Environment Waikato Technical Report 2006/40

Estuarine Vegetation Survey : Inner Firth of Thames

Prepared by:
Meg Graeme M.Sc,
Natural Solutions
Marine & Terrestrial Ecologists Ltd

For:
Environment Waikato
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HAMILTON EAST

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Table of Contents

1 Introduction

A 1997 pilot study of Whangamata, Wharekawa, and Otahu harbours 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 and Whitianga harbours were mapped in 1998 and 1999. Port Waikato, Raglan, Aotea and Kawhia harbours have recently been mapped in 2004 and 2005.

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

This report details the results from an estuarine vegetation survey of the inner Firth of Thames from Tararu to Kaiaua. Comments are included on the threats to estuarine vegetation, and other field notes of interest. This report is accompanied by aerial maps of the survey site overlaid with colour-coded vegetation communities in a digitised format.

2 Methodology

The field survey was undertaken over 13 days between the 18th April and 10th June 2006. Surveys were undertaken using a combination of boating and walking. The same methodology for mapping saltmarsh, mangrove, seagrass and weed communities was followed as that previously used to map earlier surveyed estuaries (see Graeme, 1997, 1998a, 1998b, 1999).

This is the first survey in which a personal digital assistant (PDA) loaded with 2002 aerial maps of the survey site was used as the primary mapping device. The PDA replaced notations on hard copy aerial maps, although hard copy aerials were used as a backup for when the PDA battery ran out or lighting made it too difficult to see the PDA screen clearly. Colour-coded lines were drawn directly onto the PDA aerials to define the spatial extent of wetland vegetation types as they are ground-truthed in the field.

The upper tidal limit of the saltmarsh is usually determined by the upstream limit of oioi. However as oioi was generally not present at the survey site, the upper estuarine limit was indicated by the extent of mangroves, spartina or bachelor's button.

Field notes were made of estuarine wetland characteristics and their vulnerability to threats. Historical estuarine vegetation extent has not been estimated as this would be very difficult, and potentially erroneous, due to the extensive drainage that has been undertaken on the Hauraki Plains.

2.1.1 Wetland vegetation classification

For the purpose of this investigation, wetland vegetation species influenced by the tidal cycles are split into four groups: saltmarsh, mangrove, seagrass and weed communities.

1. **Saltmarsh -** a broad-species community in which three sub-communities are distinguishable. They are:

    a) **'Rush/sedge community'** – this is generally sea rush (*Juncus maritimus* var. *australiensis*), oioi *(Apodasmia similis),* and on the West Coast three-square rush *(Schoenoplectus pungens).* Marsh clubrush *(Bolboschenus fluviatilis)* is

commonly found up streams and rivers at the upper estuarine limit but is not mapped within this study as it is a brackish-freshwater species;

b) **'Saltmarsh ribbonwood community'** - this includes areas where rushes are interspersed with saltmarsh ribbonwood *(Plagianthus divaricatus)*, giving a patchy appearance compared with the uniformity of the 'rush community'. Small areas of sea primrose *(Samolus repens)*, remuremu *(Selliera radicans)*, the silver tussock 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 silver tussock grass. The salt meadow community includes sea primrose, remuremu, glasswort, and in more brackish areas bachelor's button (*Cotula coronopifolia*), leptinella (*Leptinella doica),* sharp spike-sedge (*Eleocharis acuta*), slender clubrush *(Isolepis cernua)*, and arrow grass (*Triglochin striata*).

2. **Mangrove** *(Avicennia marina* var. *resinifera)* – this is usually a monospecific community although seagrass, spartina, saltwater paspalum and sea meadow beds can sometimes be found below mature mangrove stands.

3. **Seagrass** *(Zostera* sp.) – this is usually a monospecific community.

4. **'Weed community'** - in the Waikato Region the most significant estuarine weeds are saltwater paspalum *(Paspalum vaginatum)* and cord grass *(Spartina* spp*.).* Both of these weeds 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, particularly dominating sea meadow habitat.

   A number of other weed species tolerate salty environments but for clarity of mapping were not specifically surveyed due to their presence above the spring high tide mark. Tall fescue (*Schedonorus phoenix*) is a grass that is common along the margins of estuaries mixing with marsh clubrush and old mangroves on the landward edge of mangals. The introduced coastal sedge *Carex divisa* is present around Miranda in the grazed sea meadow paddocks, mixing with tall fescue, marsh clubrush and pastoral grasses around the edges of sea meadow patches.

Figure 1: Site localities mentioned in this report

3 Field Notes

3.1.1 Summary

The following general observations give an overview of estuarine vegetation in the inner Firth of Thames.

- A lack of seagrass.
- A lack of extensive oioi and sea rush beds.
- Miranda Stream east:
  - Extensive tall mature mangrove forests with an open canopy allowing sea meadow species to colonise beneath them.
  - Large open sea meadow communities where the landward estuarine extent is not restricted by drains and stopbanks.
  - Large remnant patches of saltmarsh ribbonwood where the landward estuarine extent is not restricted by drains and stopbanks.
- Miranda Stream north:
  - A mosaic of sea meadow, mangroves and pasture/weeds developed by the chenier ridges of the Miranda coastline.
- A general predominance of glasswort in the large sea meadow communities.
- High diversity of species within the sea meadow of the outer chenier slacks of the Miranda coastline.
- The presence of Maori musk around the Kauaeranga River.
- Sea blite is common amongst the glasswort communities at Miranda.
- Unnatural sea meadow communities line waterways where drainage activity has removed mature vegetation (e.g. mangroves and salt marsh ribbonwood).
- A number of large patches of spartina and many small patches.
- Pioneer populations of saltwater paspalum that are concentrated between the Kauaeranga and Waihou Rivers.
- Annual wild rice at the upper extremities of the salt wedge up the Waihou River.
- The upper limit of the saltwater influence is generally indicated by the extent of scattered mangrove seedlings, bachelor's button and spartina.
- The natural inland extent of estuarine vegetation has been highly modified by drainage. This makes it difficult to estimate the historical extent of estuarine vegetation.
- Stock damage is often significant where estuarine vegetation extends inland of the main drainage channels (e.g. along the seaward side of stopbanks) and where access is provided across to the seaward side of the main drainage channels.
- Significant damage to old mangals was found where care has not been taken to minimise the effects of drainage maintenance.

Table 1 lists common plant species found during the survey of the inner Firth of Thames. The 'vegetation community' category for the estuarine species corresponds to the colour coded vegetation boundaries of the aerial map.

Table 1: Estuarine and freshwater species of the upper Firth of Thames noted in the survey.

Estuarine/Coastal Species:

Common/Maori name	Scientific name	Mapped Vegetation Community
Arrow grass	*Triglochin striata*	Sea meadow
Bachelor's button	*Cotula coronopifolia*	Sea meadow
Buck's horn plantain	*Plantago coronopus*	Sea meadow
Glasswort	*Sarcocornia quinqueflora*	Sea meadow
Mangrove	*Avicennia marina* var. *australasica*	Mangrove
Manuka	*Leptospermum scoparium*	
Maori musk	*Mimulus repens*	Sea meadow
Marsh clubrush	*Bolboschoenus medianus*	
Mingimingi	*Coprosma propinqua* [t]	
Oioi	*Apodasmia similis (=Leptocarpus similis)*	Rush/sedge
Orache	*Atriplex prostrata**	
Pampas	*Cortaderia selloana, C. jubata*	
Pohuehue	*Muehlenbeckia complexa* [t]	
Raupo	*Typha orientalis*	
Remuremu	*Selliera radicans*	Sea meadow
Saltmarsh ribbonwood	*Plagianthus divaricatus*	Saltmarsh ribbonwood
Saltwater paspalum	*Paspalum vaginatum*	Weed
Sea blite	*Suadea novae-zelandiae*	Sea meadow
Sea primrose	*Samolus repens*	Sea meadow
Sea rush	*Juncus krausii* var. *australiensis*	Rush/sedge
Seagrass	*Zostera novazelandica*	Seagrass
Sedge	*Carex divisa*	
Slender clubrush	*Isolepis cernua*	Sea meadow
Spartina	*Spartina sp.*	Weed
Tall fescue	*Schedonorus phoenix*	

* commonly extends into sea meadow community

[t] can be found associated with saltmarsh ribbonwood

3.1.2 Site descriptions/notes

The Firth is described clockwise from north of Thames township around the Firth to Kaiaua. See Figure 1 for a map showing site localities mentioned in this report.

The estuarine vegetation around **Thames township** was limited to a band of mangroves (Figure 1), that thinned out north towards Tararu and was restricted landward by infilling (Figure 2), and dissected by boat moorings (Figure 3). Spartina was present from near the bird hide north of Goldfields shopping mall all the way around to, and up the, Kauaeranga River. Particularly large isolated patches of spartina were growing at the river mouth (Figure 4) and in the middle of thick tall mature mangroves lining the true right bank of the **Kauaeranga River** mouth (out from the Toyota factory) (Figure 5). These spartina populations within the mangroves may have been established during the disturbance of the mangrove band when a wide track was cut through it many years ago. By the time of this survey, the track was a tunnel as the mangroves have closed over the canopy. The mangroves were about 5 m high and supported pied shag nests within the middle of the mangal (Figure 6). This thick mature mangal graded up into coastal wetland scrub/forest and ended at the Kauaeranga Bridge. Near the bridge on higher ground, the native saltmarsh ribbonwood and karo were being invaded by phoenix palms, honeysuckle, wattle, and smilax (Figures 7 and 8). Patches of spartina were common along the river edge in between the mangroves (Figure 9). Small patches of sea rush were found in low lying areas of the river

floodplain. The saltwater influence ran out below the racecourse and marsh clubrush dominated the river edge here. One of the larger areas of sea rush found in the Firth survey was on the true left bank of the Kauaeranga River above the SH 25 bridge. Spartina was grazed here amongst the sea rush (Figure 10). The marsh clubrush seemed to have been selectively grazed out, leaving patches of sea rush and low-grazed spartina. Of significance was the sea meadow community on the true lefthand floodplain of the Kauaeranga River (immediately upstream from SH 25) that contained the threatened herb *Mimulus repens* or Maori musk (national threat status 'Sparse') (Figure 11). Downstream of the bridge large Norfolk pine and monkey puzzle trees provided roosts for ~100 large pied shags. Shags and a kotuku were also noted roosting in tall mangroves at the river mouth opposite the wharf. Saltwater paspalum was only found along a drain on the lower true left bank (true left bank) of the Kauaeranga downstream of SH 25 (Figure 12).

The mangal canopy **south of the Kauaeranga River mouth** was generally 4-5 m high. The landward edge of the mangal was characterised by sparse old mangrove trees surrounded by tall fescue and marsh clubrush, and large patches of saltmarsh ribbonwood near the Kauaeranga River (Figures 13 and 14). Further within the mangal, thick sea meadow mats often covered the ground beneath sparse old mangroves (Figure 15). These sea meadow carpets sometimes extended 100-150 m seaward beneath the thickening mangrove canopy. South towards Kopu, the drains and stopbanks seemed to have restricted the saltmarsh ribbonwood habitat. The sea meadow here was generally dominated by a monoculture of glasswort but patches of remuremu, sea primrose and arrow grass were also common. Two patches of saltwater paspalum were found associated with sea meadow patches within the mangal near the wastewater treatment ponds. The sub-canopy sea meadow patches disappeared opposite the airfield and were only represented by thin bands along the landward mangrove margins. A number of large ngaio and other plantings abutted directly onto the mangal (Figure 16). Saltmarsh ribbonwood patches appeared again near the wastewater treatment ponds, as did sub-canopy sea meadow mats and a number of saltwater paspalum infestations (Figure 17). An old chenier ridge formed a hooked spit out from the Thames airfield. Weeds on the chenier included brush wattle, tree privet, fennel, gorse and phoenix palms. Brush wattle was also present on the stopbank back near the gun club. The first flood gate encountered was opposite the wastewater ponds (Figure 18). Here the stopbank directly abutted the coastal marine area. The vegetation lining the Waihou River was restricted to a band of mature mangroves interspersed with patches of spartina along the riverside. Behind, and sometimes beneath, the mangroves there were often sea meadow beds. The mangal narrowed towards the **Waipapa River** where more spartina was present. Poor stopbank management was noticeable (Figure 19). A patch of saltwater paspalum was found on the true right bank of the Waipapa Stream (Figure 20). Mangroves extended almost to the highway up the stream bank. Upriver from the Waipapa stream mouth, a small patch of Maori musk was found amongst the bachelor's button along the drain behind the mangroves (Figure 21). The mangal became fragmented with tall fescue and marsh clubrush towards **Kopu**. More saltwater paspalum and spartina (and also the introduced sedge *Carex divisa*) was found around the Kopu boat ramp and upstream towards the Kopu bridge (Figure 22). Fencing was often within the coastal marine area or non-existent (Figure 23). Oioi and sea rush were noticeable in their absence, with only a few patches of sea rush being found near the Kopu boat ramp.

Marsh clubrush often characterised the extreme upper tidal reaches of river edges, and was found behind the mangrove zone competing with tall fescue. Tall fescue dominated the low-lying freshwater plains, with patches of raupo and flax scattered in depressions on the river side of drains and stopbanks. Small scattered sea meadow patches were found inland of the mangroves with patches of saltmarsh ribbonwood amongst marsh clubrush, tall fescue and the occasional flax behind. Cleared drains interrupted the landward extent of the riparian vegetation (Figures 24 and 25). A large patch of saltmarsh ribbonwood existed on the lower true left bank at the **Kirikiri Stream** mouth (Figure 26) behind the dense mangal (Figure 27). Raupo, lake clubrush

(*Schoenoplectus tabernaemontami*) and marsh clubrush were found above the salt influence in the Kirikiri Stream. Spartina dominated the **Waihou** River bank (Figure 28) once the mangal reduced to a thin patchy band of trees up to the **Matatoki Canal**. There were patches of raupo amongst marsh clubrush in the back-swamp of the Matatoki Canal mouth. Reed sweetgrass (*Glyceria maxima*) became common along upper drain reaches (including the Matatoki Canal) and in behind the mangrove band. The estuarine influence extended a short way up the Matatoki Canal as indicated by the presence of lush bachelor's button beds along the river banks. The bachelor's button was superseded by lake clubrush further upstream. Further up the Waihou, mangroves and spartina lined the river bank with marsh clubrush, reed sweetgrass, raupo and flax in behind (Figure 29 and 30). Mangroves and sea meadow (mainly bachelor's button) became patchy around the **Turua** island and the upper salt influence on the true right bank was reached on the river bend opposite Tarau village. The vegetation of the river bank at the top of the salt wedge included sharp spike sedge (*Eleocharis acuta*), marsh clubrush, lake clubrush), raupo, lots of reed sweetgrass, the odd small mangrove, and clumps of the tall annual rice grass (*Zizania palustris*) (Figure 31). On the true left bank, apart from one isolated mangrove, the mangroves did not appear until north of Turua island. The Turua Island had a band of mangroves at its downstream end and a couple of patches of saltwater paspalum and spartina. There was only one patch of saltmarsh ribbonwood and a band of bachelor's button lining the south-eastern side of the island. The island supported a large raupo swamp. The **true left bank of the Waihou River** was characterised by a thin band of tall mangroves and the occasional spartina and sea meadow patch with farmland immediately behind (Figure 32) downstream of Turua until it began widening towards the Kopu Bridge. The mangal then supported old mangroves perched up above the river on a high river flat. The mangroves became sparse inland and tall fescue generally out-competed saltmarsh ribbonwood. Convolulus was present climbing up mangroves and the few saltmarsh ribbonwood bushes present (Figure 33). The Thames Forest & Bird group have been planting here and downstream of the bridge, apparently with mixed success.

The mangal widened and thickened again on the **true left bank of the Waihou River mouth** (downstream of the Kopu bridge) characterised by a similar vegetation community as that towards the Kauaeranga. The stopbank and associated drains were set further back from the mangal landward limit and this has allowed dense but scattered saltmarsh ribbonwood patches to exist. Between the Kopu Bridge and the first main creek running out through the mangal, saltmarsh ribbonwood and dense diverse sea meadow patches were found under the mangrove canopy (Figures 34 and 35). The mangroves are about 4 m tall here. Of note here was the presence of an unidentified Carex sedge in the sea meadow sward (Figure 36). One patch of saltwater paspalum was also found associated with the sub-canopy sea meadow (Figure 37). The wide mangal band and landward saltmarsh ribbonwood communities (Figure 38) continued downstream until the mangal thinned at the first maintained stop-gate floodway through the mangroves. One side of the drain was covered with a pile of sediment dredged from the drain. Here the mangroves (3-4 m high) had been crushed to allow the digger room to keep the drain clear (Figures 39 and 40). Sea meadow communities were common along the landward edge of drains where they have been recently cleared or are grazed (Figures 41 and 42). These sea meadow communities may have been historically present in the vicinity but now seem to be present as the 'colonising' community of the frequently disturbed flats. Depending on tidal elevation and salinity, mangrove colonisation seemed to occur later, if not restricted by stock grazing. Otherwise, marsh clubrush or tall fescue dominates if not restricted by grazing. On the inland side of the mangal, near the Waihou River mouth, there was a patchwork of mangrove and sea meadow communities. Stock had access to this area of the coastal marine area (Figures 43 and 44).

The mangal thickened again **west of the Waihou** along the edge of the Firth of Thames and the stopbanks and drains allowed a wide 'fingered' band of saltmarsh ribbonwood to exist (poheuhue was also present) with marsh clubrush and tall fescue landward (Figure 45). This band of saltmarsh ribbonwood, marsh clubrush and tall

fescue characterised the front of the stopbank between the Waihou and Piako River mouths, varying only in thickness between the stopbank drain and landward mangal edge. The drain was lined with bachelor's button (Figure 46) and mangroves did not appear in the drain until half way along the stopbank. Where the stopbank does a 'dog leg' towards the mouth of the Piako, the estuarine communities landward of the mangal became very mixed (Figures 47 and 48). This may be due to the influence of past grazing and establishment of drains in the area. Large sea meadow patches mixed with patches of spartina (Figure 49). A few small patches of *Carex divisa* were also present between the sea meadow and tall fescue. Saltmarsh ribbonwood were scattered near the back of the main mangal while small mangroves grew in low lying areas or followed the lines of the old drains. Spartina was scattered in thick patches both in the open sea meadow areas and under the mangrove canopy (Figure 50)

The **Piako River** was lined by mangroves ~5 m tall which formed thick mangals on the inside bends towards the SH 25 Bridge (Figure 51). These downstream mangals did not have sea meadow or spartina along their river edges. Often some sea meadow was found on the landward side of these mangals. More destruction of mature mangroves was found near a stop gate channel (Figure 52). Figure 53 shows the largest patch of sea rush found around the Piako River. Further up the Piako was an example of what estuarine vegetation would have been present before drainage activities removed the vegetation (Figure 54). A large sea meadow community existed on the true right bank of the river upstream of the road bridge (Figure 55). This extensive glasswort community was not fenced from stock and was therefore pugged and defecated on. Tyre marks were also found in the glasswort, and it is possible that duck shooters drive their vehicles directly to the maimai over the glasswort field. Grazed sea meadow and a patch of spartina occured further upstream along the true right bank (Figure 56). Mangroves and bachelor's button indicated the upper extent of the saltwater wedge further upstream around the bend. A clump of annual rice grass was noted in a drain on the true left bank near the upper salt wedge.

A good example of stopbank riparian management was found immediately upstream of the road bridge on the true left bank (Figures 57, 58 and 59). Here stock were fenced from the coastal marine area with the fence appropriately located just up from the toe of the stopbank. Casuarinas have been taken out and replaced with flax. A large ngaio (possibly an original remnant) was found on high ground amongst the mangroves and oioi. In comparison, immediately upstream was an example of poor stopbank riparian management. Here the mangrove and saltmarsh ribbonwood edge was curtailed by grazing and only sea meadow could survive the pugging and grazing (Figures 60 and 61). Faecal deposits are washed into the river. Management of stopbanks could clearly be improved here, and this is an issue that should be addressed as soon as possible.

Downstream of the boat ramp, the river bank supported a community of saltmarsh ribbonwood, ngaio and flax as well as mangroves and the occasional patch of oioi and sea rush (Figure 62). The lower true left bank of the Piako River was dissected by what is likely to be duck hunter maimais and paths. A mix of mangrove, sea meadow, saltmarsh ribbonwood and tall fescue was found. Some of the worst damage to vegetation within the coastal marine area resulting from drainage management has occurred on the last true left bank inside bend at the Piako River mouth. A track approximately 7-8 m wide has been bulldozed through a 5-6 m tall mature mangal (Figures 63, 64 and 65). The track runs for about 770 m along the mangal edge to access a stop-gate floodway. Pied and little shags were found to roost and nest in the tall mangroves that line the true left bank of the Piako River mouth (Figure 66). Along the outer edge of the mangal at the **Piako River mouth** was a band of dead mature mangroves (Figures 67 and 68). It is unclear whether these trees died due to an infestation of the mangrove leaf roller moth (*Planotortrix avicenniae*) or from being smothered by sediments. The dead trees were about 3-4 m tall. Some were resprouting, and a sub-canopy of new mangroves between 0.5 and 1 m tall were growing around the dead trees. The mud was much deeper (~30-40 cm deep) on the seaward side of the mature mangrove boundary (including dead and alive trees) than

only 20 m inside the mature band of mangroves (mud ~5-10 cm deep). The dead zone stopped for no apparent reason with the same tree height and mud to the east and west. The odd large mature mangrove was found in the young 1 m tall mangrove zone at the river mouth (Figure 69). Mustelid footprints were seen at the edge of the mature mangrove band (~600 m from dry land). Pied stilts, gulls and oystercatchers were roosting in front of the band of young mangroves that had established in front of the dead band. This band of young mangroves seems to be colonising the sediment delta of the Piako. About 200 oystercatchers were roosting in heavily grazed paddocks inland of the true left bank Piako River mouth. Further west along the Firth, away from the river mouth, the scattered sparse mangrove edge was infilling with young mangroves (Figure 70).

The estuarine vegetation along the Firth coastline **west from the Piako River** was characterised by a wide mangal band, with a mosaic landward edge of thick sea meadow (predominantly glasswort but also sea primrose) and saltmarsh ribbonwood (sometimes with pohuehue). Tall fescue occurred to a more limited extent than that found along the coastline between the Waihou and Piako Rivers. Marsh clubrush was commonly found along the drain edges. Generally the saltmarsh ribbonwood followed the landward edge of the mangal and/or the drain (Figure 71 & 75), with sea meadow forming a swath between (Figure 72). The width of the saltmarsh ribbonwood/sea meadow band depended on the position of the drain and stopbank. Roughly half way along a patch of spartina occurred amongst the sea meadow. It is possible that there may have been a few more spartina patches along this stretch as it was difficult to access the landward side of the mangal in places and the survey was sometimes undertaken purely from the stopbank. A few smaller patches of spartina were also found. Stock access to the coastal marine area was found to be a major problem along the stopbank between the Piako and Waitakaruru Rivers (Figures 73 – 77).

The saltmarsh ribbonwood/sea meadow band narrowed toward the mouth of the Waitakaruru River and the stopbank left little room for the landward establishment of sea meadow or saltmarsh ribbonwood in places (Figure 78). No spartina or sea meadow was noted along the mangal edge of the lower **Waitakaruru River** (Figure 79). The estuarine vegetation along the true right bank narrowed up into the river mouth and became a thin band of grazed mangroves and/or sea meadow (Figures 80 and 81), whereas the vegetation on the true left bank was not as severely constricted by the stopbanks until half way between the junction of the two canals and the SH 25 bridge. The eastern fork of the upper Waitakaruru River (Maukoro Canal) was characterised by a band of sea meadow on both sides and a band of mangroves on the true left bank. The occasional scattered saltmarsh ribbonwood was also present. Only the true right bank was grazed. A bittern was seen on the bank well above the upstream limit of saltwater influence. The western canal (Waitakaruru Canal) was characterised by spartina and sea meadow dominating the dredged and grazed lower banks (Figure 82). Mangroves have been dredged out upstream of the SH 25 bridge (Figure 83). The upper tidal influence was indicated by patches of sea meadow and mangrove seedlings lining the grazed marsh clubrush fringe (Figure 84). A dead cow was found on the banks of the canal near the upper estuarine vegetation limit (Figure 85).

Stilts, South Island Pied oystercatchers, and possibly godwits, were seen roosting on the sand spit at the mouth of the Waitakaruru River. Mangroves seedlings were establishing out over river delta. Further west the mangrove edge along the open Firth between Waitukururu River and Miranda Stream ranged from 1.5 to 4 metres tall (Figure 86).

West of Waitakaruru River mouth the landward mangal edge became a wide mosaic of mangrove patches, open flats and sea meadow (glasswort). Some mixed tall fescue and saltmarsh ribbonwood patches were found seaward of the stopbank drain. A white goat and kid were seen in the sea meadow and mangroves and a number of culvert drain crossings were not permanently fenced/gated, thus allowing stock directly into the

coastal marine area (Figure 87). Improper stock fencing was a problem along much of the Waitakaruru – Miranda Hot Springs stopbank. A particularly bad example of stock grazing of the coastal marine area was found at E2721398 N6439648. Figures 88 and 89 show grazed and pugged bachelor's button and extensive spartina, as well as a band of dead (grazed?) mangroves. West of the large spartina infestation, the sea meadow was reduced to patches along the stopbank edge with a band of tall fescue between it and the mangal.

The mouth of the **Karito Canal** had been realigned recently leaving a redundant canal bend in the mangroves. Just about all mangroves have been dredged out upstream of the SH 25 bridge except up near the limit of the saline influence where dredging has been limited to only one side of the canal (Figure 90). The dredged canal edges were covered in sea meadow. Glasswort seemed to be the primary coloniser along dredged drains that would have been mangrove-lined if not cleared.

Moving west from the Karito Canal, open mud flats, sea meadow patches and a patch of saltmarsh ribbonwood grew between the mangal and stopbank drain. This turned into two extensive glasswort fields split by a large open mud flat, and backed by a mix of open mud flat and bands of mangroves before the main dense mangal. West of a flood gate outlet the sea meadow was fragmented and mixed with open mud flats in a narrower band, as the mangal edge moved closer inland towards the stopbank. The mangal edge then moved seaward again leaving larger open mud flats with sea meadow along the stopbank drain edge or as isolated small patches. Before the next canal, the sea meadow was replaced by a thick band of spartina that ran along the drain edge (Figure 91) and a large patch was found near the mangal edge by a maimai. Sea meadow dominated close by the canal. Mangroves and scattered sea meadow extended up the canal until just past the **Miranda Hot Springs** complex.

North west of the Miranda Hot Springs a thick sea meadow band existed between the stopbank and mangal, however this has since gone with the formation of a new large stopbank and canal drainage system (Figure 92). Scattered sea meadow was present in the paddock landward of the stopbank (Figure 93). It was assumed that this was present (maybe to a greater extent) in 2002. A large and a smaller patch of spartina were found on the mangal edge (Figure 94). The new stopbank ended at a small drain (opposite Baigents Rd). On the other side of the drain the stopbank was further seaward (but without the large cleared area for the seaward canal). There was a large sea meadow patch covering two thirds of this paddock between the stopbank and road (Figure 95). Saltmarsh ribbonwood was common along the stopbank edge and scattered up the side of the next northern canal. Immediately north of this canal was a large patch of spartina between the stopbank and mangal. Scattered sea meadow lined the stopbank and was occasionally found on the seaward side of the drain. However, generally the mangal edge extended right up to the stopbank drain edge until the next large canal (**Waiwarawara Stream**). Sea meadow communities were present along the banks of the Waiwarawara canal mouth, with an extensive sea meadow patch on the flats seaward of the northern true left bank stopbank. This large patch petered out as the mangal edge extended in to the bulge of the stopbank. The stopbank then moved landward again, forming a deep indent that supported a large sea meadow/open mud flat community. In the north western corner an extensive spartina patch was competing for space on the flats (Figure 96). At the end of the indent, the mangal again abutted directly up to the stopbank drain with only a small amount of sea meadow present along the drain edges up to the Miranda Stream.

The mangal continued up the **Miranda Stream** but thinned out after the first bend upstream of the road bridge. It was replaced by extensive sea meadow beds, particularly on the true right bank and areas of open mud flat. As the estuary reach narrowed upstream, mangroves petered out, but small areas of sea meadow and sea rush lined the stream banks up into low-lying swampy areas within paddocks. A stopbank along most of the upper true left bank of the stream restricted stock access but stock had free access to the upper reaches of the true right bank of the stream.

Saltmarsh ribbonwood lined the road past the bridge for a short distance on the upstream side (Figure 97) and around the picnic pull-off area downstream of the bridge.

The extensive 'greater Firth' mangal ended at the mouth of the Miranda Stream. North of the stream was the confusing patchwork of chenier ridges that the Miranda coastline is so well known for. These ridges produced a vegetation pattern that forms a sequence of fingers, with sea meadow and/or mangroves in low-lying land behind ridges, and pasture grasses and weeds including tall fescue, fennel and *Carex divisa* on the mid and higher ground of the ridges (Figures 98 - 101). This sea meadow/pasture grass sequence was repeated out to the open coast line. Vegetation on the active frontal chenier was more characteristic of dunes and where mangroves were present they were partially buried or eroding out the front of the chenier (Figures 102 - 103). Scattered sea rush was found infrequently amongst the sequence, except near the **Miranda Shorebird Centre** where sea rush was much more common (Figure 104). While outnumbered by sea meadow in area, mangroves formed sizeable patches in some of the ridge slacks surrounded by areas of open mud flat. Mangrove seedlings were actively colonising many of the open mud flats and along stream edges (Figure 105). Of particular note were the lush sea meadow beds in the slacks and along the lower edges of the shell banks nearer the open coast that contain sea blite (Figures 106 and 107). Higher up on the free-draining shell banks an unidentified green rosette herb was found (Figure 108).

North of the Miranda Shorebird Centre there was a large area of pasture grasses and weeds. The last extensive patch of mangroves on the coastline was found along the stream mouth of the 'Fairview Road' canal. Fingers of sea meadow extended south from the banks of the 'Fairview Road' canal stream mouth. A thin band of mangroves and sea meadow extended up the canal from the road for about 850 m.

There was then a large gap in the presence of estuarine vegetation until an abrupt boundary was reached where a stopbank stopped the parallel movement of sea water near **Rangipo**. North of this stopbank was a thick mangrove band, interspersed with a scattered mosaic of sea meadow, saltmarsh ribbonwood, sea rush and open mud flats (Figure 109). This estuarine vegetation petered out before Kaiaua. A small patch of spartina occurred in a drain with sea rush upstream of the road. At Kaiaua a mangrove band lined the lower true right bank of the **Hauarahi Stream** mouth. Upstream a mix of mangroves, sea rush, sea meadow and saltmarsh ribbonwood lined the stream banks. The last significant estuarine vegetation was found just north of the settlement in farmland drains and included sea rush, a few mangroves, small patches of sea meadow and a couple of small spartina patches.

3.1.3 Birds

Birds seen during the survey include:
White faced heron, South Island pied oyster catcher, godwit, pied stilt, black backed gull, red billed gull, swan, Canada geese, spur-winged plover, New Zealand dotterel, spoonbill, kingfisher, pied shag, little shag, fernbird, bittern, paradise duck, mallard duck, caspian tern, and white fronted tern.

3.1.4 Weeds

Estuarine weeds

Spartina:

There were too many spartina sites to describe here but their distribution is shown on the associated digitised maps. Some spartina control was undertaken earlier in 2004 (Brownell, 2004) but not all populations were treated and it appears follow-up control has not been undertaken. Spartina infestations are often associated with areas where stock have access to the coastal marine area.

Saltwater paspalum:

Saltwater paspalum had not yet established as widely as spartina and was restricted to small patches. Refer to the survey map for accurate locations. Saltwater paspalum was noted in the following areas:

- Along a drain on the true left bank of the Kauaeranga River beside the motor cross paddock (approx 2736392.9, 6446855.5) and two patches further downstream within the mangal (2736144.2, 6447036.7).
- A couple of patches out from the water treatment plant (2736507.7, 6445158.5).
- True right bank of the channelised mouth of the Waipapa Stream (2737216.3, 6444314.4).
- Patches on the Waihou true right bank between boat ramp and Kopu Bridge (2738941.0, 6440830.0).
- True left bank of the channelised mouth of the Kirikiri and Warahoe Streams (2738041.2, 6440974.8).
- Two small sites on the downstream true left bank of the Taura Island (2738273.6, 6438132.0).
- Small site (and possibly others) amongst sea meadow under tall mangrove forest true left bank downstream of Kopu Bridge (2737466.6, 6442795.8).

Terrestrial/freshwater weeds

The following weed species threaten the integrity of native coastal riparian vegetation, and were noted during this survey.

- Pampas
- Tall fescue
- Japanese honeysuckle (scattered)
- Tree privet (scattered)
- Wattle (scattered)
- Phoenix palm (Thames)
- Smilax (Thames)
- *Carex divisa*

Of these weeds, tall fescue and *Carex divisa* have the ability to invade the upper limits of salt influence.

Tall fescue was widespread and often found as a dense cover behind mangroves or saltmarsh ribbonwood, or intermingled with marsh clubrush. In many areas (e.g. the perched mangrove forest on the true left bank upstream of the Kopu Bridge) tall fescue appeared to be excluding native back-swamp species (e.g. saltmarsh ribbonwood and potentially flax and manuka).

Carex divisa (divided sedge) is an introduced sedge that mixes with tall fescue, marsh clubrush and pastoral grasses around the edges of sea meadow. *Carex divisa* was commonly found around Miranda and small patches were also noted in the historic farmed area that has reverted to sea meadow on the true right bank of the Piako River and near the Kopu boat ramp. Strahan (1997) studied the salinity tolerance of this sedge and the competition between this and other estuarine species. Strahan (1997) concluded that *Carex divisa* (and other exotic species) were so dominant in grazed areas around Miranda that it is best to continue grazing to stop *Carex divisa* from developing a closed canopy and reducing species diversity.

4 Discussion

4.1.1 General survey findings

The expansive areas of sea meadow and saltmarsh ribbonwood are significant as it is usually these more landward habitats that are restricted or destroyed by past and current land activities (e.g. farming). Sea level rise is going to put pressure upon the future existence of these estuarine communities as they will be restricted in the extent

that they can migrate inland. The siting and management of stopbanks needs to be reassessed in relation to sea level rise and the ability for estuarine communities to migrate inland.

The mature mangrove zone from the Miranda Stream in the west to the Kauaeranga River in the east is a hugely productive community. Apart from the direct organic input provided by the mangal, the large trees lining the main rivers provide important roosting sites for pied and little shags. The height and openness of some of the mangal allows dense sea meadow communities to coexist, thus greatly increasing the floral diversity of the zone. The mangal zone provides a very effective erosion buffer to the inner Firth coast line. Mangroves have been expanding for many decades due in part to the placement of stopbanks and the huge sediment loads that are being transported from the greater Hauraki Plains catchment and deposited into the upper Firth. Mangrove expansion is particularly noticeable at the river mouth sediment deltas.

A distinctive characteristic of the Firth estuarine vegetation is the lack of sea rush and oioi communities. While these rushland species form a dominant zone in all other Coromandel Peninsula estuaries, they are only found in small patches in the upper Firth of Thames. Strahan (1997) suggested that the apparent rarity of oioi at Miranda was associated with grazing and trampling by cattle. The divided sedge, *Carex divisa*, has invaded much of the potential habitat of oioi and would have to be suppressed to allow transplanted oioi to establish (Brownell, 2004).

Weeds are a significant threat to the health and integrity of the Firth's vegetation. The Department of Conservation is planning to undertake an intensive control programme for spartina populations in the Firth in an attempt to eradicate spartina from the inner Firth.

It is also strongly recommended that the few pioneer populations of saltwater paspalum be controlled at the same time, before this weed has an opportunity to spread further afield. Saltwater paspalum has shown itself to be an aggressive spreader throughout the mid and upper tide zones (Graeme & Kendal, 2001). It particularly threatens low-stature sea meadow communities. The few pioneer populations of saltwater paspalum should be eradicated as soon as possible. This can be undertaken using Gallant herbicide and so it would be a wise use of resources to co-ordinate the spraying of saltwater paspalum with the spartina control programme. The effects of Gallant in estuaries have been extensively researched and it has been successfully used to control saltwater paspalum in the Matua Estuary in Tauranga. It should only require a slight variation to the current spartina consent to include the control of the small saltwater paspalum populations in the Firth.

There were some practical issues during this survey.

1. As the aerials for this survey were flown in 2002, care was needed to decipher whether vegetation found in the field was actually there at the time the aerials were taken. It is recommended that future surveys are undertaken to coincide with the availability of recently flown aerials to minimise interpretation error.

2. It was sometimes difficult to distinguish scattered mangroves from sea meadow on the aerial. It appears as if both communities have expanded since the aerial photo was taken in 2002. It was particularly difficult, if not impossible, to distinguish between saltmarsh ribbonwood, tall fescue and marsh clubrush on the aerials. Spatial spread of saltmarsh ribbonwood relied totally on field observations. Similarly, spartina was not obvious on the aerials unless it occurred as patches surrounded by open mud.

3. Due to the far-ranging influence of drainage on the Hauraki Plains, and the flat topography, it is very difficult to determine where the saline influence would have historically reached. Generally the saline influence would have extended further inland than at present, and sometimes a considerable distance, of the stopbanks.

Today the inland presence of estuarine vegetation is modified by present drainage patterns. For example, the saline influence extends 2.4 km inland up the Karito Canal. The situation today is also considerably different due to the excessive sediment loads entering the Firth from past and present land management. This has resulted in the expansion of mangroves around the Firth, with a subsequent seaward movement of the 'land' edge and estuarine communities behind the mangroves. Records pre-dating the drainage schemes (roughly early 1900s) would be needed to indicate the original vegetation zones. There has also been reclamation of the foreshore around Thames township (most recently to the north of the Kauaeranga River).

Much of the inner Firth is an internationally recognised Ramsar site due principally to the significant habitat it provides for migratory water birds. Particular care needs to be taken with adjoining land management to ensure the values of the Ramsar site are not compromised. Similarly, drainage activity undertaken in the coastal marine area should be kept to a bare minimum. A reassessment of drainage works is needed to ensure that the significant adverse effects that occur under the current management practises cease.

4.1.2 Riparian management and stock access

A major threat to the inner Firth of Thames and its vegetation communities is from land run-off and uncontrolled stock access to the coastal marine area. There are many places where stock fencing is inadequate around the inner Firth. Unfenced farm margins along waterways do not provide a vegetation buffer that can effectively absorb and filter the run-off from the land. This type of poor land management increases the level of sediment, nutrients and pathogens in the harbour. Stock can physically damage the estuarine vegetation by pugging sediments, sea meadow turfs and rushes (rush root bases are particularly vulnerable); as well as grazing mangroves. The grazing of weed species can facilitate the spread of these weeds through trampling and dislodging fragments that can be washed away in the tide or physically transported in hooves. Generally where spartina was found, there was stock access to the coastal marine area nearby. Also, increased pathogens and sediment are a direct result of stock in the coastal marine area due to stock defecation and the mobilisation of sediments.

Many sites along the stopbanks of the Kauaeranga, Waihou, Piako and Waitakaruru Rivers and the foreshore between Waihou and the Miranda Hot Springs have inadequate fencing. As a general rule fencing along the stopbanks should be placed at the toe of the stopbank on the seaward side to prevent stock access to the coastal marine area. Figures 56-60 show examples of good and poor stopbank/riparian management.

Stock need to be immediately fenced out of the coastal marine area at E2721398 N6439648 where significant damage to the coastal environment was occurring. Goats need removing from the one site they were seen, west of the Waitakaruru River mouth.

The grazing of stopbanks which are fenced at the toe has a couple of benefits in that it reduces the likelihood of weeds establishing on the raised banks, and allows for easy access and maintenance of the stopbank. However, it was noted that the stopbank reaches that were not grazed where predominantly covered in rank grasses. Pampas and blackberry were infrequent weeds. The strip of land between the drain and the seaward toe of the stopbank, if too high for spring tides, usually supports dense swathes of marsh clubrush and tall fescue. It is likely that there will be changes to the vegetation when the grazing pressure is removed from the low-lying drain edges that currently support sea meadow communities. Depending on the ground elevation and therefore level of salt influence, either the grazed sea meadow carpet will be overgrown by marsh clubrush (which is preferentially grazed out) or the sea meadow will compete for space with mangroves (also grazed by stock).

In a number of areas (e.g. Figures 90 and 91) the benefits from stopbank placement is questionable. This is particularly so along the Miranda Road where naturally saline areas have been stopbanked to provide grazing paddocks which are very narrow and/or provide poor pasture. For example the stopbank in Figure 91 appears to provide very little grazing benefit in return for significant negative effects on the coastal marine area.

4.1.3 Land drainage activity

Extensive damage to the estuarine vegetation was observed in relation to drain maintenance. While it is necessary to undertake maintenance works within the coastal marine area, such works should be kept to a minimum and if significant damage is unavoidable, the works should be reassessed. Where any work in the coastal marine area is undertaken, remedial work is necessary where estuarine vegetation has been disturbed. As a minimum, yearly checks for, and control of, weeds is needed in these disturbed sites.

Having viewed the different methods of maintaining drains and the resultant vegetation disturbance it is clear that a restriction is needed to ensure maintenance work is only undertaken from one side of drains. This provides a sensible and workable solution to minimising the disturbance to the coastal marine area from this activity. Any drains that are too wide to be cleared from only one bank will require an alternative non-destructive method such as barge-based dredging.

Some of the worst damage to vegetation within the coastal marine area from drainage maintenance activity has occurred on the last inside true left bank bend at the Piako River mouth. A track approximately 7-8 m wide has been bulldozed through a 5-6 m tall mature mangal (Figures 62, 63 and 64). The track runs for about 770 m along the mangal edge to access a stop-gated floodway. This destruction is considerable and it is recommended that action be taken to avoid similar adverse effects in the future. A simple solution would be to bridge the parallel running stopbank drain immediately beside the main drain outlet that requires maintenance. Consent conditions can be worded to prevent such unnecessary damage.

Figure 82 shows the abrupt removal of mangroves lining the Waitakaruru Canal. This has resulted in increased bank erosion due to the loss of the protective mangrove pneumatophore network. Observations in the field indicate that banks are held up at a steep angle by mangroves, but erode to a lower angle if mangroves are absent. Eroding banks also tend to be associated with wider but shallower channels. The floodway will operate well with mangroves left to protect the canal banks as long as stopbanks are placed far enough back to leave the floodplains intact to cope with floodwaters. Such a system will help protect water quality and wildlife habitat as well as allow floodwaters to be discharged to the coastal marine area. If the drains' flood cross-section with its natural vegetation communities intact is not big enough to convey floodwaters, then the stop banks are incorrectly placed within the floodplain to cater for both.

Similar observations are made in Brownell (2004), including that current drain clearance practises result in spoils washing back into channels, and banks eroding back to a gentle slope (and making the channel shallower). Brownell (2004) has also observed oyster beds clogging up channels and increasing the build up of sediments.

Clark notes in Brownell (2004) that the demand for drain maintenance has increased in recent years. Maintenance methods should be encouraged which minimises adverse effects, such as avoiding removing bank side mangroves during drain clearing operations. Dredged sediment also needs to be removed from the coastal marine area so it does not add to the sedimentation pressure. Barge dredging could be utilised to achieve minimal damage of the coastal marine area while still allowing drain maintenance. At the same time increased work is needed to encourage (and perhaps require) all Hauraki Plains catchment land owners to fence and plant their waterways.

Landowners with poorly managed waterways contribute sediment to the coastal system as well as damaging estuarine vegetation through the increased need for drain maintenance. Poor management practises are detrimental to the wider community.

There is an excellent opportunity to utilise the drainage network as a 'managed wetland system'. It is recommended that drains are linked into large freshwater/brackish wetlands before discharge to the coastal marine area. These wetlands can be designed to provide multiple benefits including improved water quality, wildlife habitat and possible flood dampening. There may be potential for good quality grazing land owned by Environment Waikato to be swapped for more low-lying land that could be reverted to wetland.

4.1.4 Maimais & boat moorings

The inner Firth of Thames supports large populations of water birds and there are a lot of maimais along the banks of the main rivers. While no significant damage to the coastal marine area associated with maimais or boat moorings was noted, there is a potential risk at these sites of native vegetation being cleared and weeds being spread.

4.1.5 Potential community restoration sites

There are many sites along the inland edge of the estuarine vegetation zone that would be suitable for native vegetation restoration.

While much of the mature mangrove communities with associated saltmarsh ribbonwood and sea meadow communities are generally in a healthy state, weed control is often necessary in the adjacent inland vegetation zone where weeds can become dominant. Weeds that are of particular concern include phoenix palm, wattle, pampas and smilax.

The Department of Conservation will be undertaking spartina control in the near future and it would be sensible and proactive to include control of the few saltwater paspalum sites at the same time.

Possible restoration sites include:

- Most back swamp areas that have been invaded by tall fescue and other weeds. Plants that could be trialled in the back-swamp areas are flax, *Coprosma propinqua*, *Olearia solandri*, as well as manuka, kahikatea and cabbage trees further inland away from the saline influence. Ngaio was noted growing well along the true left bank of the Piako River and near Thames. This may be a good species to plant in raised areas behind saltmarsh ribbonwood. The introduced tall fescue is widespread and often dominates the back-swamp area behind mangroves. Originally much of the land that is now invaded by tall fescue was likely to have supported marsh clubrush. It seems that the shorter marsh clubrush is usually out-competed by tall fescue in drier areas.

- The spit that runs out from the Thames airfield has wattle (*Paraserianthes lophantha*), blackberry and tree privet establishing. This would make a good confined restoration site.

- The restoration of coastal vegetation along Thames' foreshore walkways would also be beneficial for the appreciation of coastal vegetation.

- The establishment of 'managed wetland systems' (as described above) associated with the Hauraki Plains drainage network.

A distinct lack of care and value of the foreshore is seen around Tararu where garden waste was commonly found dumped in the coastal marine area. This occurred along areas of foreshore backed by both private properties and public reserves (it is possible it came from council contractors?). An improvement of the visual look of the foreshore

would help to foster local community pride in their coastline. The coastline often has a hard unnatural edge which is not softened by mangroves north of the Thames town. Plantings of low native coastal species would greatly enhance the natural character of this exposed coastline. A number of 'flower gardens' were noted along reserve edges. These should be removed if they contain invasive exotic plants such as the African iceplant and coastal daisies dimorphotheca, cape weed, arctotis and gazanias.

4.1.6 Recommended action points

1. Align timing of future vegetation surveys with recently flown aerials.

2. a) Undertake an audit of which sections of stopbank are appropriately fenced (i.e. just up from the toe of the stopbank) and which are more suitably retired from grazing.
   b) Require lease holders to upgrade fences to the above standard, e.g. by the end of 2008.
   c) Withdraw leases from lease holders who have not met the deadline.

3. Review the 'Standard Operating Procedures' for drain maintenance within the coastal marine area with an aim to cease disturbances within the coastal marine area of greater than 80 m^2 [1], e.g. by 2009.
   Standard consent conditions could include:
   - a maximum area of disturbance on one side of a drain only (e.g. no more than 8 m from the drain edge where the activity is being undertaken). This will help minimise adverse effects within the coastal marine area.
   - a maximum access track length through the coastal marine area (e.g. 10 m) to encourage the close placement of bridges or use of barge dredging rather than causing extensive damage in the coastal marine area by accessing a drain over land from distant points.
   - annual weed inspections and weed control of disturbed sites in the coastal marine area until there is a complete native canopy cover.

4. Initiate a business case to investigate the potential for using barge-based channel for major channel clearance within the coastal marine area.

5. Review the placement of stopbanks in relation to floodway capacity, current landward restriction of estuarine vegetation, and likely sea level rise.

6. Identify suitable sites to create freshwater/brackish wetlands, with a focus on filtering land drainage before discharge to the coastal marine area and biodiversity enhancement.

7. Control saltwater paspalum immediately before the pioneer populations take hold. Saltwater paspalum control could be undertaken in conjunction with spartina control with a small variation to the spartina resource consent.

8. Support community initiatives to restore natural vegetation sequences inland of the estuarine vegetation zone, including fencing, planting and weed control.

[1] The figure 80 m^2 is suggested so that small disturbances i.e. a 10 m long by 8 m wide disturbance area , are permitted but longer stretches of disturbance in the coastal marine area are restricted. This will require the identification of alternative ways to access and dredge large drains. An exception may be for the long stretches of drain parallel and immediately seaward of the stopbank where barge access may not be achievable.

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Figures

Figure 2: Looking over thick mud and scattered mangroves along the outer edge of the mangrove-lined Thames foreshore (Goldfields playing fields landward).

Figure 3: Dead mangroves and 'hard fill' edge backing mangrove band along Thames township foreshore – new subdivision at mouth of Kauaeranga River.

Figure 4: **View from Thames wharf looking up the Kauaeranga River. Boat moorings dissected the mangal on the left.**

Figure 5: **Thick mud and large patches of spartina in background (mouth of Kauaeranga River).**

Figure 6: **An old track cut through the mangroves and patches of spartina in the mangal beside the Thames Toyota factory on the true right bank of the lower Kauaeranga River.**

Figure 7: **Shag nests in the mangal beside the Thames Toyota factory on the true right bank of the lower Kauaeranga River.**

Figure 8:Saltmarsh ribbonwood, mangroves and karo competing with introduced weeds (phoenix palms, tall fescue, honeysuckle, wattle and smilax between the SH 25 bridge and the Toyota factory.

Figure 9: A phoenix palm seedling and buffalo grass growing amongst glasswort, mangroves and marsh clubrush (between SH 25 bridge and the Thames Toyota factory).

Figure 10: Pugged spartina on the lower true left bank of the Kauaeranga River.

Figure 11: A grazed area of the lower Kauaeranga floodplain upstream of the SH 25 bridge. The swamp clubrush has been preferentially grazed out leaving patches of sea rush and heavily grazed spartina.

Figure 12: The threatened Maori musk (*Mimulus repens*) amongst bachelor's button in a sea meadow patch on the true left bank floodplain of the lower Kauaeranga River.

Figure 13: Saltwater paspalum (grey green in foreground and middle ground) lined a newly dug drain near the motor cross field, Kauaeranga River.

Figure 14: Saltmarsh ribbonwood lined the landward edge of this old mangal on the true left bank of the Kauaeranga River mouth. Tall fescue extended landward, while glasswort covered the ground under the mangroves.

Figure 15: The landward edge of the mangal near the Thames gun club stopbank with tall fescue and swamp clubrush (golden clumps) mixing with the outer sparse mangroves.

Figure 16: Glasswort and sea primrose patches under an open ~5 m high mangrove canopy. Lower true left bank of the Kauaeranga River.

Figure 17: Large ngaio which could be self grown abutted the mangal edge near Thames airfield along with planted flax, broadleaf, lemonwood and pohutukawa.

Figure 18: A small patch of saltwater paspalum found under open mangal canopy (opposite treatment ponds).

Figure 19: The sudden transition from mangrove, sea meadow and swamp clubrush vegetation to pastoral grasses (mainly kikuyu) at the stopbank and flood gate (coastline between the airfield and treatment ponds).

Figure 20: Heavy stock grazing of the stopbank and stock pugging and grazing of the open flats, sea meadow and mangrove edge (south of the treatment ponds). A thick bank of young mangroves is visible in front of the mature mangrove boundary.

Figure 21: A patch of saltwater paspalum upstream of the Waipapa River mouth. Mangroves and sea primrose were present around the edges.

Figure 22: Pugged and un-pugged Bachelor's button along a drain looking south toward Kopu boat ramp. A small plant of Maori musk was also found here.

Figure 23: Severe pugging of the Waihou River bank. Saltwater paspalum and sea meadow were present on the un-pugged banks.

Figure 24: South of the Kopu bridge this mangal edge with a subcanopy of sea meadow was unfenced and hence pugged and grazed. True right bank Waihou River.

Figure 25: Mangroves and bachelor's button dissected the marsh clubrush swamp behind the main mangroves due to the presence of this drain.

Figure 26: A cleared drain forms a landward boundary to the mangroves. Swamp clubrush was re-establishing on the dredgings. Kopu is in the background.

Figure 27: Marsh clubrush (dried leaves in foreground), large saltmarsh ribbonwood patches (dark patches in mid ground) and the odd flax characterised the back of the mangal near the Kirikiri Stream.

Figure 28: Dense 3-4 m mangal with no sea meadow groundcover along the true right bank of the Waihou River near the Kirikiri Stream.

Figure 29: Thick banks of spartina are eroding into the Waihou River downstream of the Matatoki Canal.

Figure 30: Mangroves, spartina, swamp clubrush and raupo intermingled along the Waihou River bank.

Figure 31: Sweet reedgrass dominating swamp clubrush, flax and raupo behind mangroves on the Waihou River bank near the Matatoki Canal.

Figure 32:Annual rice grass on the true right bank of the Waihou River opposite Tarua.

Figure 33: The thin band of mature mangroves lining the Waihou River bank downstream of Tarua. Sea meadow and orache carpeted the ground with farming immediately behind.

Figure 34: Old mangroves and tall fescue on the raised river bank near the Kopu Bridge. Convolvulus was climbing over a saltmarsh ribbonwood in the foreground.

Figure 35: Dense sea meadow beds under the mangal canopy downstream of the Kopu Bridge (true left bank).

Figure 36: Saltmarsh ribbonwood under the mangal canopy – downstream of the Kopu Bridge (true left bank).

Figure 37: An unidentified Carex amongst the remuremu and glasswort sea meadow under the mangal downstream of the Kopu Bridge (true left bank).

Figure 38:Saltwater paspalum (light green in centre) invading a glasswort bed under the mangal canopy downstream of the Kopu Bridge (true left bank).

Figure 39: Saltmarsh ribbonwood and marsh clubrush (golden) behind the true left bank Waihou mangal – downstream of the Kopu Bridge.

This is the first part of a two part report. Continue to part 2