

Estuarine vegetation survey – Kennedy Bay Estuary

Prepared by:
Meg Graeme M.Sc (Marine Science)
Natural Solutions – Marine and Terrestrial Ecologists Ltd

For:
Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
HAMILTON 3240

October 2012

Document #: 2303652

Approved for release by:
Peter Singleton

Date April 2014

Disclaimer

This technical report has been prepared for the use of Waikato Regional Council as a reference document and as such does not constitute Council's policy.

Council requests that if excerpts or inferences are drawn from this document for further use by individuals or organisations, due care should be taken to ensure that the appropriate context has been preserved, and is accurately reflected and referenced in any subsequent spoken or written communication.

While Waikato Regional Council has exercised all reasonable skill and care in controlling the contents of this report, Council accepts no liability in contract, tort or otherwise, for any loss, damage, injury or expense (whether direct, indirect or consequential) arising out of the provision of this information or its use by you or any other party.

Estuarine Vegetation Survey – Kennedy Bay Estuary

October 2012

Prepared for Waikato Regional Council



Estuarine Vegetation Survey – Kennedy Bay Estuary, October 2012

Report prepared for:

Resource Information Group
Environment Waikato
PO Box 4010
HAMILTON EAST

Report prepared by:

Meg Graeme M.Sc (Marine Science)
Natural Solutions – Marine and Terrestrial Ecologists Ltd
RD 2
COROMANDEL 3582
Ph: (07) 866 0770
Email: natural.solutions@wave.co.nz

Report submitted:

31 October 2012

Reference:

Natural Solutions Contract Report 12/108

Acknowledgements:

Natural Solutions would like to acknowledge the support received for this project from the following people: Robert Kuchlein for field assistance and Richard Glass of Waikato Regional Council for technical assistance.

Disclaimer:

While every effort has been made to ensure the accuracy of information in this report, no liability is accepted for errors of fact or opinion, or for any loss or damage resulting from reliance on, or the use of, the information it contains. This report has been prepared for Waikato Regional Council and may only be disclosed to third parties with the prior consent of Waikato Regional Council.

CONTENTS

1. INTRODUCTION	1
2. METHODOLOGY	2
2.1. WETLAND VEGETATION CLASSIFICATION	2
3. RESULTS	5
3.1. SITE DESCRIPTIONS	5
3.2. BIRDS	16
3.3. THREATS	17
4. DISCUSSION AND RECOMMENDATIONS	18
5. BIBLIOGRAPHY	19
APPENDIX A – PHOTO WAYPOINTS	21

TABLE OF FIGURES

Figure 1: Map of Kennedy Bay with points of interest and photo points	8
Figure 2: Saltwater paspalum extending from the high tide mark out through a glasswort band. Mangroves are seaward of the glasswort community.....	9
Figure 3: A glasswort bed in the foreground has saltwater paspalum intermingled through it and long runners extending out seaward over the sand flats. The large bed of saltwater paspalum in the background covered communities of coast spear grass and glasswort along the upper tidal edge and glasswort beds out on the middle intertidal flats.....	9
Figure 4: A view looking upstream with an eroding pine edge on the TRB of the Harataunga Stream, and mangroves and dense saltwater paspalum on the outwash plain of the TLB.	10
Figure 5: A view looking down the Harataunga Stream towards the Kennedy Bay road bridge. Saltwater paspalum was prevalent throughout the rushland associated with stock tracking.....	10
Figure 6: A view looking up into the head of the saltwater paspalum-infested rushland embayment upstream of the Kennedy Bay road on the TRB of the Harataunga Stream	11
Figure 7: A view looking down the Harataunga Stream from a ridge on the bend. Sea rush, oioi, saltwater paspalum and saltmarsh ribbonwood are on the lower flats with manuka, kanuka, kowhai floodplain forest behind.....	11
Figure 8: A view from the same vantage point on the river bend as Figure 7 looking over to the large freshwater wetland. The saline influence was restricted to a thin edge of oioi and saltwater paspalum which fringed an otherwise freshwater wetland with sedges, manuka, cabbage trees, flax and Coprosma species.....	12
Figure 9: Sea rush and oioi with saltwater paspalum dominating to varying degrees at the head of this small embayment north of the school. Note the clay infill in the middle background seaward of the totara.....	13
Figure 10: A view over the wetland upstream of the causeway and north of Mangatu Rd showing mangroves on the lower flats and sea rush and oioi covering the higher flats and extending into pasture. Saltmarsh ribbonwood is present in places, particularly around the northern edges. Saltwater paspalum is common, dominating or spreading into the rushland edges where stock tracking is visible. A small patch of seagrass is present in the open pool.....	14
Figure 11: A view of the constricted culvert under Kennedy Bay Road just north of Mangatu Stream.	15
Figure 12: A patch of sea primrose in the foreground with scattered short mangroves and a patch of sea primrose cover the foreground flats with one large mangrove in the centre background.....	15

1. Introduction

A 1997 pilot study of Whangamata, Wharekawa, and Otahu estuaries determined that it is feasible to map vascular estuarine vegetation from aerial photography together with field surveys. The success of this work encouraged Environment Waikato to continue with this method. The estuarine vegetation of Tairua, Coromandel, Te Kouma, Manaia, Whitianga, Port Waikato, Raglan, Aotea, Kawhia, Otama, Whangapoua harbours and the inner Firth of Thames have since been surveyed and mapped. Of these harbours, Whangamata, Wharekawa, Otahu, Tairua, Coromandel, Te Kouma, Manaia, Whitianga, Port Waikato, Raglan and Aotea have been re-surveyed to determine changes in vegetation communities over time.

The vegetation that has been mapped is within the Coastal Marine Area (CMA) and includes the spatial cover of mangrove, seagrass, sea meadow, saltmarsh and estuarine weed communities. The results of the estuarine vegetation surveys are included in Environment Waikato's Global Information System (GIS) database, and are used for State of the Environment investigations and assessing resource consent applications that may affect estuarine vegetation.

This report details the results from the survey of estuarine vegetation in Kennedy Bay. Comments are included about the estuarine vegetation present, the threats to native estuarine vegetation communities, and other field notes of interest. This report accompanies the estuarine vegetation community GIS layers of the survey site.

2. Methodology

The field survey was undertaken over 3 days between the 16th October and the 24th October 2012. The survey was undertaken using a combination of canoeing and walking access. The same methodology for mapping saltmarsh, mangrove, seagrass and weed communities was followed as that previously used to map other Waikato Region estuaries (e.g. see Graeme, 2010b), using a personal digital assistant (PDA) loaded with 2007 aerial photographs (WRAPS2007) of the survey area. Coded polygons were drawn directly onto the PDA aerial photographs to define the spatial extent of wetland vegetation types as they were ground-truthed in the field. The use of colour pen notations on hard copy aerial photographs was reserved (but not used) as a backup for when there were instrument problems or the weather made using the PDA difficult (e.g. sun exposure made it too difficult to see the PDA screen clearly in the field).

The upper saltwater influence is usually indicated by the upstream limit of oioi, saltwater paspalum or saltmarsh ribbonwood in the estuary. The limit of these plants determined the inland/upstream extent of the survey.

Field notes were made of estuarine wetland characteristics and their vulnerability to particular threats.

2.1. Wetland vegetation classification

The estuarine wetland vegetation of the Waikato Region is split into four groups for these surveys:

1. **Saltmarsh** - a multi-species community in which three sub-communities are distinguishable in the Waikato Region. They are:
 - a) 'Rush/sedge community' – This is generally sea rush (*Juncus kraussii* subsp. *australiensis*), oioi (*Apodasmia similis*), and generally only common on the West Coast, three-square sedge (*Schoenoplectus pungens*). Marsh clubrush (*Bolboschoenus fluviatilis*) is commonly found up streams and rivers at the upper estuarine limit in some harbours, although it is not generally mapped¹ within this survey as it is a species of brackish-freshwater.
 - b) 'Saltmarsh ribbonwood community' - Saltmarsh ribbonwood (*Plagianthus divaricatus*) dominates this zone, although rushes are often common giving a patchy appearance compared with the uniformity of the 'rush/sedge community'. Small areas of sea

¹ Except where marsh clubrush is intermingled with oioi and is too difficult to separate out for mapping.

primrose (*Samolus repens*), remuremu (*Selliera radicans*), the coast spear grass (*Austrostipa stipoides*) and glasswort (*Sarcocornia quinqueflora*) can also be present.

- c) **'Sea meadow community'** - This is devoid of tall plants such as rushes and saltmarsh ribbonwood, with the exception of coast spear grass. The sea meadow community can include sea primrose, remuremu, glasswort, slender clubrush (*Isolepis cernua*), and arrow grass (*Triglochin striata*), and in more brackish areas bachelor's button (*Cotula coronopifolia*), leptinella (*Leptinella doica*) and sharp spike-sedge (*Eleocharis acuta*).
- 2. Mangrove** (*Avicennia marina* subsp. *australasica*) – This is usually a monospecific community although seagrass, spartina (*Spartina* spp.), saltwater paspalum (*Paspalum vaginatum*) and sea meadow beds can sometimes be found underneath mature mangrove stands.
- 3. Seagrass** (*Zostera capricorni*) – This is usually a monospecific community, and is the vegetation which occurs at the lowest level in the tide.
- 4. 'Weed community'** - In the Waikato Region the most significant estuarine weeds are saltwater paspalum and spartina. Both of these grasses generally grow in the open estuary and trap sediment, greatly increasing the harbour's infilling rate. These weeds also compete with the native wetland communities.

There are other weed species (such as tall fescue (*Schedonorus phoenix*) which can tolerate a degree of salt influence but for clarity of mapping they have not been included in the surveys due to their presence above the spring high tide mark.

Table 1 lists common estuarine plant species (and their associated 'estuarine vegetation community') mapped during the survey.

Mixed mapping categories are used to indicate the occurrence of 'mixed' vegetation communities. Saltwater paspalum in particular is spreading and mixing with rush/sedge, sea meadow and saltmarsh ribbonwood communities. Where vegetation was found under the canopy of mangroves (e.g. seagrass or saltwater paspalum under mangroves) this was mapped as a 'mixed' community.

Saltwater paspalum is known to co-exist with spinifex (*Spinifex sericeus*) however mapping of saltwater paspalum stops once spinifex is present as it is then determined to be an 'open coastal' rather than 'estuarine' environment.

Table 1: Estuarine plant species found in Kennedy Bay estuary.

Common/Maori name	Scientific name	Estuarine Vegetation Community
coast spear grass	<i>Austrostipa stipoides</i>	sea meadow
glasswort	<i>Sarcocornia quinqueflora</i>	sea meadow
mangrove	<i>Avicennia marina</i> subsp. <i>australasica</i>	mangrove
oioi	<i>Apodasmia similis</i>	rush/sedge
remuremu	<i>Selliera radicans</i>	sea meadow
saltmarsh ribbonwood	<i>Plagianthus divaricatus</i>	saltmarsh ribbonwood
saltwater paspalum *	<i>Paspalum vaginatum</i>	weed
seagrass	<i>Zostera capricorni</i>	seagrass
sea primrose	<i>Samolus repens</i>	sea meadow
sea rush	<i>Juncus kraussii</i> subsp. <i>australiensis</i>	rush/sedge
slender clubrush	<i>Isolepis cernua</i>	sea meadow

* denotes an exotic species

3. Results

Site locations within the estuary are shown in Figure 1 as well as the position of the photos that are referred to in the site descriptions below.

3.1. Site Descriptions

The estuarine vegetation in Kennedy Bay is described clockwise from the estuary mouth.

The edge vegetation along the exposed open **sand spit** changes from spinifex, knobby clubbrush (*Ficinia nodosa*) and buffalo grass (*Stenotaphrum secundatum*) to estuarine vegetation on entering the more protected estuary. The first estuarine vegetation encountered was a band of saltwater paspalum along the shelly tidal edge. This grades into sea meadow (generally glasswort on more exposed sand ridges and sea primrose in the more sheltered upper tidal areas), rushland and mangroves within a large embayment surrounded by pines. At the back of the embayment was an extensive saltmarsh ribbonwood/rushland mix. Fernbird were heard here. Saltwater paspalum was highly prevalent within the sea meadow communities and the seaward edge of the rushland and/or saltmarsh ribbonwood. Some seagrass was found in the small channel amongst mangrove pneumatophores. Glasswort and saltwater paspalum patches extended out and around from the bay towards the seaward edge of a mangal.

The glasswort band with varying dominance of saltwater paspalum continued along the foreshore behind the mangal (Figure 2). The mangal included adult mangroves and patches of juveniles. There was also a single ~7m tall mangrove towering over the rest of the mangroves. There was quite a bit of wild ginger in from the inner spit foreshore with pine, flax, gorse, knobby clubbrush and pohutukawa, kanuka, manuka and banksia. Further along a constructed pond was encountered behind a kikuyu-dominated edge of the spit. The pond was lined by thick saltwater paspalum and scattered rush at the southern end. The spit edge also had pohutukawa, pine, knobby rush and a patch of marram grass. Mangroves occurred along the seaward side of the kikuyu land edge.

The mangrove band then finished and saltwater paspalum became the predominant community. Figure 2 shows a single large mangrove downstream of an extensive bed of saltwater paspalum. This large bed of saltwater paspalum covered communities of coast spear grass and glasswort along the upper tidal edge and glasswort beds out on the middle intertidal flats. The **Harataunga Stream** channel then cuts into the spit resulting in an eroding pine edge with little estuarine vegetation present (Figure 4). The spit land edge was armoured where the land use changes to pasture and housing. Mangroves and saltwater paspalum were found again immediately downstream of the road bridge. Flounder and many juvenile mullet were seen in the stream.

The line of mangroves with saltwater paspalum behind continued upstream of the road bridge along the true right bank (TRB) of the Harataunga Stream. The estuarine edge then widened out into a large embayment full of sea rush and oioi (Figure 5 & Figure 6). Saltwater paspalum

had extensively invaded this rushland, although maybe only recently as it had yet to dominate in most places and often could only be seen when walking through the rushland. The occurrence of saltwater paspalum closely matched the stock tracking that was common through the rushland and out into the coastal floodplain forest remnant along the river edge (Figure 7). A few pampas that were present on the river bend had been sprayed. The rushland stopped abruptly at a fence line across the top of the wetland and only saltwater paspalum was present within the low-lying land of the paddock. The coastal forest remnant had a grazed and tracked understory and a predominantly kanuka and kowhai canopy. The urban/grazed edge was unfenced and household rubbish had been dumped there.

Saltwater paspalum continued to dominate further up the TRB, mixing with rushland and sea meadow patches. Saltwater paspalum then became the sole estuarine species present at the uppermost extent of the saltwater influence.

Moving downstream along the **TLB of the lower Harataunga Stream** there was a small side creek which separated grazed land from regenerating forest. Just below this intersection, an expansive sea rush and oioi rushland extended around a small forested island and was backed by coastal forest. Saltwater paspalum was present along the river edge but did not extend into the main rushland very far except where there were a few watercourses providing an opening. Further downstream was a very large freshwater wetland backed by coastal forest (Figure 8). The only saline influence was indicated by the thin edge of oioi and saltwater paspalum which fringed an otherwise freshwater rush wetland with cabbage trees, flax, manuka and *Coprosma* species. There was an occasional kahikatea around the edges and a few willow trees had invaded. Banded rail were heard here. Further downstream before the bridge the river flats widen out again and there was a confusing mosaic of stopbanks and channels with open water, dense seagrass, mangroves, rushland and saltwater paspalum. The stopbanks were dominated by pampas and woolly nightshade. Banded rail and fernbird were heard here.

Downstream of the road bridge there was a wide outwash plain dominated by a thick mat of saltwater paspalum and scattered mangroves within shallow channel ways. Scattered mangroves extended seaward of the main saltwater paspalum mat. Smaller patches of saltwater paspalum with long sparse runners were establishing further out too.

Moving along the coastal edge and past the marae there was a fringe of mangroves with saltwater paspalum and/or rushland behind. Young mangroves had established over much of the firm open flats here. A few very tall old mangroves were prominent amongst the newer mangroves. Further on towards the **wharf** area the coastal edge was eroded and armoured and there was little estuarine vegetation except for small bits of saltwater paspalum and the occasional patch of sea meadow (mainly glasswort). Past the wharf there was some saltwater paspalum but patches of glasswort were common.

The coastal edge turns into a narrow embayment with mangroves and a rush band behind. A fringe of young mangroves occurred at the leading edge of an older mangrove band. There was a lot of rubbish (cars, tv etc) dumped into the harbour here and an area of infill (Figure 9). Saltwater paspalum was common along the edges and at the head of the embayment. Banded rail were heard here. A sheep and lamb were on the flats at the mouth of the embayment.

Scattered mangroves out on the exposed flats were struggling and several were dead seemingly from wave exposure and/or storm debris. There was also sign of animal browse.

The estuarine vegetation thinned out to a band of rush around the coastal edge and back toward the causeway. Here rushland was found along the land/causeway edge with fingers extending out into the seaward mangroves. Saltwater paspalum was common.

Upstream of the road bridge on the TRB of the **lower Mangatu Stream** a large area of rushland extended up into a small remnant of saltmarsh ribbonwood and freshwater wetland and then to farmland. Saltwater paspalum was thick where the channel had been dredged/realigned.

North of the Mangatu Stream (and above the causeway) mangroves covered much of the lower flats with extensive rushland in behind (Figure 10). There was old sign of grazing of the mangroves. Saltwater paspalum was common around the rushland edges where stock tracking was evident. Some work had been undertaken planting the landward margin and trying to fence stock out however with limited success based on the tracking sign and chewed plantings. A dredged drain cut through the wetland. The northern head of the bay seemed less impacted by stock and had a native forest margin. A perched culvert restricts tidal water movement affecting the natural hydrology of the embayment (Figure 11). Banded rail were present in the area and a bittern was seen flying by.

On the downstream side of the causeway, rushland formed a fringe with fingers extending seaward. Often there was an interface of rushland and mangroves before mangroves dominated seaward. Saltwater paspalum was common where watercourse discharges disturbed the sediment flats as well as along the causeway edges. Stock tracking (and some cow dung) was common throughout the rushland and the presence of saltwater paspalum tended to follow these tracks. Often on slightly raised gravelly areas there was sea meadow mixed in with the rushland. Scattered saltmarsh ribbonwood was found on higher bits of ground. Banded rail were present. Stock tracking and saltwater paspalum were common right up to the **TRB of the Whareroa Stream mouth**.

Across on the **TLB of the Whareroa Stream mouth** a line of mangroves with rushland seaward and landward extended out from a higher bank lining the stream mouth. Saltmarsh ribbonwood and coastal scrub occurred on higher islands. Saltwater paspalum was scattered but common within the rushland. Sea meadow was mixed within the rushland and along the seaward edge of the rushland (Figure 12). The rushland then thinned to a marginal edge and the mangroves widened out to fill much of the shallow embayment (Figure 12). Scattered titiko were noted. The estuary embayment was backed by regenerating coastal forest. Out around from the large pohutukawa at the end of the embayment, the coastline becomes more exposed and the estuarine vegetation was limited to thin bands of saltwater paspalum, the occasional mangrove and patches of sea meadow. The last major area of estuarine vegetation was found in a little stream embayment near the estuary mouth. Here rushland extends upstream either side of the straightened watercourse and into pasture. Saltwater paspalum was present and stock had access to the wetland.



Figure 1: Map of Kennedy Bay with points of interest and photo points



Figure 2: Saltwater paspalum extending from the high tide mark out through a glasswort band. Mangroves are seaward of the glasswort community.



Figure 3: A glasswort bed in the foreground has saltwater paspalum intermingled through it and long runners extending out seaward over the sand flats. The large bed of saltwater paspalum in the background covered communities of coast spear grass and glasswort along the upper tidal edge and glasswort beds out on the middle intertidal flats.



Figure 4: A view looking upstream with an eroding pine edge on the TRB of the Harataunga Stream, and mangroves and dense saltwater paspalum on the outwash plain of the TLB.



Figure 5: A view looking down the Harataunga Stream towards the Kennedy Bay road bridge. Saltwater paspalum was prevalent throughout the rushland associated with stock tracking.



Figure 6: A view looking up into the head of the saltwater paspalum-infested rushland embayment upstream of the Kennedy Bay road on the TRB of the Harataunga Stream



Figure 7: A view looking down the Harataunga Stream from a ridge on the bend. Sea rush, oioi, saltwater paspalum and saltmarsh ribbonwood are on the lower flats with manuka, kanuka, kowhai floodplain forest behind.



Figure 8: A view from the same vantage point on the river bend as Figure 7 looking over to the large freshwater wetland. The saline influence was restricted to a thin edge of oioi and saltwater paspalum which fringed an otherwise freshwater wetland with sedges, manuka, cabbage trees, flax and Coprosma species.



Figure 9: Sea rush and oioi with saltwater paspalum dominating to varying degrees at the head of this small embayment north of the school. Note the clay infill in the middle background seaward of the totara.



Figure 10: A view over the wetland upstream of the causeway and north of Mangatu Rd showing mangroves on the lower flats and sea rush and oioi covering the higher flats and extending into pasture. Saltmarsh ribbonwood is present in places, particularly around the northern edges. Saltwater paspalum is common, dominating or spreading into the rushland edges where stock tracking is visible. A small patch of seagrass is present in the open pool.



Figure 11: A view of the constricted culvert under Kennedy Bay Road just north of Mangatu Stream.



Figure 12: A patch of sea primrose in the foreground with scattered short mangroves and a patch of sea primrose cover the foreground flats with one large mangrove in the centre background.

3.2. Birds

Birds seen or heard during the estuarine vegetation survey:

- Banded rail
- Australasian bittern
- Black-backed gull
- Fernbird
- Pukeko
- Kingfisher
- Mallard duck
- Paradise duck
- Pied oystercatcher
- Red-billed gull
- Welcome swallow

3.3. Threats

The main threat to the health of the Kennedy Bay estuarine vegetation communities is the invasive grass saltwater paspalum.

Saltwater paspalum can establish over a wide tidal range and competes with all estuarine vegetation communities except with seagrass). Field observations indicate that thick bands of undisturbed rushland can withstand the invasion of saltwater paspalum. These thick bands of rushland in turn usually protect saltmarsh ribbonwood and sea meadow communities in behind from saltwater paspalum invasion. However, thin or disjunct bands of rushland, exposed sea meadow and saltmarsh ribbonwood communities are all vulnerable to invasion by saltwater paspalum. Saltwater paspalum sends out long runners which climb through rushes or up saltmarsh ribbonwood, and the grass becomes so dense that it overwhelms the native vegetation. Saltwater paspalum also establishes in open mudflat areas changing the benthic communities of open flats and affecting water flows. The spread of saltwater paspalum is enhanced by disturbance events, particularly human induced disturbance from roading and stock tracking and pugging. Stock tracking through rushland and saltmarsh ribbonwood communities provides open areas that allows saltwater paspalum to establish and spread out from, and fragments can be transported around the estuary by animals hooves. Road building and maintenance of the Kennedy Bay road causeway has left a disturbed edge which enhances the spread of saltwater paspalum along the edge and into the neighbouring rushland and mangroves.

The other major threat to the estuarine vegetation in Kennedy Bay is direct **infilling** either associated with residential areas, farmland or roading. Infilling results in the physical loss of estuarine vegetation under the fill but also causes disturbance to the surrounding vegetation.

4. Discussion and Recommendations

The results from this GIS survey provide an overview of the composition of estuarine vegetation within Kennedy Bay based on the 2007 aerial photographs. This data will also provide a baseline for any future surveys to show changes in vegetation communities over time.

The pattern of estuarine vegetation in the Kennedy Bay estuary has formed around the various streams entering the sea and the shelter provided by the large sand spit. The estuarine vegetation has been influenced by factors such as catchment sedimentation, changes in hydrology, edge modification, stock, and weeds. Mangroves are common around the mid-tidal zone and up along the edges of streams. Behind the mangroves is generally a zone of rushland (sea rush and oioi) often with scattered sea meadow communities either within the rushland or fringing the rushland. A few relatively large areas of saltmarsh ribbonwood are present where they haven't been destroyed by encroaching land use. No seagrass was found out on the open flats and the small patches found were restricted to small watercourses, usually in association with mangroves.

Large ecologically-significant wetland and forest sequences still exist in the Haurataunga Stream catchment. These sequences extend from estuarine vegetation, up through freshwater wetland communities and into floodplain, coastal and inland forest. Important ecological sequences also exist in the Mangatu and Whareroa Stream catchments, however they are more heavily impacted by drainage and grazing. Restoration of wetland and forest sequences in these catchments would be a good focus for community projects.

Saltwater *paspalum* is prevalent throughout the estuary and is a significant threat to the ongoing health and sustainability of the indigenous estuarine vegetation communities. It is recommended that this threat is discussed with the community and control options explored. Any control work will need to be associated with stock management as stock damage to estuarine vegetation enhances the spread of saltwater *paspalum*. Another vector that enhances the spread of saltwater *paspalum* is road works disturbance within the CMA that will also need to be addressed.

Areas of juvenile mangroves were noted during the survey indicating the continuing expansion of mangroves where bed levels are high enough and frosts do not restrict seedling development. Ongoing monitoring would be necessary to determine whether the rushland is also expanding seaward into the mangrove zone. This is likely to occur as bed levels are raised and become more suitable for rush and sedge species establishment. The large areas of native forest in the headwaters will be helping reduce sedimentation from these erosion prone slopes.

The estuarine vegetation around the estuary provides habitat for fernbird, banded rail and bittern. Saltmarsh ribbonwood is particularly important habitat for fernbird, while mangroves are an important part of banded rail territory, particularly for feeding. Bittern utilise densely vegetated wetland including estuarine and freshwater wetlands.

5. Bibliography

- Graeme, M. 1997: *Estuary Vegetation Survey Pilot Study: Whangamata, Otahu, Wharekawa*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 1998a: *Estuary Vegetation Survey: Coromandel & Tairua Harbours*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 1998b: *Estuary Vegetation Survey: Te Kouma & Manaia Harbours*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 1999: *Estuary Vegetation Survey: Whitianga Harbour*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2005: *Estuarine Vegetation Survey: Port Waikato*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel. Environment Waikato Technical Report 2005/41.
- Graeme, M. 2005: *Estuarine Vegetation Survey: Raglan*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel. Environment Waikato Technical Report 2005/44.
- Graeme, M. 2005: *Estuarine Vegetation Survey: Kawhia*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel. Environment Waikato Technical Report 2005/42.
- Graeme, M. 2005: *Estuarine Vegetation Survey: Aotea*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel. Environment Waikato Technical Report 2005/43.
- Graeme, M. 2006: *Estuarine Vegetation Survey: Inner Firth of Thames*. Report prepared for Environment Waikato. Contract report 06/062, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel. Environment Waikato Technical Report 2006/40.
- Graeme, M. 2007: *Estuarine Vegetation Survey: Whangamata Harbour and Otahu Estuary*. Report prepared for Environment Waikato. Contract report 07/067, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel. Environment Waikato Technical Report 2007/25.
- Graeme, M. 2008a: *Estuarine Vegetation Survey: Tairua Harbour*. Report prepared for Environment Waikato. Contract report 08/075, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel. Environment Waikato Technical Report 2008/52.
- Graeme, M. 2008b: *Estuarine Vegetation Survey: Wharekawa Harbour*. Report prepared for Environment Waikato. Contract report 08/077, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel. Environment Waikato Technical Report 2008/40.

- Graeme, M. 2008b: *Estuarine Vegetation Survey: Manaia Harbour*. Report prepared for Environment Waikato. Contract report 08/078, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2008c: *Estuarine Vegetation Survey: Waikawau Estuary*. Report prepared for Environment Waikato. Contract report 08/081, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2008c: *Estuarine Vegetation Survey: Whitianga Harbour*. Report prepared for Environment Waikato. Contract report 08/085, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2009: *Estuarine Vegetation Survey: Coromandel & Te Kouma Harbours*. Report prepared for Environment Waikato. Contract report 09/088, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2010a: *Estuarine Vegetation Survey: Otama Estuary*. Report prepared for Environment Waikato. Contract report 10/092, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2010b: *Estuarine Vegetation Survey: Whangapoua Harbour*. Report prepared for Environment Waikato. Contract report 10/095, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2011: *Estuarine Vegetation Survey: Port Waikato*. Report prepared for Environment Waikato. Contract report 11/103, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2012: *Estuarine Vegetation Survey: Raglan (Whaingaroa) Harbour*. Report prepared for Environment Waikato. Contract report 12/104, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. 2012: *Estuarine Vegetation Survey: Aotea Harbour*. Report prepared for Environment Waikato. Contract report 12/106, Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Graeme, M. & Kendal, H. 2001: *Saltwater Paspalum (Paspalum vaginatum) – a weed review*. Report prepared for Environment Waikato. Natural Solutions – Marine & Terrestrial Ecologists Ltd., Coromandel.
- Johnson, P. and P. Brooke. 1998: *Wetland Plants in New Zealand*. Manaaki Whenua Press, Lincoln, New Zealand.

Appendix A – Photo waypoints

Figure No.	Latitude	Longitude
2	-36.668425	175.552769
3	-36.674163	175.553096
4	-36.676559	175.552762
5 & 6	-36.678259	175.546318
7 & 8	-36.677262	175.546087
9	-36.666913	175.550317
10	-36.660939	175.549283
11	-36.660283	175.549808
12	-36.660675	175.551820