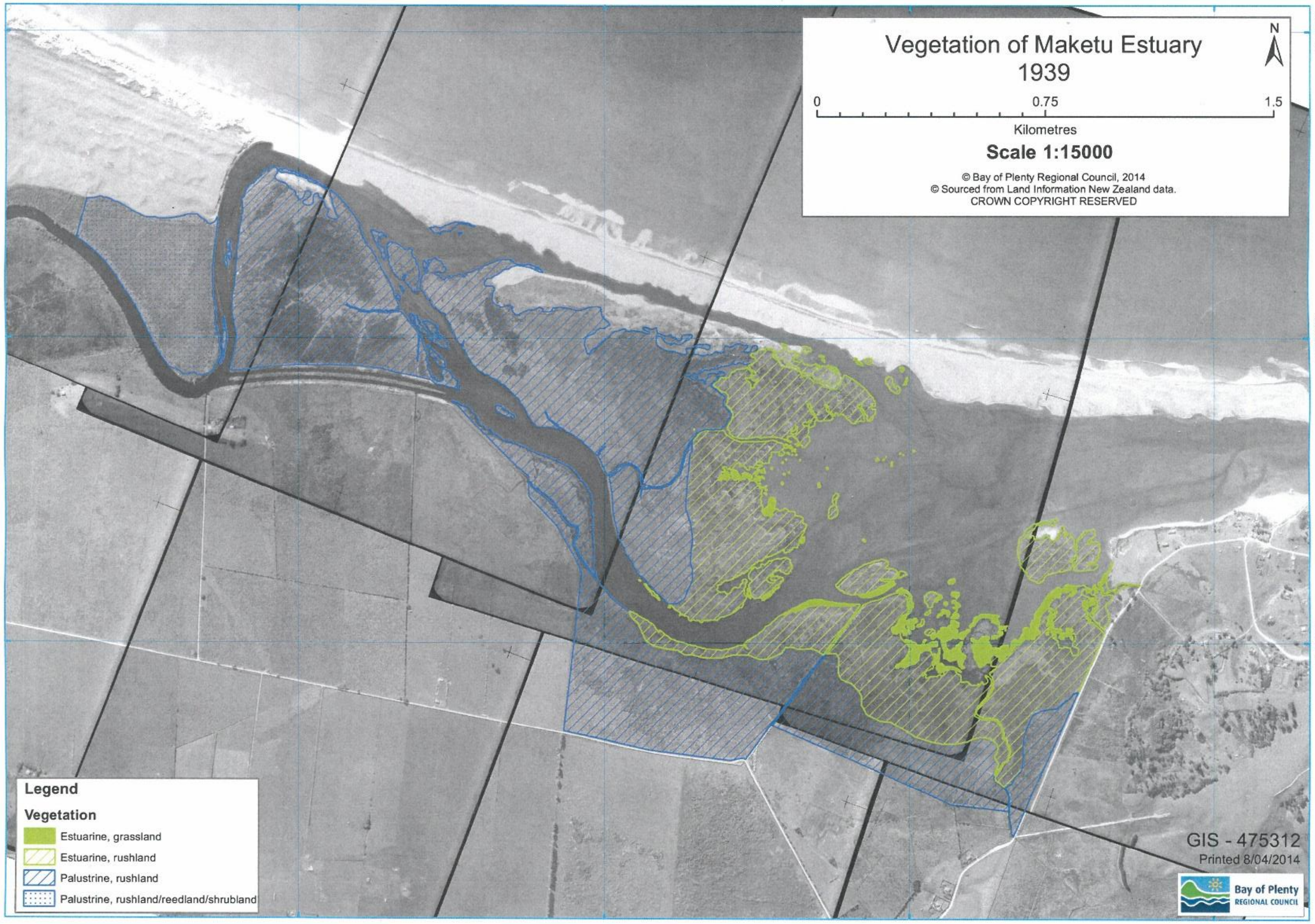


Figure 5A: Ongatoro - Maketū Estuary vegetation 1939. The hatched and coloured overlays have been derived using GIS analysis (interpreted by S. Park, BOPRC, 2014).

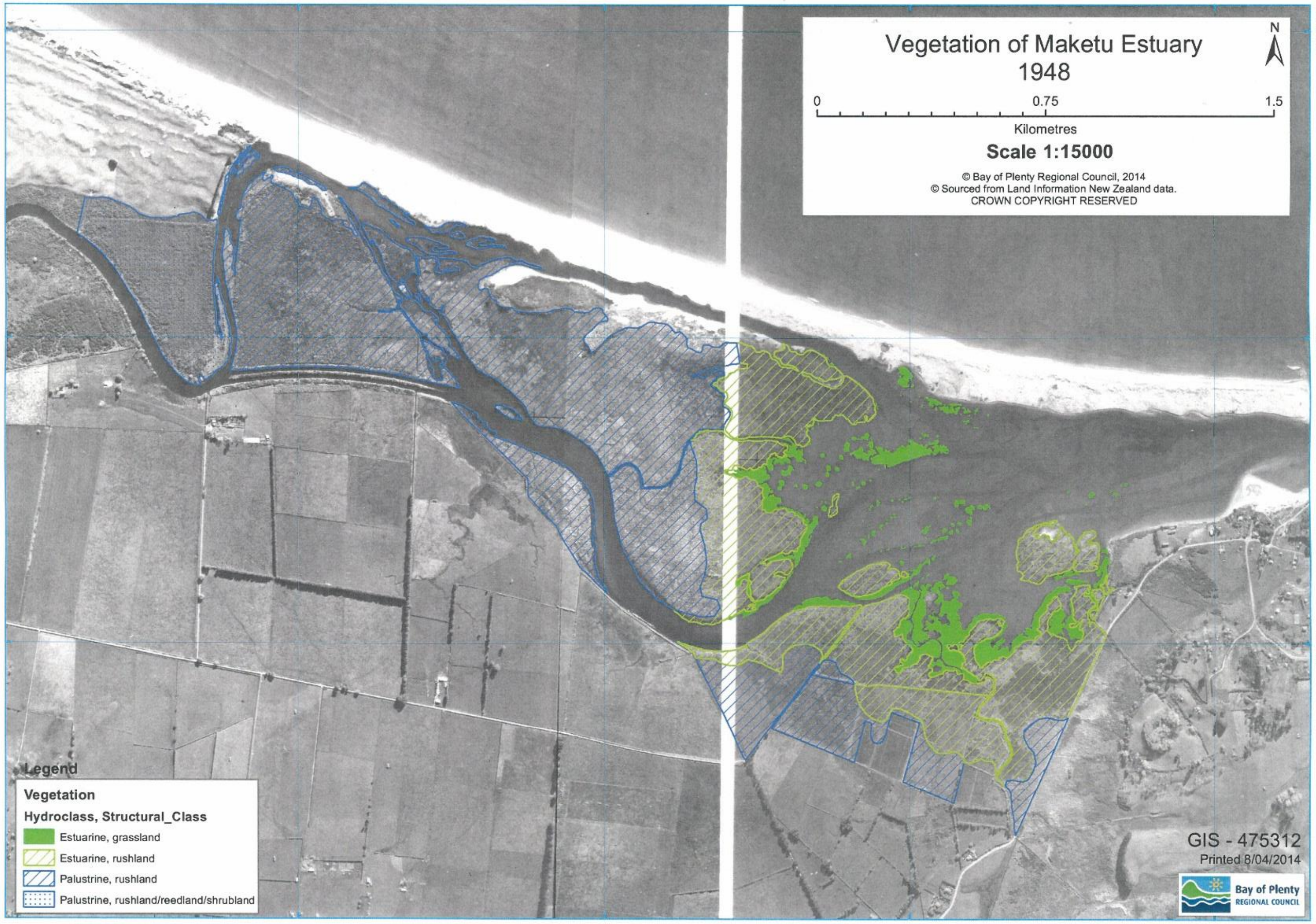


Figure 5B: Ongatoro - Maketū Estuary vegetation 1948. The hatched and coloured overlays have been derived using GIS analysis (interpreted by S. Park, BOPRC, 2014).

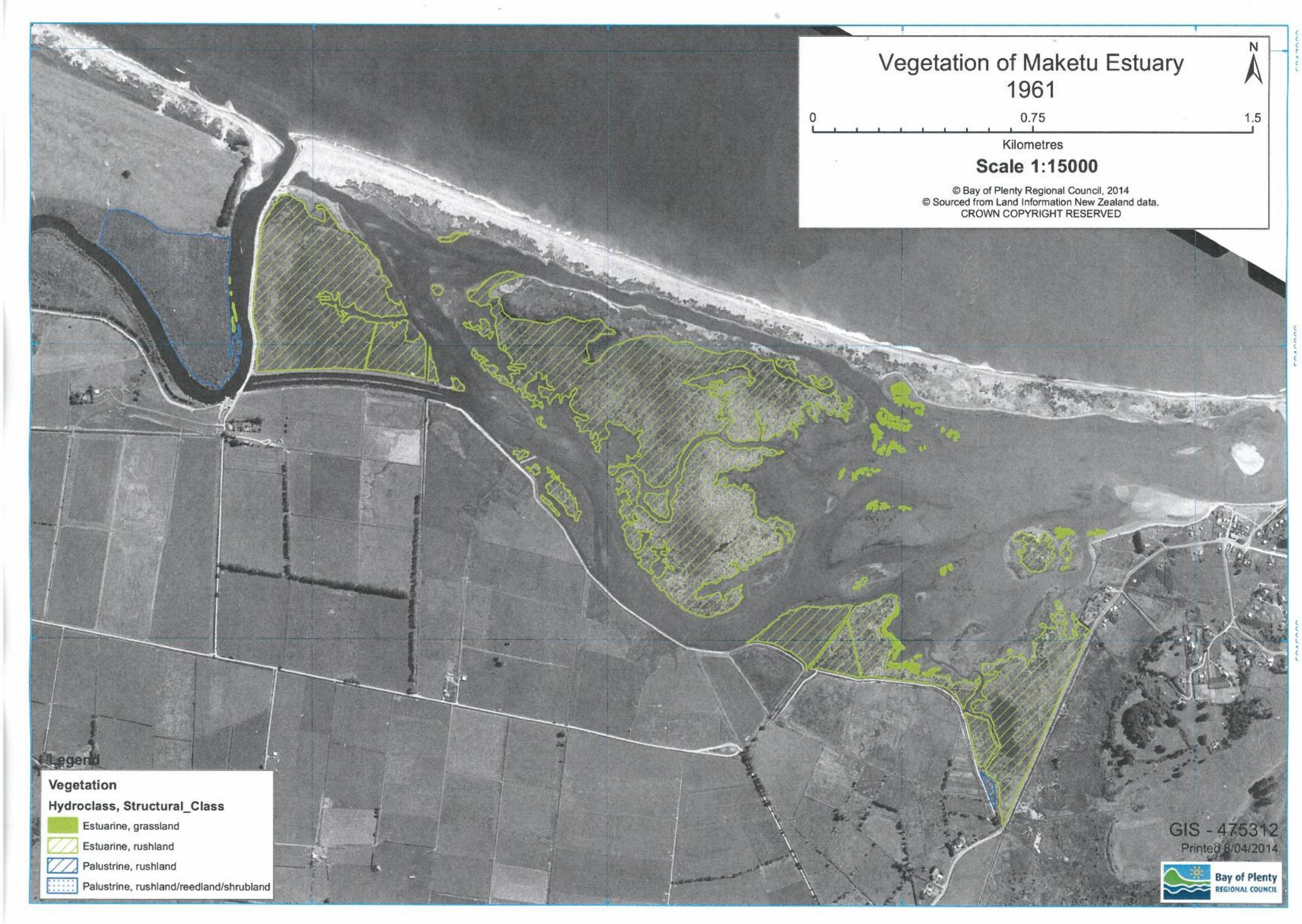


Figure 5C: Ongatoro - Maketū Estuary vegetation 1961. The hatched and coloured overlays have been derived using GIS analysis (interpreted by S. Park, BOPRC, 2014).

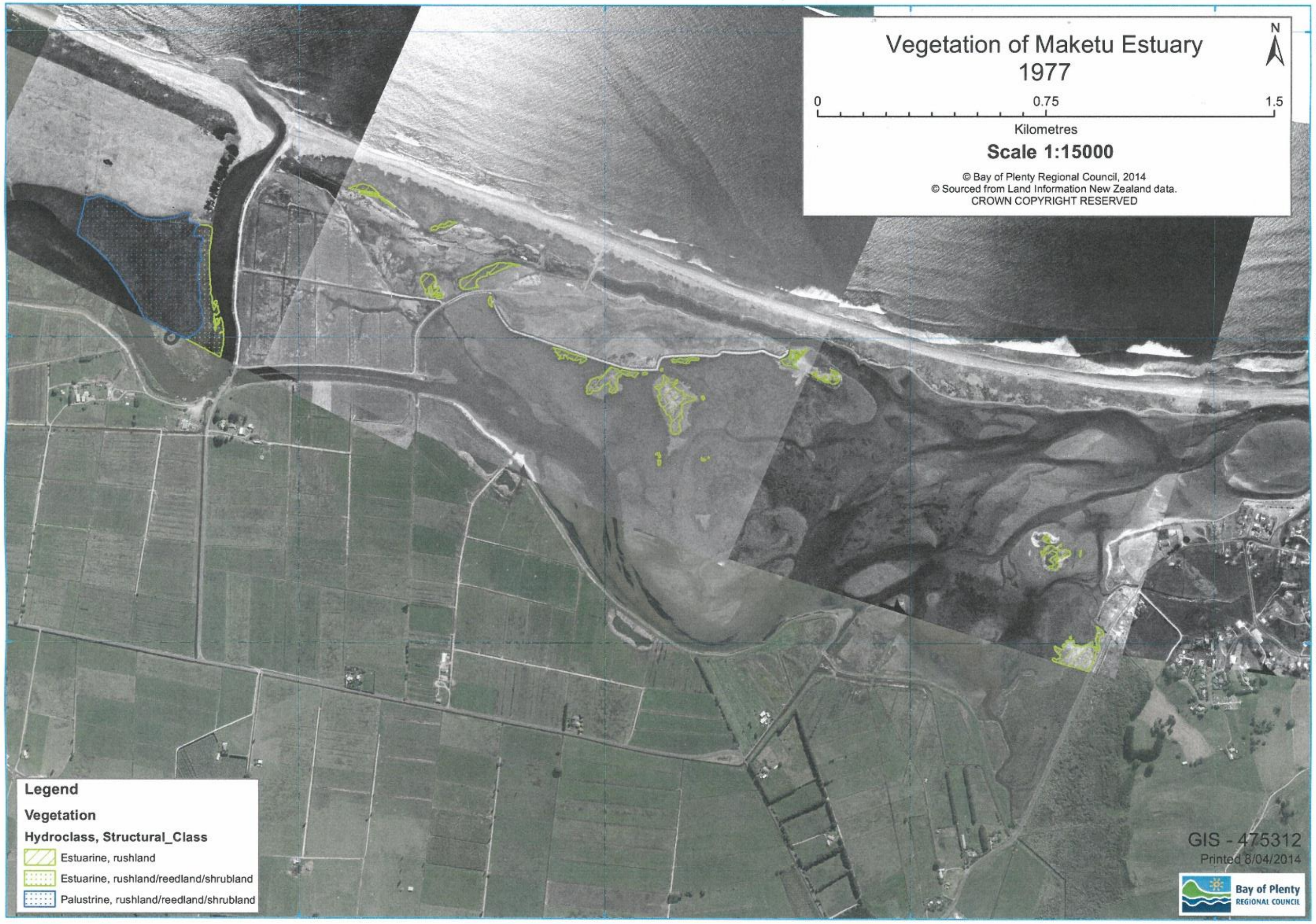


Figure 5D: Ongatoro - Maketū Estuary vegetation 1977. The hatched and coloured overlays have been derived using GIS analysis (interpreted by S. Park, BOPRC, 2014). Note that the wetland area in the south, beside Maketu Road, has not been included in the GIS analysis.

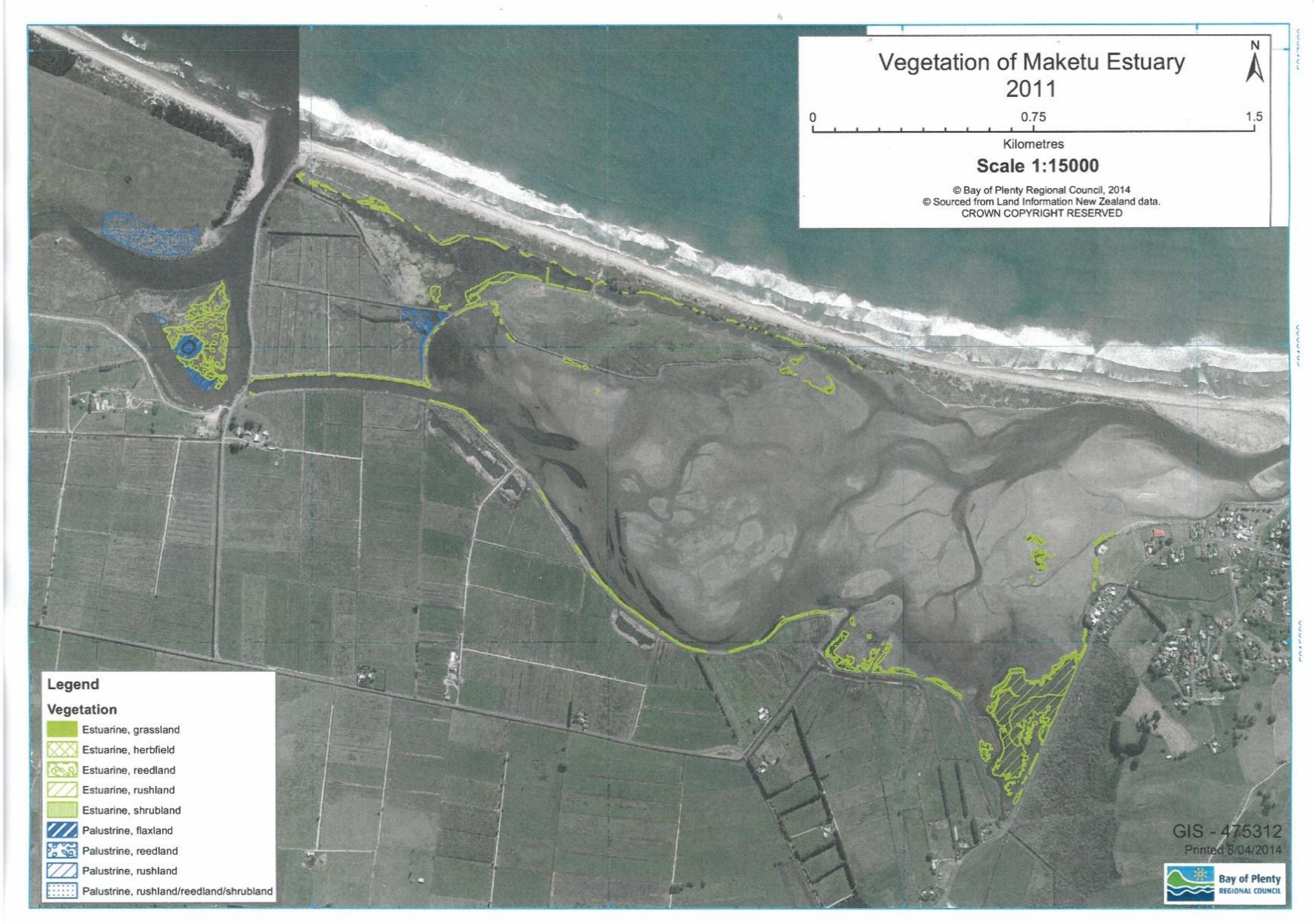


Figure 5E: Ongatoro - Maketū Estuary vegetation 2011. The hatched and coloured overlays have been derived using GIS analysis (interpreted by S. Park, BOPRC, 2014).

3.1.3 Possible causes of salt marsh decline

The decline of the salt marsh habitat that was isolated by stopbank construction was predictable because of the loss of regular salt water – freshwater oscillation necessary to sustain salt marsh species. The cause of the decline and eventual disappearance of the large area of salt marsh to the south of Papahikahawai Island, outside the influence of the stopbanks, is less clear. Several possibilities have been offered:

1. Decline due to **altered salinity profile** resulting from the reduced freshwater flow into the estuary after the Kaituna River was diverted. The decline has been attributed by some to be due to gradual mortality because of increased penetration of saline water into the salt marsh (KRTA 1986).
2. As a variation of 1 above, KRTA suggest that the dredging of substrate from the estuary to create the stopbank along the southern edge of the island may have **increased the rate of saline penetration** and therefore the rate of plant mortality.
3. Bergin (1991) has suggested that **estuary bed level reductions**, triggered by changed sedimentation patterns associated with the reduction of freshwater inflow following the river diversion, may be the cause of the decline of the salt marsh throughout the estuary. He noticed a significant difference in bed surface levels between the salt marsh edge and immediately adjacent mudflat, and observed evidence of plant root systems being under-cut and worn away by, what he considered, to be the abrasive force of wave action and suspended sediment. Plants were observed that still had root systems with all substrate removed from under the roots. KRTA (1986) and Murray (1978) both also suggested that reductions in the elevation of the estuary bed adjacent to the salt marsh areas may have contributed to the loss of salt marsh.
4. **Changes in pH** in the root zone causing root decay has also been suggested as a contributing cause of salt marsh decline (Bergin 1991). The argument for this is that if the largely anaerobic soil in the root zone has become more aerated, sulphides that accumulate under more standard anaerobic conditions may oxidise to form sulphuric acid. The resulting decrease in pH may be sufficient to kill or weaken roots. However, no pH readings were taken to substantiate this viewpoint.
5. **Inability to reproduce**. Murray (1978) postulated that increased tidal inundation during the period of seed settlement and germination may retard or prevent germination leading to gradual decline in plant numbers. Research undertaken by Partridge and Wilson (1987b) on germination in relation to salinity in some salt marsh plant species supports this view. They suggested that many salt marsh species require reduced salinity for their seeds to germinate and almost all germinate best in full freshwater. They found that most species were more sensitive at elevated salinity to germination reduction or failure than they were to reduced growth rates. While inability to reproduce does not necessarily account for the decline of the salt marsh, it may be a factor explaining why new plants did not replace those that died.

It is questionable whether altered salinity alone has been the cause of the large-scale die back of salt marsh species in the Ongatoro - Maketū estuary. *Juncus kraussii var. australiensis* (sea rush) is tolerant of a wide range of salinities and achieves maximum growth between salinity of 5 and 30 parts per thousand (ppt), with mortality unlikely to be caused even with full sea water (Partridge and Wilson 1987) (seawater in NZ has salinity of approximately 35 ppt), and it is known to form dense stands in the lower reaches of estuaries where salinity is higher. Bergin (1991) took salinity readings across the full range of the tidal cycle at his study site and found that salinity ranged from below 5 to 32 ppt, a range unlikely to cause plant decline. Sea rush predominates in the area of his study (refer to species surveyed in transects 4 and 5, see Section 4.1.5 below), which might explain why this area of salt marsh has declined considerably less than in other areas.

Plagianthus divaricatus, and to a lesser extent *Apodasmia similis,* have lower salinity tolerances than sea rush. In their experimental trials, Partridge and Wilson (1987) recorded *P. divaricatus* ceasing growth and showing signs of death when salinity reached levels a little under half full sea water strength. In their field measurements they found *P. divaricatus* growing in areas with mean soil salinity of 16.6 ppt and which experience tidal salinity variation of 7.2, compared to *Juncus kraussii var. australiensis* which grew in areas with a mean soil salinity of 28.7 ppt and variation of 9 ppt.

The recent DHI modelling (DHI 2014) has generated salinity levels of between 10 and 30 ppt (= PSU – "Practical Salinity Units", an alternate metric) under current conditions in the area where the salt marsh used to be. Salinity at these levels may well cause the decline of *Plagianthus* and *Apodasmia* but should not have caused sea rush decline. Park (2014) detected a significant shift in wetland species composition especially in the large salt marsh / wetland area immediately south of the island which may be as a result of the decline of less salt tolerant species such as *Plagianthus*. The plants that predominate in this area from 1961 may, therefore, be surviving *Juncus kraussii var. australiensis*.

While Bergin observed localised erosion of the estuary bed level at his site next to Maketū Road, evidence of significant estuary bed erosion has not been confirmed elsewhere. Murray (1978) and Hamill (pers comm 2014) have both referred to an intact estuary peat layer underlying a thin sediment layer at several locations within the estuary (including at the location of the disappearing salt marsh) that appeared to be quite resistant to erosion. This suggests that substantial, widespread estuary bed erosion is unlikely.

One possible reason for Bergin's observations may be that sedges and rushes (such as *Juncus*) naturally trap fine suspended sediments around their root systems. This surface sediment layer tends to remain unconsolidated and when a sedge or rush dies, this loose sediment is likely to be mobilised and carried away by the motion of the tide and currents, leaving the appearance of a declining estuary bed.

Recent field observations (J. Dahm pers comm) in the area provide some additional thoughts about the reasons for the demise of the salt marsh. He noted as much as a 20cm drop in sediment levels between the small areas of salt marsh that remain and the surrounding estuary bed, confirming the possibility that sediment erosion may have contributed to the decline in the salt marsh. He has also pointed out that the original (pre-diversion) meandering course of the river channel meant that the large salt marsh area was located on the inside of a bend and therefore predisposed to sediment deposition. The closure of the original channel and opening of Ford's Cut removed the propensity for sediment deposition in the marsh area, a state that remains today and will continue with the re-diversion.

It may not be possible to unequivocally determine the causes of salt marsh decline within Ongatoro- Maketū estuary. The series of aerial photographs of the estuary taken between 1939 and 2011 (Figure 5 A-E) clearly show the extent of the salt marsh decline, but do not provide any obvious reasons for the cause of decline. Certainly, marsh dieback was noticeable within 3 to 4 years of the diversion of the Kaituna River through Te Tumu. By 1961 there was evidence of marsh area decay on both the east (seaward) and west (Ford's Cut) sides of the salt marsh (C); the extent of the decay is likely to be greater than is obvious in the aerial photograph because some of the plants visible in the aerial photo are in fact dead (Park, pers comm). Absence of aerial photographs of the estuary taken between 1961 and 1977 makes diagnosis of possible causes of decline more challenging for this period. By 1977 however, only two small salt marsh areas remained next to Papahikahawai Island and they were gone by 1981.

It is unlikely that the commencement and continuation of the marsh decline was unrelated to the reduction of freshwater flow into the top of the estuary that followed the river diversion. The continued decline of the salt marsh over a period of 18 to 20 years following the diversion, and the apparent deterioration of the marsh area from the edges most exposed to the main body of estuary water suggest that one or more stressors arising from changes to the physical and/or chemical state of the estuary water have caused this decline.

3.1.4 Aquatic vegetation

The ecology of the aquatic estuarine environment is covered in separate reports. Changes in the extent of eel grass (also known as seagrass; *Zostera muelleri*) are shown in Table 1 below because it provides valuable habitat for fish and is an important indicator of the environmental state or health of an estuary. The information has been generated following GIS evaluation of a sequence of aerial photos dating back to 1939, summarised in Figure 5 A-E (S. Park 2014).

Very little eelgrass remains in the estuary today. While it appears there has been a steady decline in eelgrass since the diversion of the Kaituna River in 1956, it is interesting to note that the relative suitability of the estuarine conditions for eelgrass does seem to fluctuate, as evidenced by the smaller eelgrass area in 1939 relative to 1948.

Table 1: Extent of seagrass beds in Maketū Estuary in 1939, 1948, 1961 and 2011.

Year	Area (ha)
1939	4.784
1948	13.192
1961	2.173
2011	0.004

3.1.5 Current Ongatoro - Maketū vegetation cover

An assessment of the current terrestrial, estuarine margin, freshwater wetland and salt marsh wetland vegetation in and adjacent to Ongatoro - Maketū estuary was undertaken in January to March 2014. The purpose was two-fold:

1. To determine the major vegetation assemblages present and their location;
2. To establish marked transect lines that will enable change in vegetation composition to be measured over time.

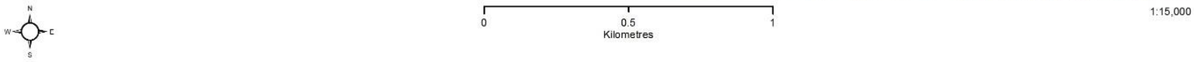
3.1.5.1 Survey methodology

Vegetation survey methodology was designed to quantify vegetation change over time at several sites within and near the Ongatoro - Maketū estuary that may occur as a result of changes in physico-chemical conditions, such as salinity, following the proposed partial re-diversion of the Kaituna River through the estuary. Survey methodology was based on the use of transects laid perpendicular to the shoreline at points within and near the Ongatoro - Maketū estuary. Each transect crosses up to three vegetative "zones of influence". Four permanent quadrats were placed randomly within 50 m of the transect line. Survey methodology was peer-reviewed by Dr Norm Mason (Landcare Research). Surveys will be repeated at regular intervals to allow vegetative changes to be quantified relative to the baseline survey conducted in 2014.

Transects

Transect start points were subjectively chosen at six sites within the estuary and at one site near the proposed Kaituna River cut on the Titchmarsh property (Figure 6). Transects were placed perpendicular to the shoreline, laid across up to three vegetative zones (see below) which extended from well above to below the high tide mark.

Figure 6: Location of permanent vegetation transects installed around Ongatoro - Maketū Estuary and the Lower Kaituna River



Habitat types

Up to three vegetative habitat types ('zones') were identified as strata along each transect. These were:

1. Tidally/permanently wet (strongly saline-influenced);

2. Wet margins - usually wet but not usually submerged (mixed saline/freshwater influenced);

3. Terrestrial - not usually wet or saturated.

This approach will enable long-term quantification of the significant vegetative change that is expected to occur particularly within zones 1 and 2, as a result of changing salinity and also as a result of restoration planting.

Not all habitat types were present along all transects and several transects included only one or two, rather than all three zones. However, characteristics of each habitat type were consistent across all transects, allowing comparison of vegetation differences between all transects.

Quadrats
Within each zone, four permanent quadrats were placed using randomly-generated numbers, within 50 m of each transect line. Quadrat size was determined by the nature of the vegetation along these transects. Where woody vegetation was found, size classes were recorded according to protocols of the RECCE method (Hurst & Allen 2007) and 5 × 5 m quadrats were used, with the following size classes recorded for all individual plants:

- Seedlings (<1.35 m tall);
- Saplings (>1.35 m tall with stem DBH[1] <2.5 cm;
- Trees (DBH >2.5 cm).

Where non-woody vegetation predominated (e.g. sedges, rushes and grasses), a quadrat size of 2 × 2 m was chosen, in line with the standard wetland sampling protocol used by the Bay of Plenty Regional Council, adapted from the WETMAK protocol (Denyer & Peters 2012). Within each quadrat the following was recorded:

- Overall cover (%) of each species. Each species can have up to 100% cover and the sum of all species can exceed 100%.
- % cover of each species in height tiers: <0.3 m, 0.3–1 m, 1–2 m, 2-5 m and >5 m.
- Maximum height and estimated average height of each species.

For most quadrats, a permanent marker was left on site at the north-west corner of each quadrat; however this was not possible for some transects as livestock are regularly present. Coordinates of all quadrats were marked by GPS to enable future repeat surveys to be undertaken at the same place.

3.1.5.2 Results

The vegetation survey results are detailed in a separate report: "Ongatoro - Maketū Estuary Vegetation Survey Report (Opus 2014a).

The main features of the existing vegetation around the estuary margins are:

1. Large sections of estuary margin along the southern stopbanks have very little natural vegetation because of the close proximity of the stopbanks to the estuary channel;
2. A small area of *Juncus kraussii* var. *australiensis*-dominant salt marsh remains adjacent to Maketū Road (referred to above); this appears to be in reasonable health and stable in area occupied (ie. it is not retreating at a significant rate);

[1] DBH = diameter at breast height

3. The vegetation composition along the Maketū Spit margin to the west of Papahikahawai Island is strongly influenced by persistently high salinity and lack of daily tidal movement (the stopbanks and causeways isolate this area from the rest of the estuary);
4. Salt-tolerant and freshwater wetland plant species are present in the low-lying grazed pasture areas on Papahikahawai Island and the Brain land, despite persistent grazing by livestock;
5. Vegetation on the Titchmarsh wetland (transect 7) provides the most contiguous area of mature wetland vegetation in the area, with a mix of freshwater and moderately salt-tolerant species spread in a mosaic depending on elevation and water intrusion;
6. The landward-facing dune vegetation on the Maketū Spit is in relatively healthy condition because of the effective rabbit control and planting undertaken by local community groups.

3.1.5.3 Discussion

Maketū Road salt marsh remnant

The area and shape of salt marsh adjacent to Maketū Road has remained constant for several decades (Figure 5 A-E). Although Bergin (1991) referred to parts of this salt marsh as retreating at a concerning rate, this retreat does not seem to have persisted (Figure 7).

Figure 7: Overlay of current salt marsh extent at Maketu Road (shown in green) on the salt marsh diagram from Bergin 1991.

Of interest, the quadrats sampled in areas with greatest freshwater influence and lowest saltwater influence (eg. Transect 4: Q38 and Q40) have the highest proportion of oioi and saltmarsh ribbonwood compared to sea rush, whereas those quadrats without significant freshwater influence (especially the Transect 5 quadrats) are composed entirely of sea rush. The freshwater influence for the Transect 4 quadrats comes from drains that bring water from neighbouring farmland and the freshwater wetland area on the southeast side of Maketū Road (referred to as the Arawa wetland). Bergin showed that the salinity in this area ranged from very low (below 4) to 19 ppt, whereas the tidal edge of the salt marsh experienced salinities between 11 and 32 ppt, with most readings over 20 ppt. This species distribution supports the theory that saltmarsh ribbonwood and oioi prefer mid to low salinity and may have died off in other parts of the estuary because of elevated salinity following diversion of the Kaituna River.

Other remnant areas of salt marsh

A number of small remnant areas of salt marsh remain scattered around the estuary. One of these exists in the old Kaituna River channel near the Maketū Spit carpark. The Transect 3, Zone 1 quadrats show an area of entirely sea rush. This coincides with modelled salinity levels of above 30 PSU in this area (figures 9.2-9.7 of DHI, 2014). Transect 2, located half way along the northern side of the island, has little or no sea rush but it is dominated by another high salinity tolerant species *Sarcocornia quinqueflora* (glasswort). The DHI salinity modelling shows that salinity levels in this area are likely to range from 20 and 30 ppt; Partridge and Wilson (1987) reveal that glasswort can comfortably flourish in all salinities up to full sea water.

One of the larger remnant salt marsh areas not included in the 2014 vegetation transects occurs off the eastern-most tip of Papahikahawai Island (Figure 5E). This area has varied in shape and size over the years but has persisted. Monitoring of the species composition and environmental conditions at this site is recommended to better understand what influences the growth and decline of salt marsh in the Ongatoro - Maketū estuary.

'Titchmarsh' wetland area

The Titchmarsh wetland area, to the immediate west of the existing cut to Ongatoro - Maketū Estuary, is the largest remaining freshwater (palustrine) wetland area downstream of Kaituna Wetland that is generally connected with the estuary. The Arawa wetland, on the south-eastern side of Maketū Road, is larger but it links to the estuary only by culvert pipes and is subject to very limited tidal influence.

The Titchmarsh wetland consists of a mosaic of freshwater wetland, wetland margin, terrestrial and low to moderate salt tolerant species (refer to Transect 7 vegetation data in Appendix 1). Species with moderate salt tolerance including *Isolepis cernua*, *Ficinia nodosa* and *Juncus kraussii var. australiensis* dominate the Kaituna River channel margins that are exposed to daily tidal changes in salinity. Away from the river, a variety of freshwater species such as *Typha orientalis* (raupo), *Macherina articulata* (jointed twig rush) and *Bolboschoenus fluviatilis* (ririwaka) are common in the wetter depressions and *Calystegia soldanella* (shore bindweed; panahi) predominates on the elevated sand / stone beds.

Estuary – Maketū Spit margin

The margin between the estuary and Maketū Spit occurs in two distinct zones: one is at the eastern end, with full exposure to daily tidal movement through the Ongatoro - Maketū Estuary mouth (transects 1 and 2); the other is to the west and isolated from immediate tidal fluctuations by the access causeways to the island from Maketū Spit and Ford Road (transect 3). Neither of the two transect lines to the east of the access causeways have any vegetation growing within the normal tidal zone and transect 1 has virtually no vegetation that is regularly immersed by the tide. Transect

2, protected from aggressive tidal movement by the narrow channel between the island and the spit, has an extensive area of glasswort at the upper tidal zone.

Transect 3 has only the highly salt tolerant sea rush *Juncus kraussii* var.*australiensis* growing in the zone influenced by estuary water. Zone 2 above that seems to be mostly influenced by freshwater seeping from the spit, as reflected by the species occurring there.

3.1.5.4 Summary

The existing indigenous vegetation on the edge of, and in close proximity to the Ongatoro - Maketū estuary is a tiny fragment of what occurred in this area before drainage and land development; this area was further reduced by wetland and salt marsh reduction following construction of stopbanks and the diversion of the Kaituna River. However, the plant communities that remain appear to have reached a reasonable state of equilibrium and there is no evidence of significant recent change or deterioration.

3.2 Assessment of Ecological Values

3.2.1 Vegetation

The ecological values of the Ongatoro - Maketū estuary and its immediate surrounds have declined in direct proportion to the reduction of salt marsh and freshwater wetlands, and the drainage of land for farming activities.

As described above, the area of salt marsh wetland has declined by 92-95% since the 1950's to be less than 9 ha, and less than 4 ha of freshwater wetland that is hydraulically linked to the estuary remains of the thousands of hectares that existed 150 years ago. Less than 0.004 ha (40 m^2) of eelgrass remains compared to around 13 ha in 1948.

In addition to the loss of wetland area, the construction of stopbanks and the reduced freshwater flow through the estuary (including reduced flood flows) has considerably narrowed the margin of wetland transitional vegetation. In some areas, such as along the southern edge of the estuary, the stopbanks lie hard up against the main channel, leaving no room for establishment of indigenous wetland margin plants. In other areas, especially along the estuary side of Ongatoro - Maketū Spit, the transition from open estuarine water to terrestrial conditions occurs over a very narrow distance. In addition to reducing the diversity and abundance of plant species occupying these zones, the reduction in aerial extent of these zones has greatly reduced the habitat for fauna (discussed in sections below).

No threatened plant species were found along any of the transects or along the courses followed during the various walk-through site reconnaissance surveys. However, the threatened tussock, *Poa billarierei,* is known to occur in the eastern most 800 metres of the spit.

3.2.2 Habitat for birds, fish and invertebrates.

3.2.2.1 Birds (refer to Section 5) and fish

Assessments of the current and historical bird diversity and abundance at the Ongatoro - Maketū estuary is discussed in a section that follows and fish ecological values, past and present, are discussed in a separate report (Connolly and Large, 2014).

Although the loss of large areas of wetland and salt marsh vegetation has inevitably reduced the habitat available for many bird species greatly, the larger expanse of mudflats that have replaced salt marsh has potentially increased the area of feeding grounds available for wading species. These changes are discussed in the next section.

River margin wetland habitat is critical for inanga spawning and important for several other whitebait species including giant kokopu. Inanga spawn on the river margin vegetation and/or wetland species that occur between the upper surface limit and bottom limit of saltwater intrusion during spring tides; the loss of much of the vegetation suitable for spawning within the estuary, especially at the zone of upper spring tide extent, is likely to have greatly reduced inanga breeding success in the Kaituna – Maketū area. Very little habitat suitable for inanga spawning remains within the estuary (although suitable rearing and feeding habitat does remain), and only a small area on the Kaituna River opposite the Kaituna wetland has vegetation suitable for spawning at the upper spring tide zone (Hamill 2014).

Giant kokopu also spawn in wetland vegetation in swampy wetlands and streams that feed into estuaries. The loss of the wetland vegetation within and adjacent to the estuary will have reduced the suitability of this area for this species.

The remnant salt marsh areas (mostly adjacent to Maketū Road) and wetland areas on the Titchmarsh land at the upstream end of the proposed new channel have significant ecological value for both native fish and birds.

3.2.2.2 Invertebrates

No invertebrate / insect surveys were undertaken around the estuary margins, although entomologist Peter Maddison has recently undertaken an invertebrate survey on the Ongatoro - Maketū Spit where he found some species not previously described. The survey findings have not been evaluated but most of the species described are likely to be predominantly dune species rather than estuarine or wetland species.

Salt marsh and freshwater wetlands provide highly productive habitat for aquatic and terrestrial invertebrates. The substantial reduction of these areas will have reduced the invertebrate populations accordingly. Refer to Hamill (2014) for benthic and epifauna invertebrate survey findings.

3.3 Assessment of Potential Ecological Effects

In this section the potential ecological effects on existing Maketū vegetation of increasing the re-diverted Kaituna River flow from 5% to 20% are discussed. The effects of restoring up to 27.5 ha of wetland and up to 12.9 ha of terrestrial habitat will be discussed in a section to follow, as will the effects of the project on native bird life.

The re-diversion of Kaituna River flow into the estuary will cause a range of physical and chemical changes to the estuary and its environment. A separate report provides an evaluation of the potential effects of those changes on the aquatic plant and animal life (Hamill 2014). This report is focused on the potential effects (positive and negative) of the changes on estuarine margin vegetation and the biota that live in and/or rely on that vegetation as a consequence of altering the freshwater inflow.

3.3.1 Potentially significant physical and chemical changes

The potential physical and chemical changes to water quality that will occur within the estuary and lower Kaituna River following river re-diversion have been predicted by DHI (2014) using mathematical modelling. The modelling projections form the basis of the analysis of effects that follows. In addition to the changes to the aquatic environment, considerable changes on the land around the estuary will occur. These will be associated with removal of the stopbanks and causeways, excavation of the new channel to link the river to the estuary, in-filling of part of the existing channel between river and estuary, and revegetation of the Brain land and Papahikahawai Island.

The following project related changes are considered to have the potential to have effects on the nature and extent of natural vegetation growing around Ongatoro - Maketū estuary:

Salinity

The DHI modelling predicted changes to salinity within the estuary and associated river inflow. Salinity at the water surface is of more relevance to the growth of estuarine margin vegetation than salinity on the estuary bed or mid water column. Modelling predicts the following for mean river flow scenarios (note that 35 PSU equates to 100% sea water):

- Mean surface salinity in the upper estuary will be 10-15 PSU compared to the current state of 5-15 PSU, while the tidal salinity range at a site at the western end of Papahikahawai Island will be 2.1-21.5 PSU (10th and 90th percentiles) compared to the existing 0.7-16.5 PSU.
- Mean salinity levels in the upper estuary north of the current causeway (Papahikahawai lagoon) will fall significantly for mean river flow because of the free daily movement of tidal water. Currently, mean salinity is higher than 30 PSU - this will decrease below 15 PSU once the stopbanks and causeway are removed (favouring more complete flushing of the upper estuary).
- Mean surface salinity in the mid estuary area will be 10-20 PSU compared to the current state of 15-25 PSU. The tidal salinity range at a mid-estuary site adjacent to the eastern end of Papahikahawai Island will be 1.9 to 22.3 PSU compared to the current 3.5-22.5 PSU.
- Mean surface salinity in the lower estuary will be 20-30 PSU compared to the current state of 25-35 PSU. The tidal salinity range at a site near the salt marsh area beside Maketū Road will be 14.9-29.3 PSU compared to the current 21.9-31.8 PSU.
- The **maximum** salinity levels in the Kaituna River channel on the north side of the Titchmarsh wetland area will increase from less than 5 PSU for mean river flow to above 30 PSU during peak spring tide periods.
- No significant changes in salinities are predicted in the vicinity of the southern drains into the estuary.
- The modelling predicts a mean salinity of approximately 10-15 PSU for the Brain land that is likely to be exposed to daily tidal water movement once the stopbanks and causeway are removed. During low flow periods this may increase to between 20 and 25 PSU.

In summary, modelling predicts that the salinity in the open part of the upper estuary will increase to some extent while the salinity in the middle and lower sections will decrease. The area currently cut off by stopbanks and the causeway are likely to experience significantly reduced salinity, whereas the Titchmarsh wetland adjacent to the Kaituna River will experience increased salinity at high tide once the re-diversion channel is constructed.

The large salt marsh that existed next to Papahikahawai Island falls into the mid estuary zone. In this zone the range of salinity is likely to increase slightly over the current state following re-diversion, with maximum salinity (90^{th} percentile) during river low flow periods rising to 32 PSU compared to a current state of around 30; minimum salinity levels (10^{th} percentile) are likely to be between 9 and 10 PSU compared to about 11 PSU currently. The maximum surface water salinity during mean river flow conditions is predicted to reach 21.5 PSU compared to a current state of 16.5 to 18 PSU, and the mean salinity (through the full tidal range) at mean river flow is likely to be between 14 and 16 PSU which is higher than the current mean of around 11 PSU. The slight elevation in salinity predicted in this area is counter intuitive and is discussed in later sections.

Nutrients

Two nutrient assessments were undertaken by DHI. One was carried out for mean river flow and the other was carried for a rainfall event. Two nutrients were assessed, nitrogen and phosphorus, and each nutrient was evaluated in two forms: total nitrogen (TN) and dissolved inorganic nitrogen (DIN – nitrate and nitrite), and total phosphorus (TP) and dissolved reactive phosphorus (DRP).

The modelling has predicted the following changes to inputs of nitrogen and phosphorus:

- An increase in mean total nitrogen (TN) and dissolved inorganic nitrogen (DIN) concentrations in the mid- to lower estuary compared to the current situation.
- No significant change to mean TN and DIN concentrations in the upper estuary.
- TN and DIN levels will be high on the Brain land compared to other parts of the estuary once stopbanks are removed and it is able to revert to wetland.
- No significant change in mean total phosphorus (TP) and dissolved reactive phosphorus (DRP) concentrations anywhere in the estuary.
- There will be relatively high mean TP and DRP on the Brain land (compared to the rest of the estuary) once it is subject to tidal inundation.
- Phosphorus and nitrogen levels will remain highest in the southern-most extent of the estuary adjacent to Maketū Road due to high nutrient concentrations in the Waitipuia Stream draining intensively farmed land.

Mean TN and TP concentrations are predicted to remain moderate following the re-diversion with the highest maximum concentrations likely in the southern corner adjacent to the drains that discharge water from adjacent dairy farms. TP concentrations also are predicted to be highest in the southern zone.

Estuarine sediment deposition and erosion

Changes to the sediment budget (sediment deposition vs. sediment loss (erosion)) are dependent on changes to the volume of water entering the estuary and the sediment content of the river inflow. Modelling predicts that the volume of water entering Ongatoro - Maketū estuary from the Kaituna River will increase by between 226 and 310% with s mean increase of 286% during normal river flows.

- Modelling suggests a potential for long term erosion of sediment from the upper estuary in the area that will be opened up (following removal of stopbanks) to the west of

Papahikahawai Island, and immediately south of the island where the large salt marsh area once grew (Figure 8). However, the authors note that the degree to which there is erosion or deposition will depend on the supply of sediment in the river. There is potential for some deposition in the upper estuary, especially in areas experiencing relatively low current velocities, if river sediment levels are significant. The area in the northwest corner of the estuary that is currently buffered from currents by the causeway to the island is one location where sediment deposition may occur.

- There is potential for long term erosion of sediment for some areas of the upper part of the estuary especially close to the exit of the proposed re-diversion channel. The authors state that the current rate of infilling in the estuary is likely to be greatly reduced, however, there may be some areas of deposition dependent on the sediment supply from the river.

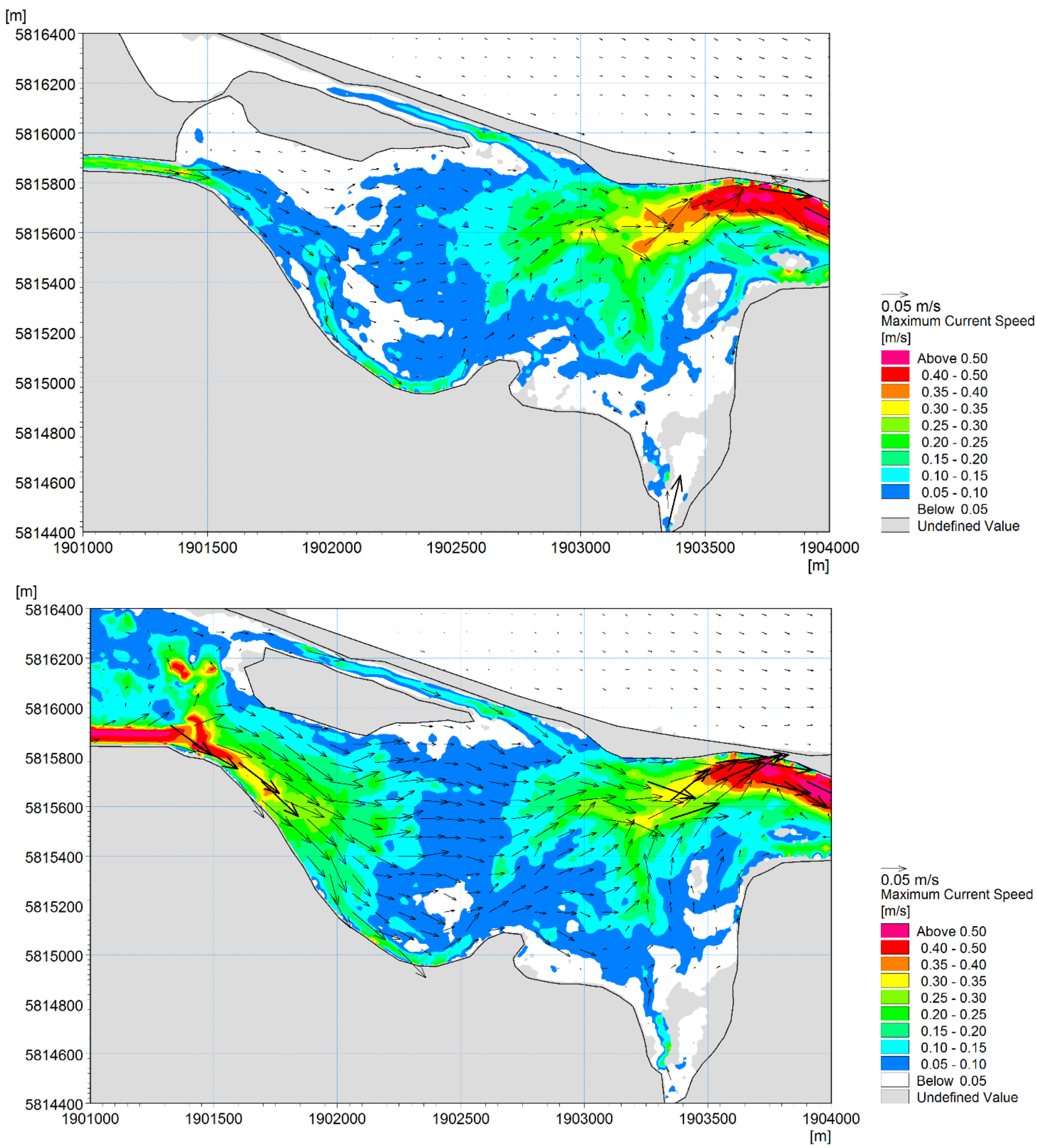


Figure 8: Estuary maximum current speeds at mean tide levels, existing situation (top) and proposed situation (bottom). Information supplied by DHI (2013)

Stopbank and causeway removal

Removal of the stopbanks at the eastern end of the Brain land and the southern side of Papahikahawai Island, removal of the causeways that link to the island from the spit and the Brain land, and the consequent reduction in effectiveness of the drains that are currently behind the existing stopbanks will increase the area of land that will be influenced by the tide, and increase the land area that will be permanently wet.

Removal of the stopbanks and causeway and deposition of material from these areas into existing drains or along the estuary margins will disturb substantial areas of land, and increase the risk of erosion and the deposition of sediment into the estuary. It is likely that the material currently forming the stopbanks around the edge of the Brain land and those on the southern side of Papahikahawai Island will be disposed of on site, mostly into existing drainage channels or, as in the case of the southern edge of the island, into the estuary margin. Most of this material is likely to have been derived from localised excavation to form the drains and stopbanks.

The fill material used to construct the causeway will need to be disposed of somewhere. Disposal options include placement on sections of the Brain land, deposition on parts of the island, fill to help close off Ford's Loop Channel on the west side of Ford Road, deposition along the eastern side of Ford Road to widen the road platform (in part approved by Western Bays District Council and a design approved by their roading and reserves managers), or off-site disposal. This is discussed below along with management of the new channel excavations.

Excavation deposition

50,000 m^3 will be excavated from the new channel that will direct water from the river to the estuary - this material will need to be deposited on site or disposed of off-site.

All or most of this material could be placed in the old river loop next to Ford's Road, which could then enable a wetland to be established there. Other options for deposition include along the eastern side of Ford Road to provide room for parking, along the western edge of the Brain land next to Ford Road, into the old river channel adjacent to the Ford Road coastal carpark, evenly spread over all of the Brain land, or localised use of the material to create mounds , cheniers or ridges above mean high tide mark. This last mentioned option is discussed more in the restoration section of this report.

Of these options, the placement of the fill into the old river loop channel is most favoured. The option of spreading it over the entire surface of the Brain land remains a possibility to counter the estimated 600mm land shrinkage over the last 30 years and elevate the land above mean high tide level, but a large amount of material (more than 24,000 m^3) would be necessary at considerable cost to elevate even half of the block to a level above mean high tide (a minimum fill depth of 25cm is required to achieve this). The addition of fill across all of the Brain land is also likely to be less suitable for establishing planted wetland species than the existing remnant wetland soils.

Care will be required with all options involving the spread of excavated fill to minimise sediment erosion by surface runoff into the estuary. Use of the material to widen the Ford Road platform would require the slopes from that platform down onto the Brain land to be sufficiently gentle to prevent erosion and to merge into the wetland area as naturally as possible, and fill spread across the main area of the Brain block would need to be consolidated and planted quickly to prevent mobilisation of the sediment with each tide.

3.3.2 Assessment of potential effects on estuary vegetation

Of the physical and chemical changes that are likely to occur when the volume of Kaituna River flow into the estuary is increased to 20% following re-diversion, none are expected to have significant negative effects on the vegetation on the edges of and surrounding the estuary, but there is a potential risk, albeit low, to an area of freshwater wetland in the lower reaches of the Kaituna River.

Salinity

Salt marsh wetland areas

The predicted minor changes in salinity in the estuary are not expected to accelerate loss of the one significant remaining area of salt marsh in the south of the estuary adjacent to Maketū Road. Existing evidence suggests that the retreat of this wetland reported by Bergin (1991) has halted or slowed to a very low rate and the species composition seems to have established some form of equilibrium, with salt marsh ribbonwood common in the low salt waters adjacent to Maketū Road and sea rush predominating along the outer, more saline edge of the marsh. The DHI modelling predicts minor changes in salinity in this area.

The remnant areas of salt marsh in the north-western corner of the estuary behind the existing stopbanks and causeway will experience a significant decrease in salinity. This could well lead to an increase in wetland species diversity and an accompanying decline in the dominance of sea rush but should not lead to a decline in the size of the marsh area. If anything, it is quite possible that the area of salt marsh / freshwater wetland in this area will increase naturally once the stopbanks are removed, especially in the area closest to the Ongatoro - Maketū Spit margin between the Brain land and Papahikahawai Island. This area will be reasonably sheltered from increases in current speed and this, along with the return of daily tidal influence and more moderate salinity, may allow more extensive wetland/ marshland areas to establish.

Freshwater wetland areas

The only major freshwater wetlands that remain and are directly connected to the estuary and lower river flow are the Titchmarsh wetland and sizeable parts of Ford Island especially along the southern and eastern edges. These wetland areas will probably experience salinity increases on the northern river side, because tidal waters are predicted to push further up the river channel than at present (Figure 10). Modelling predicts maximum salinity levels at high tide of over 30 PSU but this will only occur for a brief period at the peak of high tide. A decline in less salt tolerant species along the northern edge of the Titchmarsh wetland, and an increase in more salt tolerant species, especially sea rush is likely. However, the northern river edge of the wetland is dominated by salt tolerant species (Figure 9) and it is expected that these species will prevail when the salinity levels rise. Consequently, wetland vegetation collapse (ie. reasonably rapid plant mortality without corresponding natural replacement by alternative native species) is not expected to occur as a result of the re-diversion.

Contrary to the visual impression conveyed by the modelled salinity changes shown in figure 10, the height of the land between the Titchmarsh wetland area and Ford Island is sufficiently above mean high tide level (Figure 11) to prevent regular tidal intrusion into this zone. Occasionally large spring high tides will push salt water into more of this area (Figure 12). This area has a higher proportion of less salt tolerant species so if the wetland soil conditions become more saline, due to occasional spring tide intrusion and/or elevated salinity on the shallow groundwater, then there may be a change in species composition to those more tolerant of salt water. Vegetation collapse is not expected in this zone and it is also considered unlikely that there will be significant changes in vegetation composition however contingency mitigation measures are proposed in the section below in case significant salt-induced dieback does occur.

Significant changes in tidal salinity are not predicted in the upstream end of the proposed new river channel. Consequently, the wetland vegetation along the southern edges of the Titchmarsh wetland and Ford Island, which have a higher proportion of less salt tolerant species, are not considered to be at risk from the salinity changes.

The northern edge of Ford Island, adjacent to the river channel, climbs quickly to a height well above the river level at high tide so the risk of salt water intrusion onto this area is very low. The southern and eastern edges of Ford Island are more low lying but once the current loop channel is sealed off and the new channel opened these areas will be exposed to salinity levels that are much the same as now (southern edge) or lower (eastern edge) and, consequently, the vegetation growing there is not likely to be compromised upon re-diversion. Much of the eastern flank of Ford Island will no longer be exposed to tidal or river water of any kind because the proposal is to fill in the existing river channel and plant it with wetland species. The removal of river and tidal erosion along most of the eastern edge of Ford Island is likely to result in the natural expansion of the wetland species in this area.

In summary, significant vegetation change within the Titchmarsh wetland and on Ford Island is not considered likely as a result of the river re-diversion, although there is likely to be a change in vegetation composition to more salt tolerant species in areas most exposed to tidal flows. Plant diversity and cover is likely to increase on the eastern side of Ford Island.

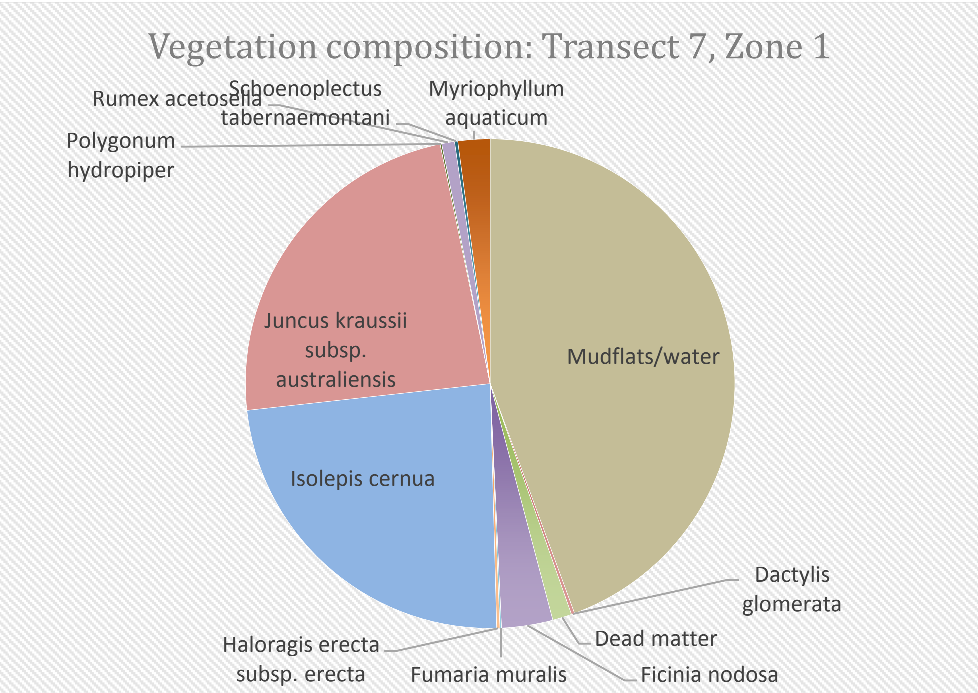


Figure 9: Wetland species composition of 4 vegetation quadrats on the northern (Kaituna River) edge of the Titchmarsh wetland showing the predominance of species with high salt tolerance (*Juncus krausii var. australiensis* and *Isolepis cernua*).

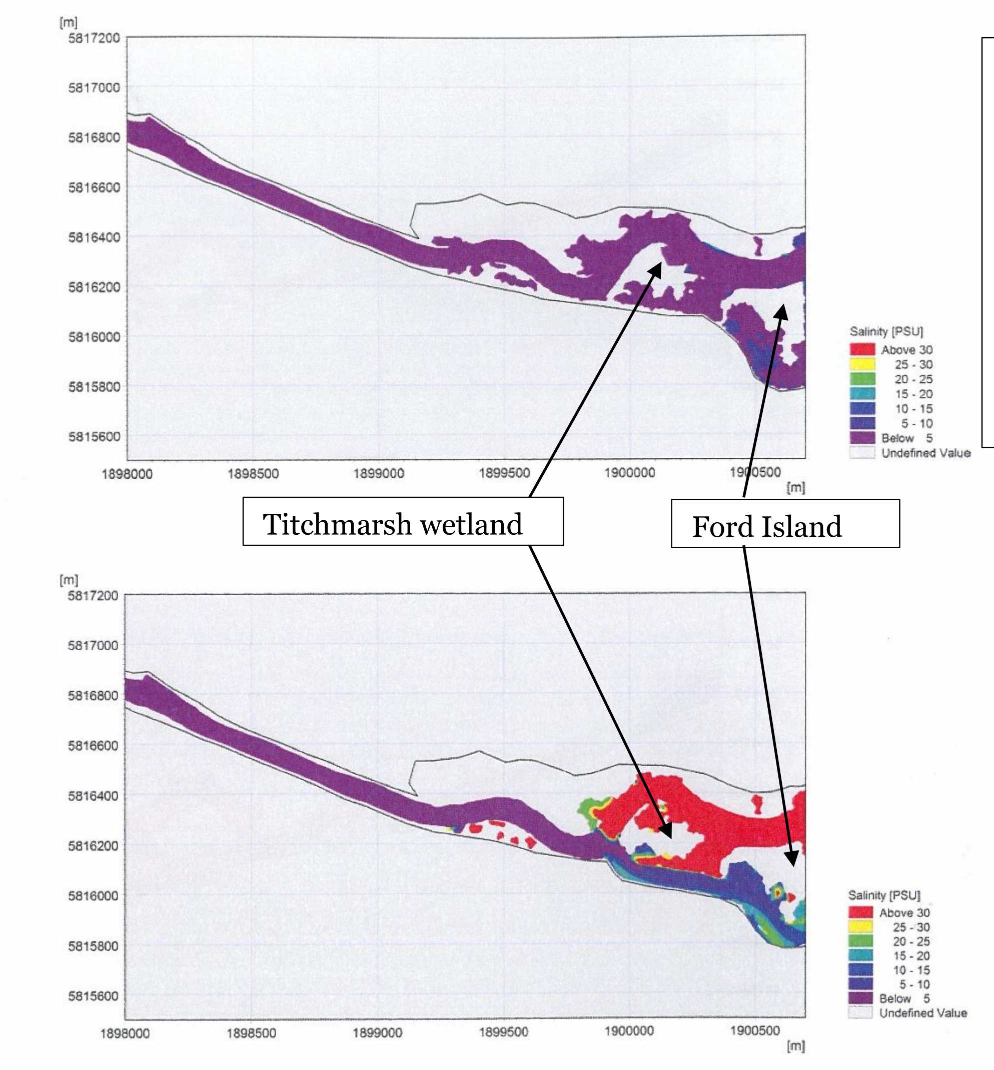


Figure 10: Maximum salinity, lower Kaituna River water surface for existing (top) and proposed situations (bottom) for mean river flow and neap/spring tidal cycle (sourced from DHI 2014).

Nutrients

Modelling predicts an increase in nitrogen and phosphorus concentrations in some parts of the estuary after re-diversion. These changes are unlikely to impact negatively on any estuary margin vegetation - in fact, it is conceivable that moderate increases in nutrient concentrations may benefit marshland/wetland plant growth, promoting productivity. The salt marsh species alongside Maketū Road have persisted in relatively high nutrient conditions prior to and since the river diversion; with no projected change in nutrient status in this area, these can be expected to thrive in future.

Increased nutrient concentrations may however lead to increased algae growth within the estuary. The likelihood of this response in the Ongatoro - Maketū estuary is discussed in Hamill(2014).

The removal of livestock from both the Brain land and Papahikahawai Island can be expected to reduce the input of both nitrogen (especially in the form of soluble nitrate) and phosphorus loads entering the estuary from these locations. Recent nutrient budgeting work (using Overseer®) undertaken on dairy farm land adjacent to Ongatoro -Maketū estuary has shown that nitrogen is leaching at around 40 to 45 kg N/ha/year (P. deMonchy pers comm). The quality of pasture on both the Brain land and the island is substantially less than that on the surrounding farmland, with the likelihood that the average stocking rate over a year would be half that of the more productive farmland. If it is assumed that leaching losses occur at 20 to 23 kg N/ha/yr, removal of livestock from the Brain land and the island will eventually reduce the nitrogen load entering the estuary by between 700 and 800 kg per annum.

Phosphorus does not leach down through the soil to the same extent as nitrate-N. The P load generated by livestock on the Brain and Papahikahawai Island land that currently enters the estuary is likely to be relatively small, consequently, the reduction in P load following removal of livestock is likely to be less significant than for nitrogen.

Residual nutrient loads arising from the farmed areas can be expected to fall away within a few years of destocking.

Estuarine erosion or deposition

The predicted increase in current speed and potential for sediment erosion around the southern side of Papahikahawai Island and through the main body of the estuary is unlikely to have any negative effect on existing estuary vegetation. The remaining areas of wetland and marsh exist in areas where current flow is not likely to be high or where significant current change is unlikely (eg. Titchmarsh wetland and Ford Island).

The increase in current velocity and increase in erosion potential predicted in the area south of Papahikahawai Island (where the 60 ha area of salt marsh / wetland existed pre river diversion) may prevent the re-establishment of a sedge–rush wetland in this area, whether through natural re-establishment, managed restoration or a combination of these two processes. The modelling suggests that allowance of 20 % of river flow through the estuary will create conditions that are different from both the current state and the pre-diversion state, consequently, salt marsh wetlands in this area may not be sustainable under the proposed conditions.

Some concerns have been expressed by the Maori owners of the island that the low-lying wetland area along the south side of Papahikahawai Island might be at risk of erosion and loss to the estuary when the stopbanks are removed. While this risk is considered to be low, largely because a significant portion of the flats lie above the mean high tide mark, monitoring, management and restoration options have been proposed in Section 4.4.

Sediment

Increased sediment loads, generated by the proposed greater river flow into the estuary, may influence benthic flora and fauna (see Keith Hamill report), but are not expected to have a negative effect on estuarine margin vegetation. Wetland sedges, rushes and reeds generally thrive in areas where sediment and nutrients are filtered out of the water column and settle around the plants' roots.

Sediment erosion has the potential to cause more significant problems if good sediment management practices are not put in place during construction and at the sites likely to receive the material excavated from the new channel and following removal of the stopbanks and causeway. Heavy rain events could mobilise large quantities of exposed sediment, causing it to enter the estuary water body over short periods, smothering estuarine flora and fauna. The production of a comprehensive Sediment Management Plan based on the Bay of Plenty Regional Council "Erosion and Sediment Control Guidelines for Land Disturbing Activities" will help minimise the likelihood of catastrophic sediment mobilisation events. It may be possible to further reduce the risk of mobilising sediment during construction by preventing river inflow into the estuary during this phase. This option has been addressed in the construction report (Everitt 2014).

Figure 11: Likely level of tidal inundation at mean high tide on the Titchmarsh wetland and Ford Island after re-diversion. [Inundation mapped at 0.75m above 0m RL Moturiki Datum]

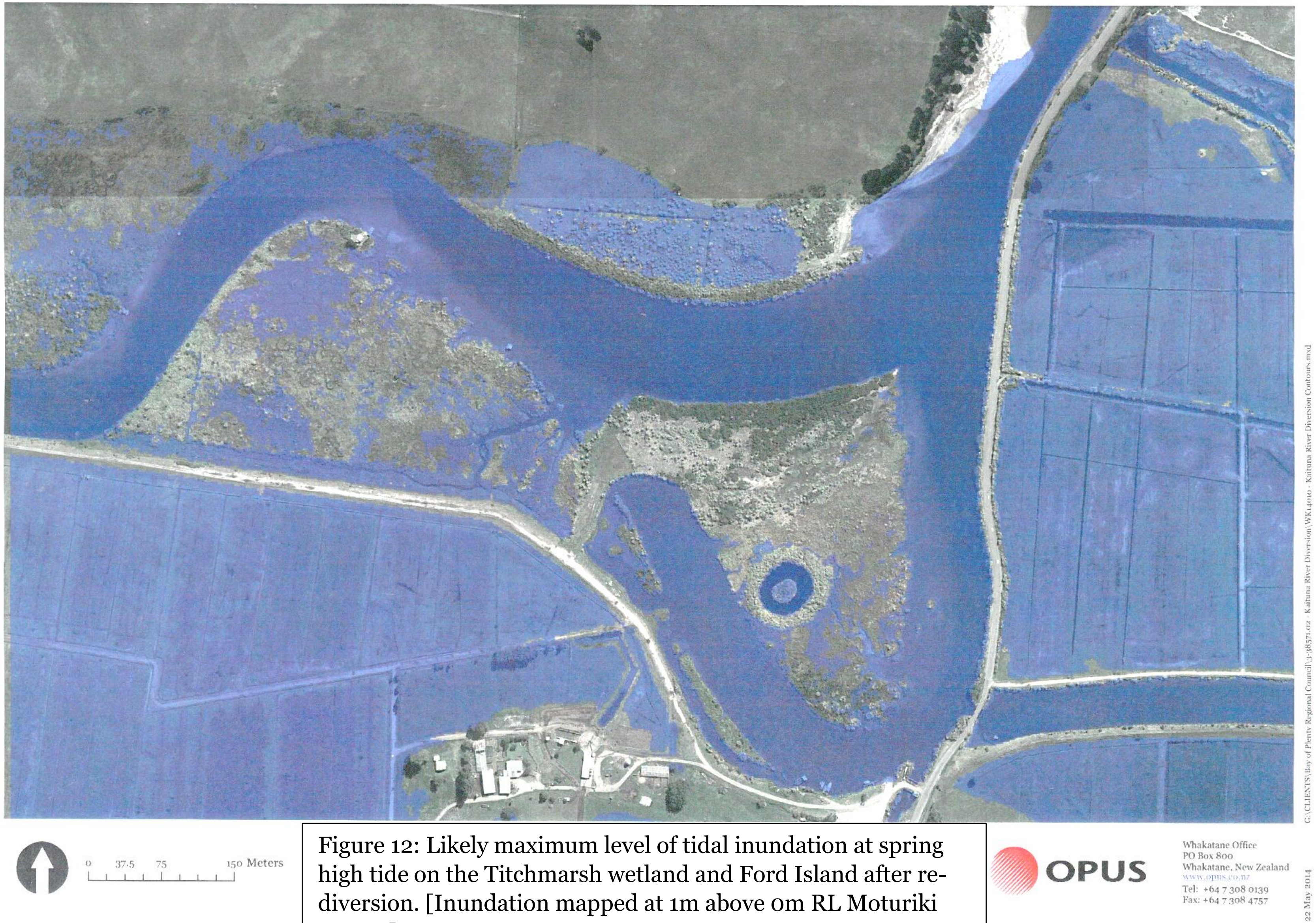


Figure 12: Likely maximum level of tidal inundation at spring high tide on the Titchmarsh wetland and Ford Island after re-diversion. [Inundation mapped at 1m above 0m RL Moturiki Datum]

Mangroves

Relatively small mangroves have occurred within Ongatoro - Maketū estuary in reasonably low numbers as far back as the mid 1800's. Today a handful occur in the estuary; all of them are small and most are growing alongside the Maketū Road salt marsh. Some reports suggest that they were more common in the 1800's and early 1900's than more recently, but they seem never to have dominated any areas within the estuary, nor have they ever grown to any significant height.

The re-diversion is unlikely to create conditions more favourable to the growth of mangroves than at present. Sediment loads would need to increase substantially to greatly improve the suitability for mangroves.

Ongatoro - Maketū Spit vegetation

None of the changes predicted to follow the proposed re-diversion of the Kaituna River are likely to have a significant effect on the vegetation growing on Ongatoro - Maketū Spit. The composition of sedge/rush vegetation growing along the junction between the terrestrial dune vegetation and the estuarine margin vegetation may change in response to changes in water chemistry, especially at the western end. No other effects are predicted.

3.3.3 Summary of potential ecological effects on vegetation

- None of the physical and chemical changes likely to occur as a result of the river re-diversion are expected to have significant negative effects on the remaining salt marsh areas within Ongatoro - Maketū estuary.
- It is likely that there will be some changes in species composition of the vegetation in parts of the Titchmarsh wetland in response to the predicted increase in salinity in the lower Kaituna River. However, significant vegetation change within the Titchmarsh wetland area is not considered likely as a result of the re-diversion because of the existing predominance of salt tolerant species along the margins that are likely to be exposed to the increased salinity. A monitoring programme has been recommended to track any vegetative changes and contingency mitigation measures proposed should they be necessary.
- The vegetation on Ford Island is not expected to change greatly, with a small improvement in species diversity and percentage cover likely on the eastern edge.
- There is a low risk of accelerated erosion along parts of the southern edge of Papahikahawai Island once the stopbanks are removed.
- Changes to salinity and removal of the stopbanks in the north-western corner of the estuary may create conditions suitable for salt marsh species to establish naturally or be replanted.
- Predicted increases in current flow may make the estuarine conditions in the area of the large salt marsh that has since disappeared unsuitable for the re-establishment of salt marsh or for freshwater wetlands.

3.4 Monitoring and Mitigation Recommendations

3.4.1 Titchmarsh wetland

The potential changes in species composition in the Titchmarsh wetland due to increased Kaituna River salinity is one effect of re-diversion that should be closely monitored and may benefit from preventative mitigation.

The likelihood of plant decline in this wetland is considered to be low. However, it is recommended that the vegetation composition and spatial extent of the wetland, especially along the margins, is surveyed in more detail prior to river re-diversion and closely monitored thereafter.

It is also recommended that contingency provisions are made for replacement / enhancement planting with salt tolerant wetland species in areas where wetland plants are dying or showing signs of ill-thrift.

3.4.2 Potential erosion of the southern edge of Paphikahawai Island

The risk of erosion of the southern edge of Papahikahawai Island following the removal of the stopbanks is considered to be low, however the following actions are recommended to further reduce the risk of erosion:

- The material used to construct the stopbanks along the southern shore of the island should be used to elevate the height of the land on the most low-lying sections of the island and to reduce the depth of the estuary margins. This should reduce the impact of erosion arising from tidal action and increased estuary channel current.
- The new land – estuary margin that will be created on the southern edge of the island when the stopbanks are removed should be the target area for revegetation with salt and sediment tolerant wetland species including sea rush. Plantings should be at close spacings and advanced out into the tidal zone of the estuary to provide maximum protection.
- Establishment of permanent water depth monitoring poles at several locations along the southern coast of the island, and regular monitoring of water depth and erosion after re-diversion.

3.4.3 Additional monitoring

While the modelling information and knowledge of the historical biological changes within the estuary enable post re-diversion predictions about biological effects to be made with reasonable confidence, it is recommended that all significant vegetation in and around the margins of the estuary should be monitored at regular (annual) intervals for several years following the re-diversion to confirm that the predicted effects (or lack of them) are occurring. This will enable corrective interventions to be considered before any unpredicted effects advance too far.

The permanent vegetation transects and quadrats established by Opus in February - March 2014 have been established in locations to enable changes to be monitored at regular intervals. It is recommended that further transects are established on land that was previously not accessible, especially the Brain land, and land that may have been determined to be a greater risk of change , notably the Titchmarsh wetland and the southern edge of Papahikahawai Island. It is also recommended that similar transect lines should be established in the areas where active revegetation takes place (see later sections).

4 Avian Ecology

4.1 Ecological Description

4.1.1 Comparison of past and present

Ongatoro - Maketū estuary is recognised as an important habitat for New Zealand shore bird species and is likely to have been so dating back to pre-European and pre-Maori times. Owen at al (2006) describes the Ongatoro - Maketū estuary and Kaituna River mouth as the “Bay of Plenty hotspot” for shorebird species having recorded 16 Arctic species and 8 native species over a 20 year survey period from 1984 – 2003. The significance of the habitat to shorebirds is emphasised when compared to approximately 68 shorebird species recorded for the whole of New Zealand (Turbott 1990 in Owen et al 2006).

The recent diversity and abundance of shorebird species is discussed in sections below but little information exists about the state of the estuary’s avifauna pre 1970. Shorebird numbers over time are likely to be closely related to the abundance and diversity of fauna in the intertidal zone. On this basis, and the anecdotal recollections from locals of a much more abundant fishery and shell fishery in the past, especially before the diversion of the Kaituna River and the development of the surrounding wetlands into farmland, the abundance of shorebirds is likely to have once been considerably greater.

No bird surveys have been found that pre-date the loss of the salt marsh and palustrine wetlands in and around Ongatoro - Maketū estuary. A wide diversity of New Zealand species once occupied marshland and wetland habitat, as illustrated by the 61 species that have been recorded in the nearby Kaituna Wildlife Management Reserve. All or most of these would likely have also occupied the Ongatoro - Maketū wetlands; few have been recorded in recent decades (Bioresearches 1976; Murray 1978; KRTA 1986; Sagar et al 1999; Owen at al 2006).

4.1.1.1 Methodology

Bird surveys have been undertaken in Ongatoro - Maketū estuary in 1977 (Peter Anderson, Wildlife Division of Internal Affairs (in Murray 1978), 1981 by Bioresearches, from 1983 – 1994 by Sagar et al (1999), 1996 - 2013 by the Ornithological Society of NZ (OSNZ, now referred to as “Birds New Zealand”). Further OSNZ survey data between 1984 and 2003 was also published by Owen et al (2006). While a variety of survey methods have been adopted, which limits our ability to evaluate trends in a statistical way, the data collected does provide useful information about the value of the estuary as habitat for shorebird species.

The data collected in these surveys has been collated and evaluated. Species diversity and abundance, and possible trends, are discussed below.

<u>OSNZ data</u>

A set of annual and seasonal shorebird census data from the Ongatoro - Maketū estuary was made available by the Ornithological Society of New Zealand (OSNZ) for analysis. This data included annual winter and summer censuses for most years between 1994 and 2013 inclusive. Data for several years – 2001, 2002, 2004-06 – was missing from the OSNZ data, as was seasonal data for several other years (November 1995 & 2000, June 2003, 2007, 2009). In some years, counts taken in the months of January and March were included in addition to, or instead of, November/December counts. There appeared to be a change in count methodology from 2007, in that counts from that year onwards were recorded across a wider area within the estuary. Given the data gaps, and in order to maintain a consistent approach, it was decided to limit analysis of the OSNZ data to a summary of bird species observed.

With regard to illuminating any coarse (but not statistically significant) long-term trends in bird counts, a targeted set of OSNZ count data for 11 species published by Owen et al (2006) was deemed most useful, as it comprised full June/November counts over a 20-year period and counts appeared to have been collected in a consistent manner. This set of count data was summarised into bar-charts for each of the 11 species and season covering a 20-year year time-span, with a 5-year running mean overlaid (Battley & Brownell, 2007).

4.1.1.2 Results

Species diversity

i) Ongatoro - Maketū estuary and Kaituna River mouth

In total, 61 bird species have been recorded at Ongatoro - Maketū estuary and the Kaituna River mouth/cut areas since 1984. 23 of these are seasonal visitors from northern hemisphere breeding grounds, 34 are native species, and 3 are waterfowl species introduced to New Zealand. 29 of the 61 species could be defined as shorebird or coastal species and many of these are infrequent visitors to Ongatoro - Maketū estuary. The remaining species consist of gulls and terns (7), shags (4), swans, geese, ducks and teal (7), heron and egrets (5), wetland/marsh species (4), royal spoonbill, black fronted dotterel, Australasian coot and gannet. A list of the species recorded can be viewed in Appendix 2.

Of the species recorded, four (black-billed gull, NZ dabchick, grey duck and white heron) have a threat classification of "threatened – nationally critical"; three (reef heron, Australasian bittern and black-fronted tern) have a 'threatened – nationally endangered" status; eight (banded dotterel, black shag, Caspian tern, lesser knot, northern NZ dotterel, pied shag, red-billed gull, and wrybill) are classified as "threatened – national vulnerable"; and eight (banded rail, white-fronted tern, eastern bar-tailed godwit, little black shag, pied stilt, royal spoonbill, South Island pied oystercatcher, and variable oystercatcher) are considered to be "at risk".

Owen at al. (2006) reported that the Ongatoro - Maketū Estuary / Kaituna River mouth held more than 1% of the national Pacific golden plover population during the period 1984-2003 and just under 1% of the northern New Zealand dotterel population.

Only four marshland or wetland species (Australasian bittern, banded rail, NZ dabchick, and pukeko) have been recorded in any of the data (and in very small numbers) although these species were not the focus of the surveys. Opus field staff heard fernbird calls on the Titchmarsh wetland area in March 2014 (T. Connolly pers comm).

ii) Kaituna Wildlife Management Reserve

The 259 ha Kaituna Wildlife Management Reserve is located 2.8 km upstream of the head of Ongatoro - Maketū estuary and 2.5 km from the mouth of the Kaituna River. The habitat is described as riverine / palustrine – not influenced by tidal water.

McDougall (2001) states that 59 bird species were recorded in this wetland in surveys undertaken during 2000 and as described by Garrick (2000). 16 of the species in this list have been recorded in the Ongatoro - Maketū estuary since 1990; many of the remaining 43 are species that could be expected to inhabit the estuary margins if suitable wetland and salt marsh habitat existed.

Of the species listed at the Kaituna Wildlife Management Reserve, eight are classified as "threatened" - three (NZ dabchick, grey duck and white heron) are considered to be "nationally critical"; two (Australasian bittern and reef heron) are "nationally endangered"; and four (Caspian tern, black shag, pied shag, and red-billed gull) are "national vulnerable". An additional nine species (banded rail, little black shag, marsh crake, North Island fernbird, NZ pipit, pied stilt, royal spoonbill, spotless crake and white-fronted tern) are currently considered to be "at risk".

Population trends

Varying survey methods used prevents the statistical analysis of all survey information. Owen at al. (2006) has, however, determined some arguably statistically significant trends from the data they collected on 11 targeted species:

- South Island pied oystercatcher counts have increased substantially at the estuary since 1994. Only two records of the species are recorded prior to 1994, but since then numbers have increased from 114 in 1994 to 250 in 2002. The reasons for this marked increase are unclear (Owen at al 2006).

- Variable oystercatcher relative abundance has shown a statistically significant increase from 1984 to 2003, although the increase has been less pronounced than for South Island pied oystercatcher.

- Pied stilt have shown a statistically significant decrease in relative abundance from 1984 – 2003 in both summer and winter.

- Northern NZ dotterel have exhibited statistically significant declines in summer and winter over the survey period. The decline is attributed more to the loss of open sand nesting and roosting sites on the Maketū spit than to changes to the state of the estuary.

- A small numerical increase in banded dotterel has been recorded but this is not statistically significant.

- Wrybill have been very infrequent visitors to the estuary since 1983 with only two recorded in the study period, both during 2001. Previously, 10 birds were counted in 1981 and 17 in 1982.

- 3.7% of the national Pacific golden plover population was recorded at Ongatoro - Maketū between 1984 and 2003. There has been a decline in relative abundance between the decades 1984-1993 (average count: 28) and 1994-2003 (average count: 19).

- The spur-winger plover population nearly trebled from 1984 to 2003 but this increase has been attributed more to the substantial areas of adjacent farmland rather than to the qualities of the estuary.

- Turnstones breed in Siberia, Scandinavia and Greenland and migrate to NZ for the northern winter. Numbers visiting Ongatoro - Maketū have declined significantly from 1984-1993, when 30 visited each year on average, to 1994-2003 when an average of only 10 were counted.

- Lesser knots (also known as red knots) migrate from Siberia each year. Ongatoro - Maketū estuary has typically been the temporary summer home for the largest population of knots in the Bay of Plenty, but numbers have declined substantially over the period of the survey with 110 present on average each year from 1984-1993, compared to 73 for the years 1994-2003.

- Eastern bar-tailed godwit migrates each year from a northern zone extending from eastern Siberia to northern Alaska. Numbers visiting Ongatoro - Maketū have increased from an average 556 birds per summer count (1984-1993) to 715 birds (1994-2003).

Changes in relative abundance of the 11 species targeted by the Owen at al. study show no clear overall trend in the size and nature of the shorebird population at the Ongatoro - Maketū estuary. Three of the seven New Zealand native species in the study have increased in number since 1984; two have reduced in number and three have not changed greatly. Three of the four migrant species have declined in recent time (Figure 13) but this is more likely to be as a result of influences in their northern hemisphere breeding grounds than at the Ongatoro - Maketū estuary.

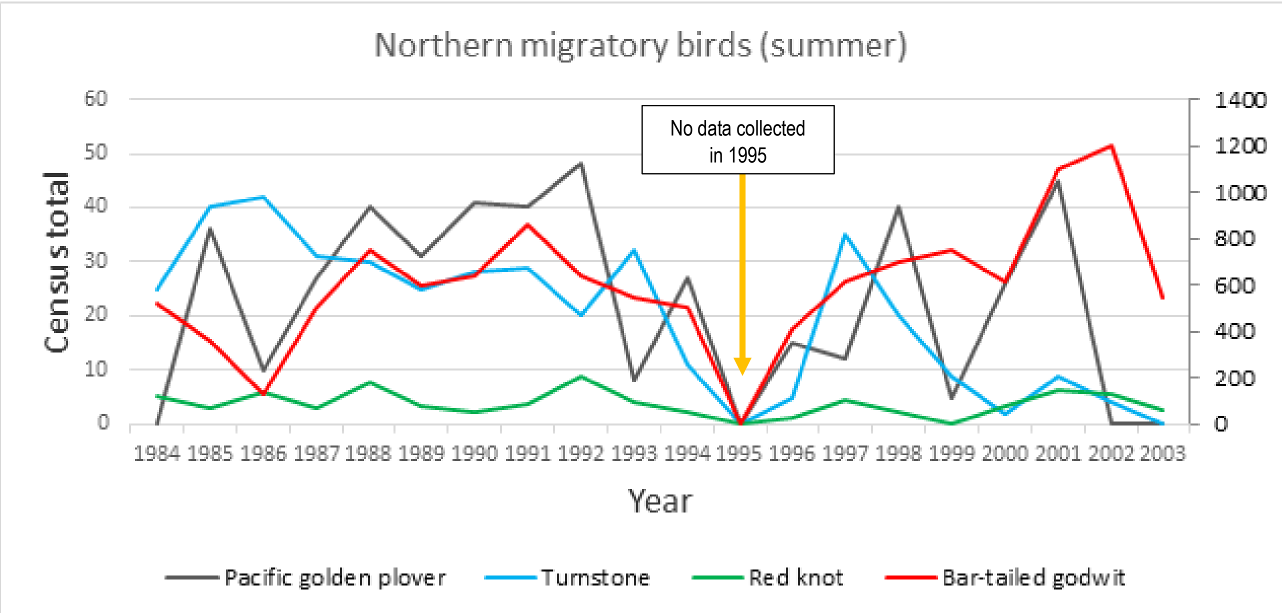


Figure 13: Annual census counts for 4 northern hemisphere summer migrant bird species at Ongatoro/Maketū estuary and Kaituna River mouth, 1984-2003.

All OSNZ-supplied data from Ongatoro - Maketū and Kaituna River mouth bird counts between 1996 – 2013 were amalgamated into a single spreadsheet and species numbers recorded for each season and year (where supplied) graphed (Figure 14). While statistical analysis is not possible because of data gaps and the different survey methods used, the information provides some general indication of species diversity trends. Summer (November – December) surveys have counted between 24 species (2012) and 31 species (1996) each year, average – 26 species; and winter (June – July) surveys have ranged from 19 species (1998) to 26 species (1996), average – 22 species). There is a slight (non-statistical) downward trend in the number of species observed in summer and winter but this may be a product of variable observer experience and/or survey method rather than a decline in species using the upper estuary – river mouth area.

Of interest, the June 2013 survey counted the most individual birds (n=4036) of any survey between 1996 and 2013 (range for years 1996-2012: 596 (June 1998) to 1624 (June 1997)). Over 1000 pied oystercatcher, 625 pied stilt and 520 eastern bar-tailed godwits made up a substantial proportion of the 2013 total count.

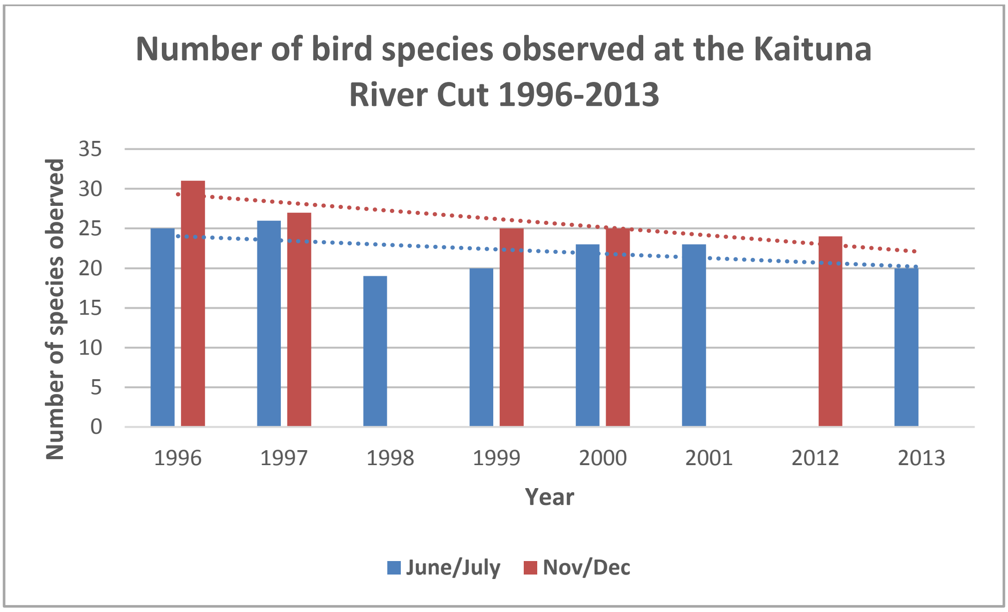


Figure 14: Comparison of the number of species counted during OSNZ surveys at the Kaituna River Cut, 1996 – 2013. Note that several years are missing.

4.1.1.3 Discussion

The number of shorebird and water species occurring in the Ongatoro - Maketū estuary and Kaituna River near its mouth does not appear to have varied greatly over the past 30 years, with most of the species recorded in 1996 still present in 2012-13.

Wetland and marshland bird species have been counted infrequently and in very low numbers in the estuary and near the river mouth, reflecting the lack of suitable habitat remaining. While there is no survey data to indicate the size and nature of the pre-diversion wetland bird populations, the loss of 170 ha of marshland and wetland habitat is likely to have had a considerable impact. Most of the 59 species recorded by McDougall (2001) at the Kaituna Wildlife Management Reserve are likely to have been present around the margins of the Ongatoro - Maketū estuary before the Kaituna River was diverted.

No bird survey data is available from prior to the river diversion from which to gain any impression of what effects the diversion had on shorebird species. While the quality of habitat is likely to have deteriorated, particularly with the decline in the estuarine and shell fishery, the area of available habitat for wading and shorebird species has increased due to the loss of salt marsh and freshwater wetlands.

4.2 Assessment of Ecological Values

4.2.1 Shorebirds

Ongatoro - Maketū estuary is a recognised site of high ecological value for shorebirds, especially annual migrants from the northern hemisphere. 22 migratory species have been recorded in or near the estuary over the last 30 years, and another 29 native species, many of them shorebirds, have also been observed.

No substantive bird survey data has been found that pre-dates the 1970's, including the period prior to the diversion of the Kaituna River in 1956/7. Consequently, there is no clear picture as to whether avian diversity and abundance has increased, decreased or remained static following the diversion. The area of tidal mudflats has increased as a result of the decline of the salt marsh in the estuary, potentially increasing the feeding habitat available for shorebirds, however, Hamill (2014) has noted that the upper parts of the estuary has low macrofauna abundance and diversity suggesting that the extent of the feeding grounds in the estuary may not have changed greatly.

The bird survey data collected since 1984 provides no clear picture of any trends in species diversity and abundance over the past 30 years. Owen et al. (2006) has shown that some species have shown statistically significant increases over that period while others have declined significantly. The diversity and abundance of species using the estuary remains high enough for the area to warrant the continued status as a "hot spot" for shorebird species.

4.2.2 Marshland and wetland species

The diversity and abundance of marshland and wetland bird species in the estuary is now small, reflecting the substantial loss of salt marsh and freshwater wetland habitat since the river diversion. Only 16 of the 59 species that inhabit the Kaituna Wildlife Management Reserve have been recorded in the Ongatoro - Maketū estuary and Kaituna River mouth areas, and many of those are in very small numbers and mostly in the area of the Titchmarsh wetland and lower river margins. While no data exists from the period prior to the Kaituna River diversion, it is very likely that all or most of the species currently inhabiting the Kaituna Wildlife Management Reserve were present within the 170 ha of salt marsh and wetlands that existed within the estuary prior to diversion and conversion to farmland.

The Titchmarsh wetland and the remaining areas of salt marsh (especially the area beside Maketū Road) are important remnant areas of high ecological value for wetland bird species. For this reason, protection and enhancement of those areas as bird habitat should be a priority.

4.3 Assessment of Potential Ecological Effects

4.3.1 Shorebirds

There are no predicted biological, physical or chemical changes to the estuary that will occur with the proposed river re-diversion that are likely to have a significant negative effect on the existing shorebird and wader populations other than the possibility of disturbance from increased human usage of the estuary if the state and extent of the shell fishery improves.

DHI modelling predicts that the proposed re-diversion will generate increased residual current velocities towards the ocean and Hamill (2014) predicts this change should have a positive effect on benthic invertebrate fauna by “improving the rate of food supply for filter feeders such as cockle and by reducing the extent of the estuary that is currently degraded by accumulations of free floating algae and anoxic muds”. He expects the improvements will be most apparent in the upper estuary, mid-estuary south of Papakahawai Island and the lagoon area to the west of the island. He also predicts that the likely salinity changes will have little impact on benthic invertebrate fauna. The consequence of this is a likely improvement in the extent and quality of feeding grounds for waders and shorebirds, a positive effect.

Periodic breaches of the Maketū spit can reduce the area of suitable breeding habitat for species that occupy dunes and beaches, such as Northern NZ dotterel. Spit breaches are a natural occurrence at Maketū and several have been recorded since the 1860’s. The proposed re-diversion is not expected to increase the likelihood of spit breaches (J. Dahm pers comm) but breaches can be expected to occur from time to time and this may have an effect on those species breeding on the dunes.

4.3.2 Marshland and wetland species

The remaining small areas of salt marsh within the estuary are not expected to deteriorate as a result of river re-diversion (see Section 4.3) and so the small numbers of birds utilising these areas should not be affected in any negative way by the proposed re-diversion.

There is some risk of species composition change and possibly wetland decline at the Titchmarsh wetland as a result of predicted salinity increases in the Kaituna River. If the wetland area was to retreat, the area available as habitat for wetland bird species would also decline. However, the restoration of 27.5 ha of wetland habitat is proposed as part of this project (see Section 6) and this will substantially increase the area of habitat available for wetland birds and more than compensate for any decline in the Titchmarsh wetland should that occur.

4.3.3 Summary of potential ecological effects on avifauna

- No significant negative effects are expected on the shorebird and wader avifauna currently using the estuary.
- The potential increase in estuarine benthic invertebrate fauna may lead to increased and improved feeding grounds for waders.
- Birds inhabiting the remaining salt marsh areas are unlikely to be negatively affected by the re-diversion because the existing salt marsh areas are expected to remain intact (and some may enlarge naturally).

- There is some risk of a decline in the size of the Titchmarsh wetland which may have an effect on the wetland bird species inhabiting this area but this is likely to be more than compensated for by a substantial increase in wetland habitat that will occur with the proposed restoration of 27.5 ha of wetland on the Brain land and Papahikahawai Island.

4.4 Monitoring and Mitigation Recommendations

Measures to reduce the likelihood of decline in the Titchmarsh wetland area are proposed in Section 3.4.1. No other active preventative or remedial actions are considered necessary to safeguard the avian ecological values in the estuary and river mouth areas. Continued effective pest control around known roosting and breeding sites, especially on Maketū spit, are recommended.

An improved programme of monitoring of bird species on and around the estuary is recommended so that the impacts of the re-diversion, both positive and negative, can be determined and responded to if necessary. Standardisation of bird survey methodology and survey timing is strongly recommended so that the collected data can be evaluated statistically.

It is also suggested that surveys are undertaken at low tide (as well as the current high tide counts) to gain a more complete picture of what parts of the estuary are being used by different species. Currently, estuarine bird surveys in New Zealand are generally undertaken at high tide and these counts tend to provide data on birds roosting rather than those feeding. Low tide counts are more challenging (and require greater resources) because of the spatial spread of birds but the information to be gained from low tide counts would enhance our knowledge of the behavioural ecology of Ongatoro - Maketū estuarine avifauna.

5 Wetland Restoration Proposal

5.1 Introduction

Approximately 170 ha of salt marsh and palustrine wetland existed in Ongatoro- Maketū estuary prior the diversion of the Kaituna River and the stopbanking and drainage of the Brain land and the flats of Papahikahawai Island (see section 3.1.1). Today, only about 7 ha of salt marsh and less than 0.5 ha of palustrine (freshwater dominant) wetland remain within the estuary (Table 2). Additional areas of wetland persist on Ford Island and the Titchmarsh wetland but they amount to a small fraction of the area that once existed.

Wetlands provide many key biological and physical benefits to an estuarine environment such as Ongatoro - Maketū (Clarkson et al 2014). They provide important feeding and breeding habitat for many native fish, birds and aquatic and terrestrial invertebrates, and they serve to buffer the forces of tides and river flow especially during flood and storm events by slowing down flow velocity, encouraging sediments to settle and by acting as a sink for nutrients. The loss of the large proportion of the original wetlands from the estuary has greatly reduced the biodiversity of the Ongatoro - Maketū estuary ecosystem from that pre-land development times.

The Kaituna River Re-diversion and Ongatoro - Maketū Estuary Enhancement project proposes to restore at least 20 ha of wetland around the Ongatoro - Maketū estuary margins. The wetland areas proposed for restoration include the Brain land (19 ha), the southern low-lying flats of Papahikahawai Island (8 ha), and the portion of Ford's Loop Channel that is to be filled (0.5 ha). All of these areas were wetland habitat prior to drainage and development for farming. The availability of the Brain land is subject to negotiation of a purchase agreement between Bay of Plenty Regional Council and the landowners, and the restoration undertaken on Papahikahawai Island is at the discretion of the Maori landowners.

5.2 Restoration Philosophy and Strategy

The primary restoration objective is to restore the land available to a state where there is a sustainable cover of indigenous plants that is as close to the original natural species diversity that can be achieved taking into consideration the substantial and irreversible human-induced changes that have occurred to the landscape surrounding the estuary.

The project will re-establish freshwater, estuarine margin and saltmarsh wetlands where environmental conditions allow once the Kaituna River is re-diverted. The species chosen for planting and the wetland types created will be governed particularly by the nature and extent of tidal influences, soil salinity, and soil saturation. After consideration is given to matching species tolerance ranges to the site conditions, effort will be made to create habitat at appropriate locations for important/threatened fauna. For example, creation of increased areas suitable for inanga spawning is considered to be a priority, as is the establishment of wetland habitat suitable for breeding for threatened marsh species such as North Island fernbird, marsh crake and Australasian bittern.

Because the growing conditions will change more on some parts of the wetland restoration areas than others after re-diversion, a restoration strategy will need to be produced that includes the following:

- Initial monitoring of site growing conditions (especially soil salinity, soil saturation, tidal induced sediment erosion and deposition);
- Creation of a planting zone plan based on site growing conditions and species tolerances;
- Trial planting of plant species especially in areas where growing conditions are likely to be challenging (eg. areas exposed to open tidal water and those with higher salinity);
- Details of mass planting once species can be matched to site conditions with high confidence of success.

This restoration strategy is designed to reduce the risk of large-scale and expensive planting failure. Low risk locations, such as those on the terrestrial sites well above tidal influence on the Brain land and Papahikahawai Island, can be planted without need for initial trial plantings, whereas some of the wetland areas on Paphikahawai Island may not be planted for several years after re-diversion until erosion risk has been evaluated and a decision has been made about whether the stopbanks should be removed and how rapidly they should be removed.

While the primary restoration objective is to restore existing drained and stopbanked areas back to wetland, there is also interest in investigating whether estuarine / salt marsh vegetation can be re-established back into areas that were previously clothed in indigenous vegetation prior to the original river diversion. Two areas are proposed for investigation:

1. Salt marsh expansion. The owners of Papahikahawai Island would like to regain some or all of the 53 ha of salt marsh that was lost from the southern part of the island following the river diversion if vegetative reclamation is possible. The practicality of this is discussed in more detail in sections below.

2. Eelgrass (Zostera) bed rehabilitation. New Zealand eelgrass (*Zostera muelleri*) provides important habitat to estuary fauna but the beds in the Ongatoro - Maketū estuary have declined substantially since the river diversion. Natural regeneration of eelgrass beds tends to be slow because the species mostly expands by root runners. Restorative planting of eelgrass, which has been undertaken with some success in Whangarei Harbour, would speed up the re-establishment of beds in the Ongatoro - Maketū estuary if sufficient resources can be found to support it.

5.3 Description of Proposed Restoration Works

All of the land proposed for restoration back to wetland, with the exception of the small section of Ford’s Loop Channel, has been protected by stopbanks and drained to create pasture for grazing. As part of the physical works associated with the re-diversion of the river, it is proposed that the causeway between the Brain block of land and Papahikahawai Island will be removed as will all of the stopbanks around the margins of the Brain land (Figure 15). It is also proposed that the stopbanks along the southern side of Papahikahawai Island should be removed, with the Maori landowners’ permission, but only after measures have been taken and experience gained to be confident that more of the island will not erode away when the stopbanks are removed. This is discussed in more detail in later sections. The access causeway to Papahikahawai Island will be removed and replaced with a bridge.

The removal of the causeways and stopbanks will result in re-flooding or increased ground saturation of significant sections of the Brain land and the low-lying sections of Papahikahawai Island. Figures 16 and 18 show the minimum areas that will be flooded at high tide if all physical barriers to tidal movement are removed. Figure 17 and 19 show what might be the maximum spring high tide area of inundation. The extent to which these land areas become re-wetted and the level of soil salinity created by opening this land to the tide will determine the range of plant species that can be re-established.

Salinity from tidal waters and soil saturation from the tide and river flow will be the major environmental factors influencing the plant species that can successfully be established on the 3 proposed wetland areas. While modelling has given us some idea of how wet and how saline the wetland planting areas will become we will not know enough about the localised conditions to choose the plant species mixes until the full river diversion has been implemented and the stopbanks and causeway have been removed.

Each of the three wetland restoration areas will require different strategies that reflect land ownership and the environmental conditions and risks that will arise following the river re-planting zones, species mixes, plant spacings, plant grades, site preparation and post-planting maintenance requirements. Recommended restoration strategies for each restoration area are described below.

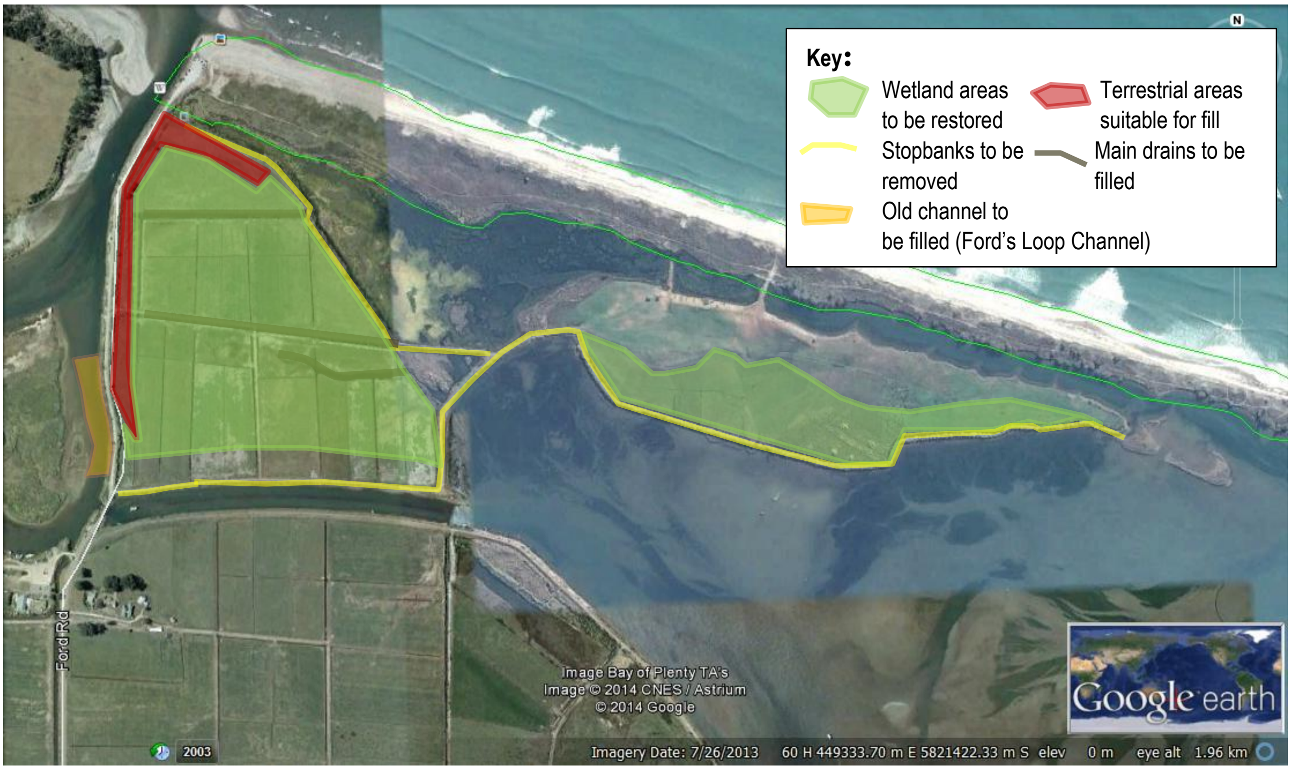


Figure 15: Aerial view of the Brain block of land and Papahikahawai Island showing stopbanks to be removed, drains to be filled, wetland areas to be restored and areas proposed for deposition of fill from the new channel and from the widening of Ford's Cut.

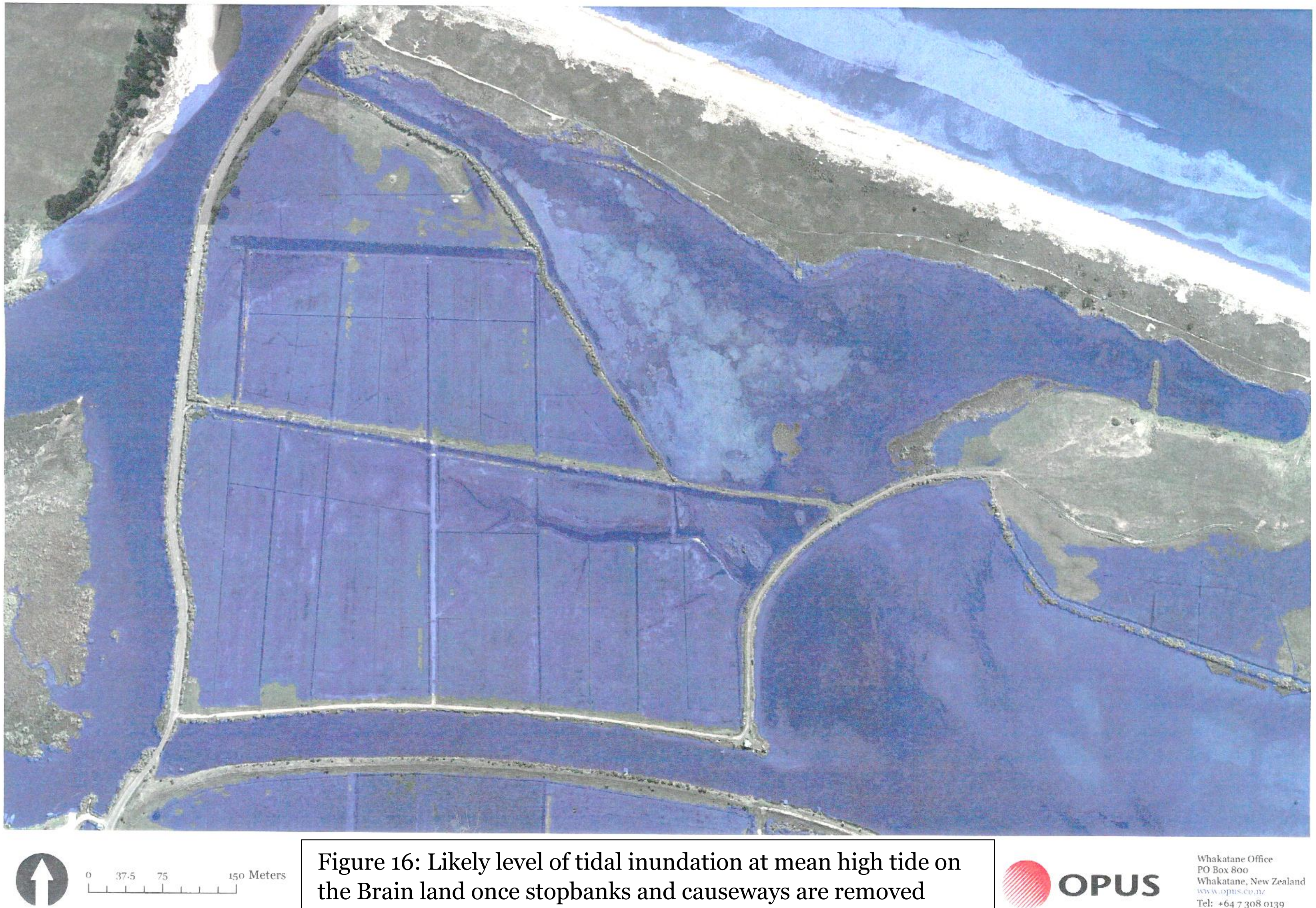


Figure 16: Likely level of tidal inundation at mean high tide on the Brain land once stopbanks and causeways are removed after re-diversion. [Inundation mapped at 0.75m above 0m RL Moturiki Datum]

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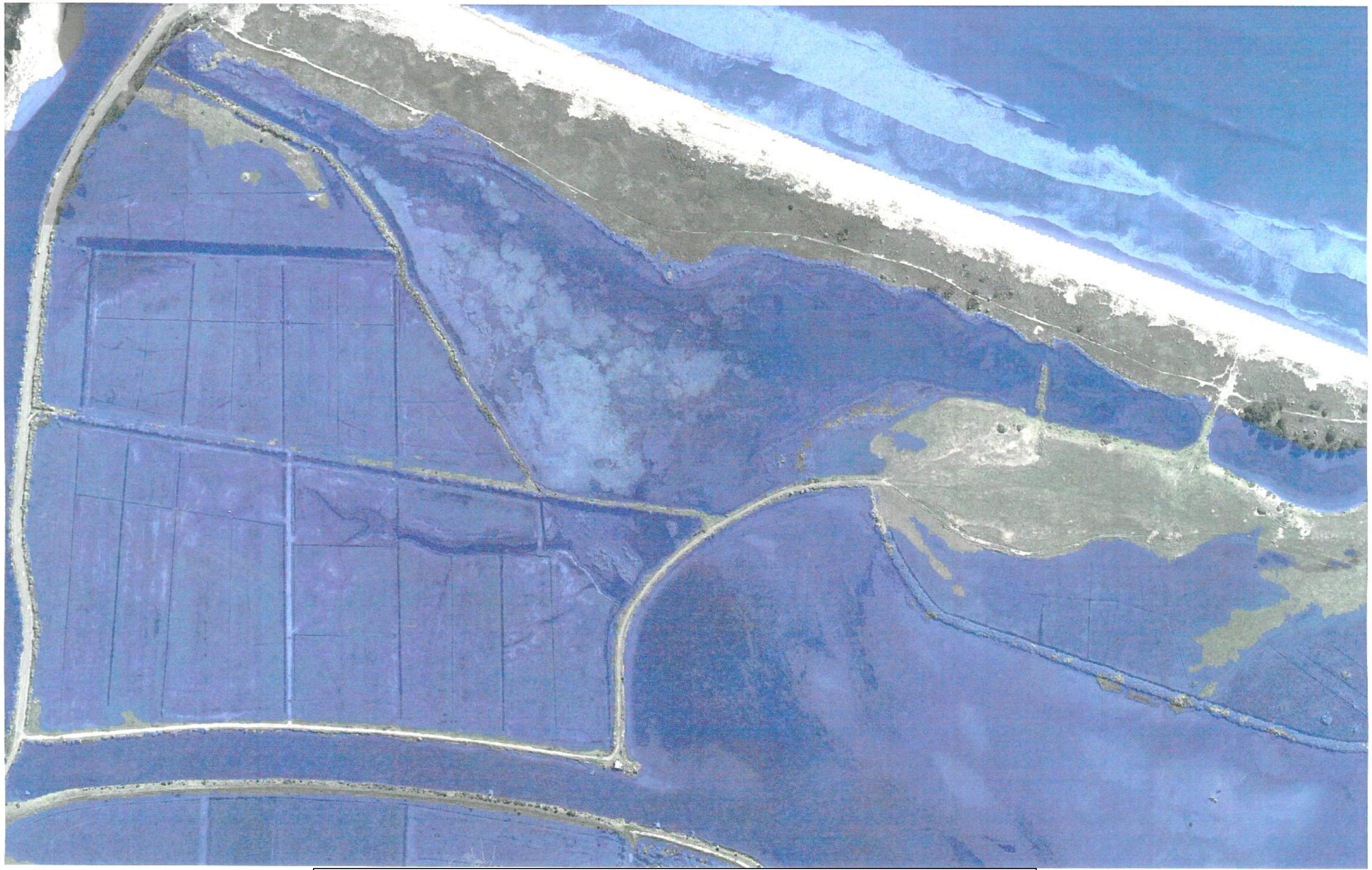


Figure 17: Likely maximum level of tidal inundation at spring high tide on the Brain land once stopbanks and causeways are removed after re-diversion. [Inundation mapped at 1m above 0m RL Moturiki Datum]

5.3.1 Brain land

5.3.1.1 Detail of earthworks

It is recommended that the drains that currently draw water off the Brain land should be filled prior to the removal of the stopbanks so that when the stopbanks are removed the penetration of tidal water will occur on a reasonably even front along the eastern edge of the Brain land. If the drains, several of which lie perpendicular to the eastern edge of the block and extend well into the block, were to remain open then salt water would penetrate further into the block creating an unnatural mosaic of high vs low salt water exposure which in turn would create complexity in selecting suitable plant species. Most of the material for filling the drains will come from the sediment excavated from the drains in the past which has been deposited alongside the drains, and from the stopbanks that will be removed.

It is recommended that some of the fill contained in the stopbanks is used to create a gentle slope into the estuary so as to reduce the energy of the tide and wave action and therefore reduce sediment erosion and increase the likelihood of successful establishment of plant material.

Most of the Brain land will be flooded regularly at high tide (Figure 16). Only small sections close to Ford Road and in a section close to the original river channel at the northern end of the block (Figure 15) will sit above the tidal zone and will require plant species that have largely unsaturated/terrestrial soil preferences. Anecdotal information (R Waugh pers comm) suggests that much of the Brain land may have “shrunk” by as much as 600mm over the last 30 years as a result of peat soil mineralisation and compaction since the area was drained for grazing. This would explain why it is predicted that much of the Brain land will be exposed to daily tidal waters (once the stopbanks are removed) when in the past (pre-drainage and grazing) it was thought that most of the Brain land was palustrine (ie. non-tidal wetland).

Several options have been considered for the disposal of the large amount of sediment that will be excavated from the new river channel and to widen Ford’s Cut. While it is unlikely that it will be cost effective to use excavated sediment to elevate the entire Brain block above mean high tide level, one option worth consideration is to create elevated patches, mounds and ridges some of which will receive tidal water during spring tides and other areas which will sit above the tidal zone. This will enable a greater variety of plant species to be established which in turn will create a greater diversity of bird and invertebrate habitat. If excavated sediment is to be used in this way to elevate portions of the Brain land care will need to be taken to stockpile any topsoil or organic soil component for spreading over the surface of formed mounds and ridges. Some of the excavation material may not be suitable or ideal for plant growth so any material that will assist plant growth should be put aside and used for this purpose.

The removal of the stopbanks on the Brain land side of Ford’s Cut is necessary to widen that channel. However, it is recommended that the level of the land alongside the new northern edge of the Cut be reinstated to a little above mean high tide level to prevent daily tidal influx into and erosion of parts of the Brain land. As is illustrated in Figure 16, there is a sizeable area of low-lying land on the Brain property immediately to the north of the current stopbank. If the ground level is not raised above its current height it is possible that the main inflow of water onto the Brain land will occur from Ford’s Cut rather than from the east and the greater current flowing through this zone may pose an erosion risk. The proposed bund should not, however, be built so high that it prevents occasional spring tide overtopping.

Salinity modelling suggests that there will be few if any locations within the estuary that will be suitable for inanga spawning. This is because inanga choose to spawn at the spring tide extent of the salt wedge and most of the estuary will remain too saline to create the right conditions. Suitable salinity will exist in the main river channel at the western end of the Titchmarsh wetland following re-diversion and there is also a small possibility that the salinity may be suitable for spawning along the Ford's Cut channel. It is suggested that any bund or chenier built along the northern bank of the Cut is set back several metres from the channel edge and constructed with a very gentle contour (perhaps 1:20) leaving a shallow slope to be planted in native vegetation suitable for inanga spawning.

5.3.1.2 Restoration planting specifications

In preparing comments on the revegetation of the Brain land it has been assumed that land ownership will be transferred to the Bay of Plenty Regional Council.

Approximately 19 ha of land on the Brain property will need to be planted once livestock are removed. The intention will be to clothe the island in a mix of salt marsh, freshwater wetland and terrestrial/dryland indigenous plants.

<u>Low-lying marsh and wetland areas</u>

The plant growing conditions on the Brain land will change significantly once the stopbanks and causeway have been removed and the river is fully re-diverted. Most sections of the Brain land are likely to receive daily high tide waters and will be exposed to moderate salinity (10-15 PSU) during normal river flows and up to 30 PSU during low flow periods. Some small areas may be sufficiently elevated to sit outside normal tidal range and these areas will receive occasional elevated pulses of salt water during spring tides and some may be influenced by elevated soil salinity as a result of salt water intrusion into shallow groundwater. The areas closest to Ford Road and a small area near the original river channel at the northern end of the Brain block are mostly above the predominantly wet zone and will be suitable for dryland plant species.

The exact extent of each of these zones will not be known until after the stopbanks and causeways have been removed and the full river re-diversion has occurred. It is recommended that ground conditions, particularly salinity and soil moisture levels, are monitored from the time of stopbank removal and the results from these measurements used to map the planting zones. The plant species chosen for each planting zone will be selected on their ability to survive the prevailing salt and soil moisture conditions and on their natural occurrence in the Ongatoro - Maketū estuary environment. Almost all of the salt water tolerant marsh species that grow in New Zealand estuaries grow optimally in freshwater or very low salinity levels but only a few are tolerant of prolonged period of exposure to salinity greater than 50% saltwater (ie. above 15 PSU) (Wardle 1991). Because of this a conservative approach should be taken to species selection with known medium to high salt tolerant species planted in zones where soil salinity rises above 10 PSU. The saltmarsh / wetland species known to occur in the Ongatoro - Maketū estuary area with medium to high salt water and soil tolerances are: *Juncus kraussii* var. *australiensis, Apodasmia similis, Isolepis cernua, and Ficinia nodosa*. The salt meadow species *Sarcocornia quinqueflora* has very high salinity tolerance and may be able to be used where rushes and sedges are less likely to occur.

Once the key environmental conditions have been determined and mapped it is proposed that trial planting plots are established to test and monitor species performance (survival and growth) in a scientific way under a variety of growing conditions. Different plant grades (ie. plant and container size) and planting densities may also be compared with the aim of the planting trial work being to reduce the risk of large-scale (and expensive) plant failure when full-scale planting commences.

The initial trial plantings should be established in one season and a reasonable understanding of species tolerances should be obtained after 12 to 24 months of growth. Repeat trial plantings should only be necessary if all trialled species fail to perform in a particular planting zone or if soil or environmental conditions continue to change.

Final planting densities to achieve effective vegetative cover will be clarified during the planting trials but it is likely that plant spacings for the wetland – marsh areas will range between 1 and 3 plants per square metre (10,000 – 30,000 plants/ha) depending on the species planted.

The establishment of marked monitoring plots through the planting zones is strongly recommended. Plant survival and seedling growth (height and breadth) should be measured at regular intervals (at least 6 monthly) particularly during the initial 24 months following planting. This information in conjunction with the physical site monitoring data will provide useful tolerance and performance information on which to base species selection for the large scale plantings.

<u>Dryland – terrestrial areas</u>

The dryland areas of the Brain land will not require trial plantings to determine the appropriate plant selections so planting could commence on these areas as soon as the deposition of sediment from the excavation of the new channel has been finished and the changes to Ford Road completed.

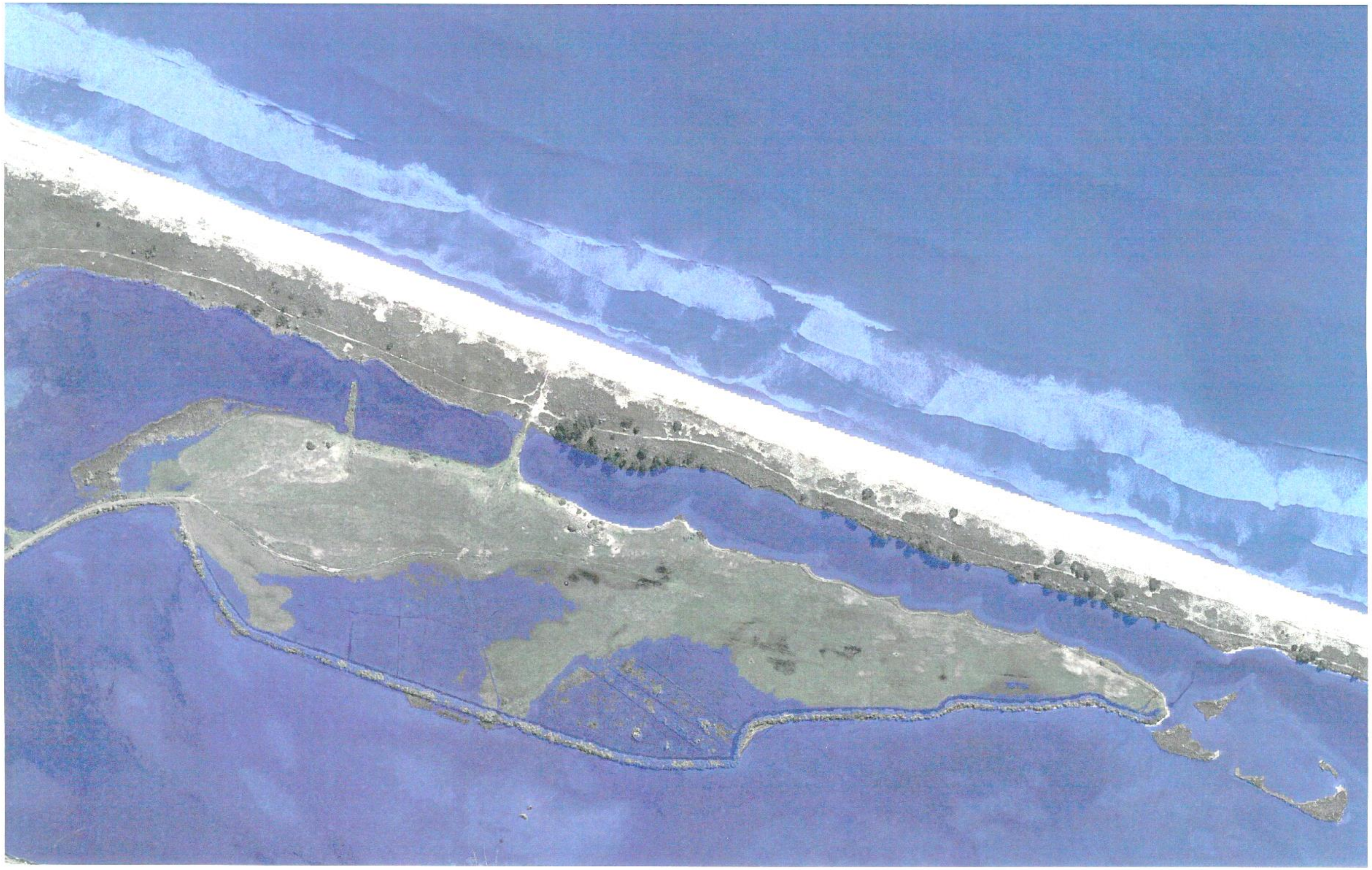
Once the planting zones have been determined and the trials have provided the species information required planting should occur as rapidly as resources will allow. Weed invasion will occur rapidly if planting is delayed too long, and because the most of this block of land will revert to being wet continued grazing of the unplanted areas by sheep to control weed and grass growth is probably not an option.

Plants should be planted at 1.5 to 2 metre spacings (4444 to 2500 plants /ha).

5.3.2 Papahikahawai Island

5.3.2.1 Detail of earthworks

Sections of the flats of Paphikahawai Island lie at mean high tide level and below likely spring high tide levels (Figure 18 and 19). Evidence of this is illustrated by salt water intrusion through the stopbanks and in the groundwater. It has been identified that a low level of risk of accelerated estuary margin erosion may exist when the river is re-diverted (see sections above). To ensure accelerated erosion of the southern margin of the island does not occur when the stopbanks are removed it is recommended that stopbank removal does not occur until the river has been re-diverted and sufficient time has passed to judge the erosive force of the increased river flow. If the erosion is found to be negligible, or manageable, then the stopbanks can be removed progressively.



0 37.5 75 150 Meters

Figure 18: Likely level of tidal inundation at mean high tide on Papahikahawai Is. once stopbanks and causeways are removed after re-diversion. [Inundation mapped at 0.75m above 0m RL Moturiki Datum]

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0 37.5 75 150 Meters

Figure 19: Likely maximum level of tidal inundation at spring high tide on Papahikahawai Is. once stopbanks and causeways are removed after re-diversion. [Inundation mapped at 1m above 0m RL Moturiki Datum]

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Stopbank removal is recommended, if it can be achieved without risking further land loss, to enable more natural wetlands (salt marsh and palustrine) to be established and maintained. Unmanipulated tidal movement and salt and freshwater hydrology, and maximum interface of the wetlands with the estuary are likely to create higher quality habitat for indigenous marsh fauna than would be the case if the stopbanks were retained in part or totally. Furthermore, the marshland vegetation – tidal estuary margins provide important habitat for aquatic fauna; this margin will not exist if the stopbanks remain. Any attempts to re-establish salt marsh in the estuary south of the island are also likely to have a greater chance of success if the stopbanks are removed. This is discussed further below.

If stopbank removal is agreed to, it is recommended that the material contained in the stopbanks is pushed out into the estuary to create a gentle slope from estuary to land. This will serve to dissipate tidal energy and increase the likelihood of successful establishment of salt marsh species.

5.3.2.2 Restoration planting specifications

The objectives of and strategy for revegetation of the 16.4 ha Papahikahawai Island are currently being discussed by the Papahikahawai Trust and Bay of Plenty Regional Council, and culmination of those discussions will be the production of a restoration plan for the island. Ultimately the decision as to what is planted and when is up to the Trust.

Discussions to date have revealed a strong interest by all parties to return most of the island to indigenous species and varieties that once occurred naturally there. Restoration of the low-lying areas back to wetlands is a priority including the re-establishment of stands of locally sourced harakeke (flax) which once were a predominant component of the vegetation around the margins of the Ongatoro - Maketū estuary. Approximately 8 ha of the island is sufficiently low-lying to be restored to freshwater wetland or salt marsh / salt meadow conditions while the remaining 8.4 ha is made up of elevated sand dune and flats that sit mostly above tidal and wetland influence.

<u>Terrestrial revegetation</u>

Revegetation of the 8.4 ha terrestrial zone can commence as soon as the resources and plants are available. It is recommended that the terrestrial planting begins at the eastern end of the island and that manageable blocks are planted annually moving progressively from east to west. If the planting is to be done by the Island Trust and/or by volunteers it is recommended that no more than 1 ha of the island is planted each year. The plantings will need releasing (ie. weed control) for 5 years so planting just one hectare per one year will create a maximum area of 5 ha to manage for weeds at any one time. Any more than this is likely to be a considerable challenge for volunteers and might lead to unacceptable plant failure if resources are over stretched. However, if the planting and maintenance is to be undertaken commercially then larger areas can be planted annually and effectively maintained.

Plant spacings should be between 1.5 and 2 metres apart for the entire terrestrial area. Between 21,000 and 37,300 plants will be required to fully plant the terrestrial area.

Because the planting will take several years to complete it is recommended that sheep are used to control grass and weed growth on the unplanted areas. Existing fencing could be strengthened to make them sheep proof with each year's planting effort focussed on filling out a fenced block.

Low-lying wetland – marsh restoration

Restoration of the wetland areas will create a greater challenge. A substantial area of the island, originally in salt marsh, has been lost to the estuary since the river diversion, and Papahikahawai Island trustees have expressed concern that the river re-diversion might increase the risk of erosion along the southern edge of the island. As described in section 5.3.2.1 above, if it is shown that further erosion is not likely it is strongly recommended that the Island stopbanks are removed so that a more natural tidal – wetland interface can occur and a more healthy salt marsh – palustrine plant assemblage can flourish.

If the decision is made to remove the stopbanks and the fill contained in the stopbanks is pushed out into the estuary it will be important to establish a thick cover of salt tolerant marsh species immediately after stopbank removal along the tidal edge of the new land-estuary interface to create a natural buffer to the tide and current and to reduce the risk of sediment erosion. Planting densities should be 2 to 3 plants per square metre on the tidal edge and 1 to 2 plants /m^2 further back into the less saline wetland areas. Flax and wetland shrubs can be planted at 1.5 m spacings. The lessons learned from the planting trials on the Brain land should enable good plant species selections to be made and a high plant survival achieved.

Stopbank removal could occur progressively or all at once. If some threat of erosion remains then it is recommended that the section of stopbank opposite the eastern large wetland area (see Figure 20) is opened up first and the revegetation of that wetland area is completed and monitored before moving onto the western areas. This recommendation is made because the modelling suggests that the potential erosion risk is lower at the eastern edge of the island than western end. This wetland area is the most low-lying of the flats on Papahikahawai Island and with stopbank removal and revegetation should establish as a sizeable area of salt marsh that will provide high value habitat for estuarine organisms.

If the erosion risk is thought to be too high on the western end of the island to allow stopbank removal, consideration should be given to the removal of the stopbanks from the eastern wetland to the eastern tip of the island only. As figure 18 shows, the eastern wetland area on the island is separated from the western wetland area by a zone of land that sits above the mean high tide mark, but as Figure 19 shows, spring tides may carry tidal water further across to the western wetland area on occasions. Spring tide inundation of the western area could be reduced or eliminated if necessary by extending the existing natural bund (using fill from the stopbanks) to sever any links between the two lowland areas. Opening up the eastern wetland area to the estuary would maximise the development of estuarine margin habitat. The eastern edge of the island will face some risk of erosion from wave action but this is likely to be considerably less than the risk of erosion to the western end of the island. Monitoring of erosion is recommended for a period post re-diversion before any decision is made to remove stopbanks.

As for the strategy for the Brain land restoration, it is recommended that soil monitoring occurs to gauge the reach and concentration of salt water intrusion onto the Island flats and that this be used to determine planting zones and appropriate species for each zone.

The same moderate to high salt tolerant species listed for planting on the Brain land should be used in the areas exposed to daily tidal waters on the island. The establishment of flax "plantations" and other freshwater wetland species will need to occur on higher ground where soil salinity levels to not rise above 5 PSU, and the areas in between the freshwater and salt marsh zones will need to be planted with species tolerant of low to moderate soil salinity (refer to Appendix 1). Planting of the salt marsh and tidal areas will need to be a densities of 2 to 3 plants per square metre, and the remaining wetland areas at between 1 and 2 plants per m² for the remaining wetland areas where rushes and sedges are planted. Flax and tree and shrub zones can be planted at 1.5 to 2 metre spacings.

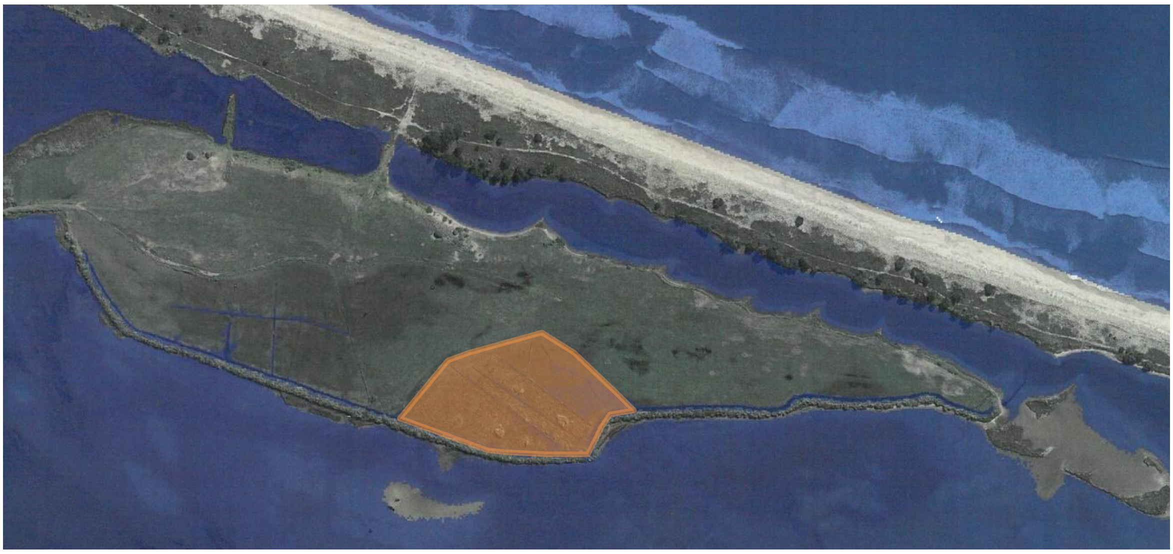

Figure 20: Papahikahawai Island showing low-lying wetland area recommended as the first area to have stopbanks removed and to be revegetated if some risk of erosion exists at the western end of the island.

If the Papahikahawai Island stopbanks are to be removed progressively then all of the wetland areas opened to the tide by stopbank removal should be fully planted in the first planting season. For example, the eastern wetland area that will be exposed to the tide when the stopbanks next to it are removed is about 0.5 ha in size and all of it should be planted immediately after the stopbanks have been taken out.

As has been recommended for the Brain land restoration, marked vegetation monitoring plots should be established throughout all planting areas and each should be surveyed at 6 monthly intervals at least for the first 2 years following planting.

5.3.3 Filled Ford's Loop Channel

Revegetation of the filled zone between Ford Road and Ford Island (approximately 0.5 ha) can occur as soon as the fill has settled. This area will sit above the height of salt water intrusion and so will become a freshwater wetland area if water seepage from Ford Island and from the river and diversion channel can be initiated. It is likely that this area will dry on the surface in summer so species tolerant of wet and dry soils will need to be used.

Recommended planting densities should be between 1 and 3 plants per square metre.

5.4 Maintenance of Planted Areas

5.4.1 Weed management

The removal of grazing livestock, the introduction of increased salinity and wetness, and the disturbance of planting will create opportunities for significant weed invasion if not effectively managed. A comprehensive weed management programme, documented in a written plan, will need to be developed and implemented.

The first stage of the programme will need to consist of control of the most invasive weed species (such as pampas and *Glyceria maxima*) from the surrounding accessible land and in areas being prepared for planting. Because full revegetation of all three areas is likely to take several years considerable on-going investment in the management of weeds on unplanted land will be necessary.

The second stage of weed management will commence as each area is planted and will consist of twice yearly weed control and plant releasing until at least 5 years after planting.

In effect, all 27.5 ha of wetland restoration area will need to be managed for weeds from the time the land is procured and the re-diversion works begin. The size of the land area to be managed will increase above this as blocks of the terrestrial land on Papahikahawai Island are set aside from grazing and planted. The scale of the weed management requirements means that this work should only be undertaken by experienced commercial operators.

5.4.2 Pest animal management

Removal of grazing livestock and the commencement of the planting programme will generate significant animal pest pressures. Rabbits, hares and pukekos will provide the greatest threat to new plantings, and as the planted vegetation establishes and is inhabited by wetland, marshland and shorebird species predators including stoats, ferrets and Norway rats will become more numerous.

It is recommended that rabbit and hare control across all of the Brain land, the Ford's Loop Channel area and all of Papahikahawai Island should begin as soon as the project commences, and should work in with the pest control work that is currently being undertaken on Ongatoro - Maketū Spit. With the removal of both access causeways to Papahikahawai Island the island will be easier to defend from pests than is currently the case. It is recommended that the bridge that will provide access to the island from the spit should be designed to prevent rabbit and hare access.

Pukeko can be particularly destructive to newly planted native seedlings. They habitually pull small seedlings out of the ground and will continue to do this repeatedly unless removed from the site. Pukeko numbers are generally low around the proposed planting areas now but they can be expected to increase in abundance as grazing pressure is reduced and the extent of the wetland habitat increases. The damage caused to new plantings can be reduced by using larger grade plants (planter bag stock rather than root-trainers) that pukekos find harder to pull out.

As the ecological value of the restored wetland habitat improves and occupation by indigenous fauna increases predator numbers will also increase. Periodic mustelid and rat control effort will be necessary especially approaching and during breeding season, however, perpetually controlling stoats and rats to very low levels in marsh – wetland conditions is not realistic.

5.5 Re-establishment of Salt Marsh into the Open Tidal Zone

The Papahikahawai Island trustees have expressed interest in reclaiming all or some of the area of their land that was eroded into the estuary following the river diversion in the late 1950's. While a number of factors are considered to have contributed to the significant decline of the salt marsh area, the reduction in sediment deposition in the salt marsh zone is likely to have been a major factor.

Modelling of likely conditions in the estuary after the re-diversion is implemented suggests that there is unlikely to be any significant increase in sediment deposition along the southern edge of Papahikahawai Island, in fact, there may be some sediment loss due to possible increases in erosion. Salt marsh species generally prefer areas of sediment accretion or areas with little or no erosion. Trials to establish transplanted clumps of sea rush (*Juncus kraussii* subsp. *Australiensis)* and oioi (*Apodasmia similis*) in Ongatoro - Maketū Estuary in the early 1990's achieved reasonable success when the clumps were large and the planting sites were sheltered (Bergin 1994), but no sea rush or oioi transplants survived at the open sites exposed to tidal action and waves. Consequently any efforts to restore marshland vegetation to the original salt marsh zone off the southern edge of Papahikahawai Island are likely to have a low chance of success unless the wave and tide induced erosion is less than predicted or some action can be taken to reduce the wave and tide energy in this zone.

Further planting trials to test new and alternative methods to establish sea rush into open estuary conditions should be encouraged but large scale investment in planting of this nature would not be wise until successful plant establishment methods can be found.

The construction of sand chenier mounds off the south-western edge of Papahikahawai Island have been proposed as one potential method of reducing wave and tide energy and therefore reducing the likelihood of continued erosion of the southern edge of the island after re-diversion (Everitt 2014). If this method proved to be successful then conditions for salt marsh revegetation may improve.

The lagoon area to the northwest of Papahikahawai Island, currently cut off from the main part of the estuary by the causeway, may be a more suitable location for an attempt at salt marsh re-establishment when the causeway is removed. This is because the area is shallow and less exposed to the main freshwater and tidal flow of the estuary. While modelling would suggest that there will not be any significant sediment deposition neither is significant sediment loss predicted.

Mangroves (*Avicennia marina)* have been proposed as a species that might assist in the reclamation of some of the estuary. Attempts to plant mangroves to control erosion have occurred at a number of New Zealand locations but without any great success (Morrissey et al 2007). The general conclusion is that if suitable environmental conditions for mangroves are present then the species will more than likely occupy those areas naturally. Their failure to thrive and spread in most parts of Ongatoro - Maketū estuary in the past would suggest that conditions do not favour them but this may change with the re-diversion.

5.6 Eelgrass (Zostera) restoration

As discussed in section 3.1.4, the extent of estuary occupied by eelgrass has shrunk considerably to where there is now only 0.004 ha remaining. Eelgrass provides important habitat for estuarine animal life and its decline is likely to be related to the decline in health of the Ongatoro -Maketū estuary.

Eelgrass is likely to increase naturally if improved growing conditions are created in the estuary after re-diversion however expansion of the area occupied is likely to be very slow because of the very small remnant remaining and because the species spreads mostly by runners rather than by seed.

Re-establishment of eelgrass in Ongatoro - Maketū estuary by transplant is a method that should be investigated after re-diversion. NIWA undertook an eelgrass restoration trial in Whangarei Harbour in 2008 (Matheson et al 2009; NIWA 2009). Small plots of seagrass were extracted from a healthy pocket of remnant seagrass and transplanted to a site where the species was known to have grown previously. 18 square metres of seagrass were transplanted using two transplant methods: ‘sods’ (blocks of intact plants and sediment) and ‘sprigs’ (clumps of intact plants with sediment washed from roots). After two years the transplanted eelgrass had expanded to occupy an area of 2400 square metres and 9 months after extraction the eelgrass stands from which the transplants were taken had fully recovered.

Use of the methods used by NIWA to re-establish eelgrass across previously occupied areas of Ongatoro - Maketū estuary would have a good chance of success if the growing environment improves with re-diversion. Initial small scale trials are recommended.

5.7 Assessment of Potential Ecological Effects

No adverse effects are expected on the existing ecology as a result of the restoration of the proposed 27.5 ha of land. On the contrary, substantial beneficial effects are anticipated. The diversity and abundance of indigenous plants and animals will increase substantially as a result of the increased area of high value habitat and increased biological productivity. Aspects of water quality may also improve as a result of the removal of grazing livestock from the estuary margins and the nutrient trapping and extraction capacity of healthy functioning wetlands.

5.8 Summary of Restoration Recommendations

Restoration of 27.5 ha of drained and stopbanked land within and adjacent to Ongatoro - Maketū estuary back to salt marsh and freshwater wetlands is practically realistic and ecologically desirable if the land is made available. The potential wetland habitat lies on 3 blocks of land – 19 ha on the Brain property, 8 ha on Paphikahawai Island, and 0.5 ha in the Ford Loop Channel. The re-establishment of wetlands on this land that are directly linked to the estuary will greatly benefit the ecology of Ongatoro - Maketū estuary after re-diversion.

The primary restoration objective is to restore the land available to a state where there is a sustainable cover of indigenous plants that is as close to the original natural species diversity that can be achieved taking into consideration the substantial and irreversible human-induced changes that have occurred to the landscape surrounding the estuary.

The project will re-establish freshwater, estuarine margin and saltmarsh wetlands where environmental conditions allow it after the Kaituna River is re-diverted. The species chosen for planting and the wetland types created will be governed particularly by the nature and extent of tidal influences, soil salinity, and soil saturation that occur after stopbanks and causeways are removed. To ensure restoration efforts are successful a restoration strategy and plan will need to be produced that includes the following:

- Initial monitoring of site growing conditions (especially soil salinity, soil saturation, tidal induced sediment erosion and deposition) after re-diversion;
- Creation of a planting zone plan based on site growing conditions and species tolerances;
- Trial planting of plant species especially in areas where growing conditions are likely to be challenging (eg. areas exposed to open tidal water and those with higher salinity);
- Details of mass planting once species can be matched to site conditions with high confidence of success.
- Monitoring plan to objectively measure plant and species performance.

Each of the three wetland restoration areas will require different strategies that reflect land ownership and the environmental conditions and risks that will arise following the river re-diversion, and each area will need to have a restoration planting plan produced that details the planting zones, species mixes, plant spacings, plant grades, site preparation and post-planting maintenance requirements.

Trial plantings are recommended on the Brain land prior to any mass plantings to ensure species tolerances are well understood and well matched to monitored soil conditions. These trial plantings will provide information that will allow species to be selected for planting at all 3 wetland sites.

The removal of all of the stopbanks on the Brain land and Papahikahawai Island is preferred to enable natural hydrological conditions to develop and to optimise the quality of habitat available for terrestrial and aquatic fauna. However, the owners of Papahikahawai Island have expressed concern about the potential erosion risk on the south coast of the island so it is recommended that stopbank removal and wetland revegetation is delayed on the island until a better understanding of the erosion potential is obtained.

Expansion of the remnant eelgrass area, using methods successfully applied in Whangarei Harbour, is proposed.

Weed and pest control will be essential components of the restoration plan for each area and weed management will need to begin as soon as livestock are removed and continue for at least 5 years following planting.

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Appendix 1: Plant species recorded in Ongatoro - Maketū estuary margin vegetation transects (2014) and their salt tolerances

[√√√ = tolerant of full salt water for prolonged periods; √√ = tolerant of medium to high salinity for prolonged periods; √ tolerant of low salinity levels]

Species	Common name	Salt tolerant?
Agrostis sp.		√
Apodasmia similis	oioi	√√
Avicennia marina	manawa, mangrove	√√√
Bryophytes		
Bolboschoenus fluviatilis	ririwaka	√
Calystegia soldanella	panahi	√
Carex testacea		-
Coprosma propinqua var. *propinqua*	mingimingi	-
Coprosma repens	taupata	-
Cotula coronopifolia	bachelor's button	√
Ficinia nodosa	wiwi, knobby clubrush	√√
Haloragis erecta subsp. *erecta*	toatoa	√
Isolepis cernua var. *cernua*	slender clubrush	√√
Juncus edgariae	edgars rush	-
Juncus kraussii subsp. *australiensis*	wi, sea rush	√√
Machaerina articulata	jointed twig rush	-
Muehlenbeckia complexa	pohuehue	-
Myoporum laetum	ngaio	√
Phormium tenax	harakeke, flax	√
Plagianthus divaricatus	Makaka, salt marsh ribbonwood	√
Sarcocornia quinqueflora	glasswort	√√
Senecio lautus subsp. *Lautus*	shore groundsel	√
Schoenoplectus pungens	three square	√
Schoenoplectus tabernaemontani	kuawa	√
Selliera radicans	remuremu	√
Spinifex sericeus	kowhangatara, spinifex	√
Typha orientalis	Raupo	√ slight

Appendix 2: List of bird species recorded at Ongatoro - Maketū Estuary and the Kaituna River Mouth 1984-2014

Common name	Scientific Name	Native (breeds in NZ)	Migrant	Introduced	Threatened/ At Risk
1. Arctic skua	*Stercorarius parasiticus*		✓		
2. Australasian bittern	*Botaurus poiciloptilus*	✓			T-NE
3. Australian coot	*Fulica atra australis*	✓			
4. Banded dotterel	*Charadrius bicinctus*	✓			T -NV
5. Banded rail	*Gallirallus philippensis*	✓			AR - dec
6. Black fronted dotterel	*Elseyomis melanops*	✓			
7. Black backed gull	*Larus dominicanus*	✓			
8. Black-billed gull	*Larus bulleri*	✓			T-NC
9. Black-fronted tern	*Chlidonias albostriatus*	✓			T-NE
10. Black shag	*Phalacrocorax carbo*	✓			T-NV
11. Black swan	*Cygnus atratus*			✓	
12. Black tailed godwit	*Limosa limosa*		✓		
13. Canada goose	*Branta canadensis*			✓	
14. Caspian tern	*Sterna caspia*	✓			T-NV
15. Cattle egret	*Bubulcus ibis*		✓		
16. Curlew sandpiper	*Calidris ferruginea*		✓		
17. Eastern bar-tailed godwit	*Limosa lapponica baueri*		✓		AR - dec
18. Eastern curlew	*Numenius madagascariensis*		✓		
19. Gannet	*Morus serrator*	✓			
20. Grey duck	*Anas superciliosa*	✓			T-NC
21. Grey phalarope	*Phararopus fulicaria*		✓		
22. Grey plover	*Pluvialis squatarola*		✓		
23. Grey teal	*Anas gracilis*	✓			
24. Hudsonian godwit	*Limosa haemastica*		✓		
25. Hybrid black stilt	*Himantopus novaezelandiae*	✓			
26. Large sand dotterel	*Charadrius leschenaultii*				
27. Little black shag	*Phalacrocorax sulcirostris*	✓			AR - n unc
28. Little egret	*Egretta garzetta*		✓		
29. Little shag	*Phalacrocorax melanoleucos*	✓			
30. Little tern	*Sterna albifrons*		✓		
31. Mallard	*Anas platyrhynchos*			✓	
32. Marsh sandpiper	*Tringa stagnatilis*		✓		
33. Mongolian dotterel	*Charadrius monogolus*		✓		
34. Northern NZ dotterel	*Charadrius obscurus apuilonius*	✓			T-NV
35. NZ dabchick	*Poliocephalus rufopectus*	✓			T-NC
36. NZ kingfisher	*Todiramphus sanctus*	✓			
37. NZ shoveler	*Anas rhynchotis*	✓			
38. Pacific golden plover	*Pluvialis fulva*		✓		
39. Paradise shelduck	*Tadorna variegata*	✓			
40. Pectoral sandpiper	*Calidris melantos*		✓		
41. Pied shag	*Phalacrocorax varius*	✓			T-NV
42. Pied stilt	*Himantopus himantopus*	✓			AR - dec
43. Pukeko	*Porphyrio melanotus melanotus*	✓			
44. Red billed gull	*Larus novaehollandiae*	✓			T-NV
45. Red knot (lesser knot)	*Calidris canutus*		✓		T-NV
46. Red-necked stint	*Calidris ruficollis*		✓		

Common Name	Scientific Name	Native	Migrant	Introduced	Threatened/ At Risk
47. Reef heron	*Egretta sacra*	✓			T-NE
48. Royal spoonbill	*Platalea regia*	✓			AR- n unc
49. Sanderling	*Calidris alba*		✓		
50. Sharptailed sandpiper	*Calidris acuminata*		✓		
51. Siberian tattler	*Tringa brevipes*		✓		
52. South Island pied oystercatcher	*Haematopus ostralegus*	✓			AR - dec
53. Spur-winged plover	*Vanellus miles*	✓			
54. Terek sandpiper	*Tringa cinerea*		✓		
55. Turnstone	*Arenaria interpres*		✓		
56. Variable Oyster	*Haemotopus unicolor*	✓			AR - rec
57. Whimbrel	*Numenius phaeopus*		✓		
58. White faced heron	*Ardea novaehollandiae*	✓			
59. White-fronted tern	*Sterna striata striata*	✓			AR - dec
60. White heron	*Ardea modesta*	✓			T-NC
61. Wrybill	*Anarhynchus frontalis*	✓			T -NV

Key: T-NC : Threatened – Nationally Critical; T-NV: Threatened – Nationally Vulnerable; T-NE: Threatened Nationally Endangered; AR – dec: At Risk – declining; AR – n unc: At Risk naturally uncommon; AR – rec: At Risk recovering.

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