Wriggle

coastalmanagement

Kapiti, Southwest, South Coasts and Wellington Harbour

Risk Assessment and Monitoring Recommendations

Prepared for
Greater Wellington Regional Council

September 2007

Kapiti, Southwest, South Coasts and Wellington Harbour

Risk Assessment and Monitoring Recommendations

Prepared for
Greater Wellington Regional Council

By

Barry Robertson and Leigh Stevens

Cover Photo: Eastbourne Wellington Harbour

Wriggle Ltd, PO Box 1622, Nelson 7040, Ph/Fax 03 548 0780, Mob 021 417 936, 021 417 935, www.wriggle.co.nz

Contents

All photos by Wriggle except where noted otherwise.

EXECUTIVE SUMMARY

SCOPE

Developing an understanding of the distribution and risks to coastal and estuarine habitats is critical to the management of ecological resources. Recently, Greater Wellington Regional Council (GWRC) contracted Wriggle Coastal Management to identify the habitat vulnerability and monitoring priorities for coastal ecological resources in the Greater Wellington Region. The Wairarapa section was completed in 2006 (Robertson and Stevens 2006). The remainder (i.e. Otaki to Baring Head) is presented in this current report and uses existing coastal habitat maps (i.e. Wellington Harbour, South Coast, and the Kapiti Coast - Stevens and Robertson 2004, 2006) to provide the underpinning description of habitat types. For areas where habitat mapping and ground-truthing has not yet been undertaken (i.e. most of the area between Porirua Harbour and Owhiro Bay; and parts of the South Coast and Wellington Harbour), an interim approach using aerial photographs to identify habitat was employed. This enables preliminary assessment and conclusions to be made prior to habitat mapping and groundtruthing being undertaken.

HABITATS

The mapping and risk assessment study identified the Kapiti Coast as an exposed shoreline, dominated by sandy beaches, and situated on a strip of coastal lowland between the upland hard greywacke rock of the Tararua Ranges and the Tasman Sea. It also identified the South and Southwest Coasts as exposed and rugged coastlines backed by hard rock and primarily grassland catchments, and Wellington Harbour, a large sea-filled basin, 10-30 m deep, with a hard rock catchment which includes highly urbanised areas as well as forested and agricultural areas.

The study identified a wide range of coastal shoreline habitats including:

- **Rocky Shores:** Primarily hard greywacke reefs and rockfield shorelines bathed by mainly clear waters and providing habitat for a diverse assemblage of plant and animal species.
- **Beaches:** Primarily broad, flat, sandy beaches and wide surf zones on the Kapiti coast (bathed by cloudy waters); steep gravel/sand beaches, with little surf zone and clear waters on the SW and Sth Coasts; and sheltered beaches with turbid water at times, in the Harbour. Biodiversity is greatest in the less harsh environment of the dissipative and intermediate type beaches to the north and sheltered beaches in the Harbour.
- **Dunes:** Present along much of the Kapiti Coast but were very thin or absent elsewhere. Most were dominated by the introduced and invasive marram grass but in many locations there were significant areas of native duneland species. Biodiversity is expected to be greatest in the native dominated dunes where a more diverse range of habitats is available.
- **Estuaries:** Three estuary types were found along the coast; large tidal lagoon (e.g. Porirua Harbour), small tidal river mouth (e.g. Mangaone Estuary), and larger tidal river estuaries (e.g. Hutt and Otaki Estuaries). The majority were small tidal river mouth estuaries on the Kapiti Coast which experience frequent mouth blockage and a susceptibility to water and sediment quality degradation. Most were highly valued and widely used by humans and contain a wide variety of plant and animal life.
- **Hinterland (inland of beaches and dunes):** Inland of the shoreline the land was predominantly grassland used for extensive grazing of sheep, dairying or cattle, but in some areas there were extensive urban areas and some exotic forest and scrub.

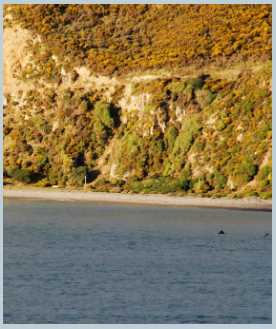
EXECUTIVE SUMMARY (CONTINUED)

ISSUES

The major coastal ecological issues were identified as follows (in no particular order):

1. **CLIMATE CHANGE:** Loss of habitat and biodiversity through sea level rise and temperature change.
2. **ESTUARY WATER AND SEDIMENT QUALITY:** Threats to water and sediment quality of estuaries from landuse intensification and wastewater discharges.
3. **BEACH AND HARBOUR WATER AND SEDIMENT QUALITY:** Threats to water and sediment quality of beaches and harbours from stormwater discharges and catchment runoff contaminating river plumes.
4. **ESTUARY HABITAT LOSS:** Loss of saltmarsh and tidal flat habitat through drainage, reclamation, lagoon opening and channel shifting activities.
5. **INVASION OF MARRAM GRASS:** Invasion of introduced marram grass which overstabilises dunes and results in a reduction of sand released to the foreshore during storm erosion.
6. **LOSS OF NATURAL VEGETATED MARGIN:** Loss of the buffering effect of the coastal vegetated margin (includes duneland, grassland, scrub, forest etc), primarily through erosion and urban development.
7. **WEED INVASION:** Invasion of weed species along the coastal margin which threatens the natural vegetation and reduces biodiversity.
8. **VEHICLES ON BEACHES:** Damage to shellfish, birdlife and aesthetic values from widespread use of vehicles on beaches.
9. **HABITAT LOSS THROUGH SEA WALLS AND STRUCTURES:** Loss of habitat diversity and area through narrowing of coastal shoreline.

RECOMMENDED MONITORING



Long term coastal monitoring is recommended to address issues and includes (refer to Sections 3 to 9 for full details):

Monitor long term condition of representative estuaries with highest biodiversity and risk to ecology (e.g. Waikanae, Porirua and Hutt Estuaries)

- Broad scale habitat mapping and risk assessment every 5 years.
- Fine scale, 1-2 sites (incl. sedimentation rates), 3 year baseline then 5 yearly.
- Monitor catchment landuse every 5 years.

Reduction in dune area and condition through marram grass and weed invasion, sea level rise, erosion, grazing, property development

- Measure change in area of duneland, beaches and change in position of seaward margin of dune (5-10 yearly intervals).

Reduction in biodiversity of high biodiversity beaches through climate change

- 1 long term monitoring site on dissipative beach (most species rich), e.g. North Waikanae. Establish 3 year baseline then 5 yearly.

Reduction in biodiversity of high biodiversity rocky shores through climate change

- 2 monitoring sites sampled 5 yearly (Cape Terawhiti, Camp Bay).

Monitor disease risk of at-risk shorelines and shellfish areas

- Monitor disease risk of shellfish and bathing waters near contaminated river plumes and urban SW discharges (Kapiti, Petone, Porirua Harbour, Titahi Bay, Oriental Bay, Sth Coast beaches and rocky shores).

Monitor the major stressor leading to estuary degradation

- Monitor intensive landuse in all estuary catchments at 5 yearly intervals.

Monitor area of freshwater wetlands in Kapiti estuary catchments

- Map (at a broad scale) area of wetlands in catchments 5 yearly.

Monitor Sediment Source Hotspot

- Map (at a broad scale) sediment source hotspots and areas where exposed soils produce suspended solids in runoff with low settling rates.

Develop monitoring and management plans to improve habitat diversity and condition in small tidal river mouth estuaries (esp. those on Kapiti coast)

- Undertake in a staged manner, one estuary at a time.

1. INTRODUCTION

AIM AND SCOPE

Surfing Lyall Bay

Canoeing Waikane Estuary

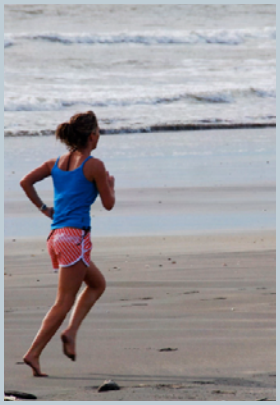
Whitebaiting Mangaone Estuary

Developing an understanding of the distribution and risks to coastal and estuarine habitats is critical to the management of ecological resources. Recently, Greater Wellington Regional Council (GWRC) contracted Wriggle Coastal Management to identify the habitat vulnerability and monitoring priorities for coastal ecological resources in the Greater Wellington Region. The Wairarapa section was completed in 2006 (Robertson and Stevens 2006) and produced the following outputs:

- **Coastal Habitat Map**: An ArcMap GIS data set depicting current broad-scale habitat cover types along the Wairarapa coast using aerial photographs, and ground truthing techniques (Robertson et al. 2002).
- **Vulnerability Assessments**: An assessment of the "vulnerability" of the Wairarapa coastline habitats based on the sensitivity of the receiving environment, human uses, and the upstream catchment area risk factors (stressors) associated with each section of the coast. The approach used is an adaptation of an existing UNESCO methodology (UNESCO 2000) and a risk-based matrix developed for broad scale assessments of beaches, dunes, rocky shores and estuaries (Robertson et al. 2002, Robertson and Stevens 2006a, 2006b) - see Methods for details.
- **Monitoring Priorities:** A recommended coastal monitoring programme for the management of coastline biological resources in the region.

The remainder of the GWRC coastline (i.e. Kapiti Coast, Southwest Coast, South Coast and Wellington Harbour) was assessed using a similar approach to that used for the Wairarapa, and the findings are presented in this report.

STRUCTURE



Running Peka Peka Beach

Fishing Titahi Bay

Section 1 provides an introduction to the scope and structure of the study.

Section 2 introduces the methods used for the habitat mapping, vulnerability assessments and identifying monitoring recommendations.

Section 3 provides a broad introduction to the coast by identifying the major coastal shoreline habitats (their characteristics, issues, values and uses and key stressors).

Sections 4, 5, 6, 7, 8 , 9 and the conclusions (Section 10) provide the summary detail for the coast in a section by section approach. For each section of the coast, it describes their characteristics, issues, values and uses, recommended monitoring, existing condition and susceptibility ratings. These summary details are derived from the following appendicised outputs:

- **Appendix 1:** Vulnerability Matrix details
-
- **Appendix 2**: Detailed summary information on estuaries.
- **Appendix 3:** Vulnerability assessments for coastal habitats.

MAP OF WESTERN AND SOUTH COASTS AND WELLINGTON HARBOUR

2. METHODS

Coastal Habitat Maps: GWRC coastal habitat maps of Wellington Harbour, the South Coast, and the Kapiti Coast (Stevens and Robertson 2004, 2006) have been used to provide the underpinning description of habitat types. For areas where habitat mapping and ground-truthing has not yet been undertaken (i.e. most of the area between Porirua Harbour and Owhiro Bay; and parts of the South Coast and Wellington Harbour), an interim approach using aerial photographs to identify habitat types was employed.

Vulnerability Assessments and Monitoring Recommendations:
The Ecological Vulnerability Assessment is a tool adapted from a UNESCO methodology (UNESCO 2000) that is designed to be used by experts to represent how an estuary ecosystem is likely to react to the effects of potential "stressors" (the causes of estuary issues - often human activities).

The approach uses various assessment techniques to produce an overall "vulnerability" rating of the extent to which potential stressors may affect the uses and values of an area. This is then combined with how susceptible the uses and values are to the identified stressors to identify the priority issues that need addressing.

The approach used is to summarise background information in four key areas (for details see Appendix 1);

1. **Human Uses and Values**
2. **Ecological Values or Richness**
3. **Presence of Stressors (Likely Causes of Issues)**
4. **Existing Condition and Susceptibility to Stressors**

This information is then summarised within a pre-developed Coastal Vulnerability Matrix (see example on following page, including details on how to fill it in) that ascribes a "vulnerability" ratings (e.g. "very high" "high", "medium", or "low") based on an expert appraisal of the combined inputs. The "vulnerability" ratings are then used to design a monitoring programme for the priority monitoring indicators using currently available tools including; the National Estuary Monitoring Protocol (EMP) (Robertson et al. 2002), plus recent extensions developed by Wriggle (Robertson & Stevens 2007a).

National Estuary Monitoring Protocol (EMP) (Robertson et al. 2002)	• Broad scale habitat mapping using GIS. Broad scale habitat mapping records the location and type of vegetation (e.g. saltmarsh, seagrass, macroalgae) and substrate (e.g. mud, sand, gravel, etc); and is used to provide information primarily on the issues of habitat and margin loss, sedimentation (through the mapping of substrate type), and eutrophication (by mapping macroalgae percent cover). • Fine scale (i.e. detailed) monitoring of dominant habitat. Fine scale monitoring focuses primarily on the physical, chemical, and biological characteristics of coastal and estuary habitat.
Recent Extensions (Robertson & Stevens 2006, Robertson & Stevens 2007a,b)	• Establishment of sedimentation rate measures (using plates buried in sediment). • Estimation of historical sedimentation rates (using radio-isotope ageing of cores). • Assessment of the % cover of macroalgae and macrophytes (separate GIS layers). • Broad scale mapping of the 200m terrestrial margin surrounding the shoreline habitats. • Development of regional condition ratings for key indicators. • Provision of georeferenced digital photos (as a GIS layer).

The project scope was limited to the use of expert judgement to quickly and cost effectively review existing knowledge and identify what issues are most likely to affect the Wellington coastal habitats, and from this make recommendations on monitoring and managing identified issues. A key feature of the methodology is that it can be used with varying levels of detail. Because many potential stressors may be either absent or unlikely to have a significant impact, expert judgement is commonly used to quickly and cost effectively review existing knowledge and identify what issues are most likely to affect a particular estuary. This then provides a basis for deciding what level of effort should be put into addressing different issues. For example, existing knowledge or a synoptic survey may be sufficient to identify an issue as being both significant and present in a susceptible estuary. If more detailed studies are likely to reach the same conclusion, it may be most appropriate to focus resources on management rather than further study. Conversely, more detailed study may be needed to determine whether management is possible or likely to be effective before it is initiated.

2. METHODS (CONTINUED)

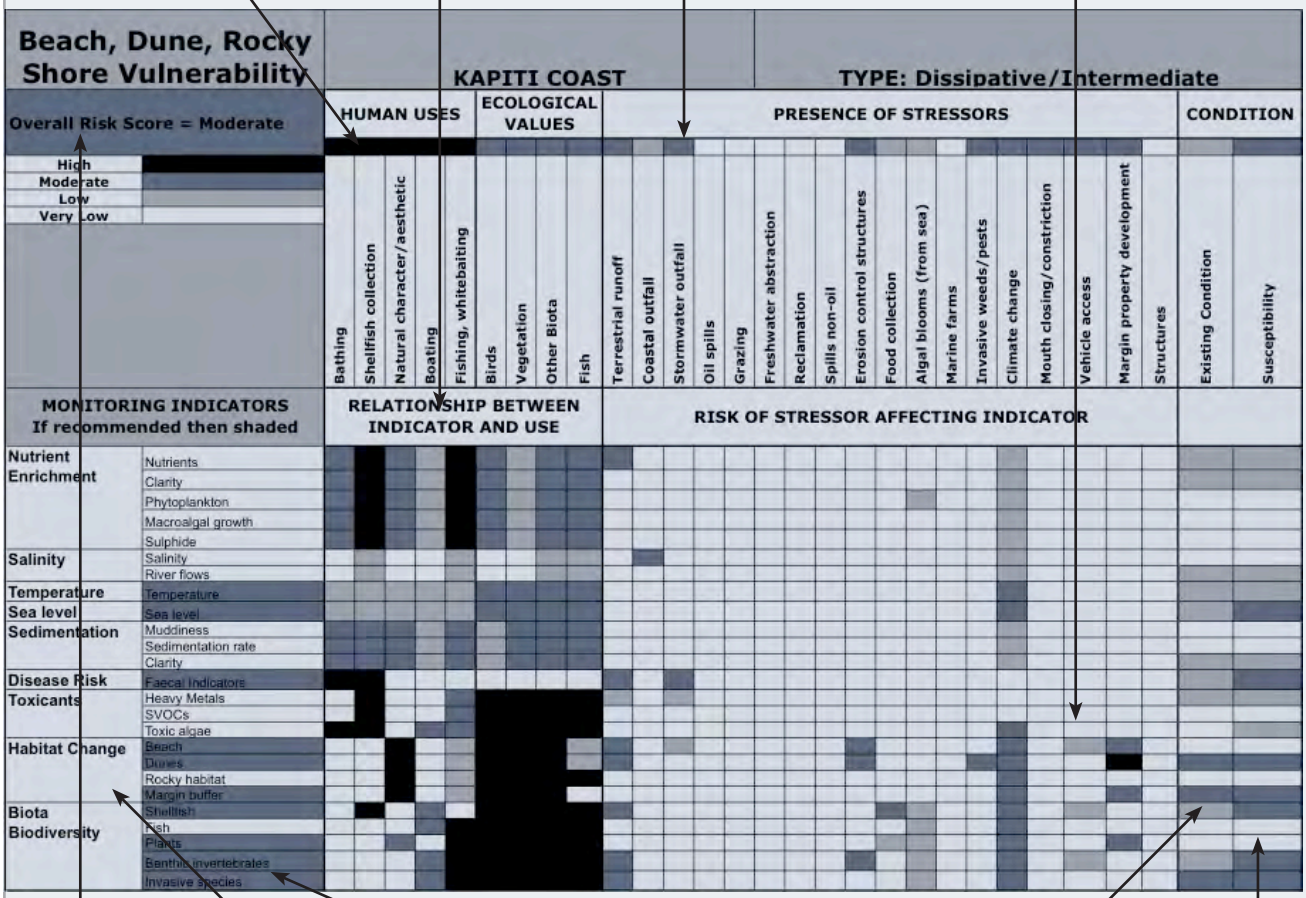
STEPS IN FILLING OUT A VULNERABILITY MATRIX

Step 1
Rate Human Uses and Ecological Values

Step 2
Rate the risk of a particular indicator affecting a human use or ecological value

Step 3
Rate the presence of existing stressors or pressures

Step 4
Rate the likelihood of a stressor affecting a particular indicator (and consequently an issue)



Step 9
Determine the overall rating based on monitoring indicator priorities

Step 8
Identify which are the major issues based on indicator ratings

Step 7
Rate each indicator for monitoring priority

Step 6
Rate the existing condition for each indicator

Step 5
Rate the physical susceptibility for each indicator

3. COASTAL HABITAT TYPES

The major coastal habitat types found on the coast include; beaches, dunes, rocky shores and estuaries. Their general characteristics and key stressors are summarised in this section.

BEACHES

Dissipative-intermediate type beach Kapiti Coast

SUMMARY

Broad range of types.
Flat sandy beaches and turbid waters (Kapiti) to the north and steep gravel beaches with clearer waters to the south.
Sheltered beaches in harbour.

KEY STRESSORS

- Sea Level Rise
- Discharges
- Sea walls
- Vehicles

Beaches are common (especially the Kapiti coast) and include 4 broad types.
(1) Dissipative to Intermediate Type Beaches (e.g. Raumati). Relatively flat, and fronted by a wide surf zone in which waves dissipate much of their energy. They have been formed under conditions of moderate tidal range, high wave energy and fine sand. Their sediments are well sorted (usually fine to medium sand), and they have weak rip currents with undertows. The tidal flat is at the extreme end of dissipative beaches. Compared with other beach types their ecological characteristics include the following:

- Interactions within and between species are generally more intense.
- High level of primary production, diversity and biomass of macrofauna.
- Exporters of organic matter.
- More highly regulated by biological interactions.

(2) Intermediate Type Beaches (e.g. Lyall Bay). There are few intermediate state beaches in the area (Lyall Bay being the major exception). These are characterized by plunging & spilling breakers, steeper than dissipative beaches but less steep than reflective beaches, very mobile sediments, and rip-currents are common. Ecologically, they tend towards intermediate species richness.
(3) Reflective Type Beaches (e.g. SW, Sth Coast and Fitzroy Bay).
Steep, reflective type beaches with sand, gravel and cobble sediments are the main type of beach south of the Kapiti Coast all the way through to Wellington Harbour and at Fitzroy Beach. These beaches tend to be accumulating coarse sediments rather than eroding. They have little or no surf zone and wave energy is reflected back to the sea from waves breaking directly on the steep beach face. Their ecological characteristics include the following: low primary production, impoverished macrofauna, low species richness and populations mainly physically controlled, and reliance on organic material imported from sea.
(**4) Low Energy Beaches (Wellington Harbour Beaches e.g. Petone Beach).**
Moderately steep, often productive and generally narrow beaches, where sand movement is restricted because of low wave action.
The type of beach is important in determining beach ecology (Defeo and McLachlan 2005). For example, the number of species decreases as the beach slope and grain size increases. In addition, there is generally a strong natural variation in abundance within a beach, with greatest numbers in the centre and fewer at the boundaries, even though environmental gradients (e.g. wave exposure and salinity) can cause asymmetries. Such zonation is generally highly dynamic and not sharply defined. This is attributed to short (hourly) or medium term (seasonal) reactions to environmental conditions, passive transport and sorting by the swash (e.g. bivalve recruits getting washed up to the least preferable high tide sands during storms), active micro-habitat selection (e.g. bivalve adults digging in to preferred habitat) and interactions within and between species. Such high natural variability means that the design and interpretation of any ecological monitoring must consider carefully the establishment of reference sites and baseline conditions. Intermediate beaches are spatially and temporally the most dynamic (Wright and Short 1984). They can undergo rapid changes as wave height fluctuates, causing reversal in onshore/offshore and alongshore sediment transport.

The key stressors were identified by us as: sea level rise, sea walls, vehicles on beaches, and discharges. Habitat loss or degradation and disease risk were the main ecological threats.

3. COASTAL HABITAT TYPES (CONTINUED)

DUNES

Marram dunes near Waitohu

Spinifex dunes Kapiti Coast

SUMMARY

Broad range of types.
Extensively modified.
Major stressors: marram invasion, erosion, climate change, grazing, property development.
Marram dominates.
Native species dominant north of Peka Peka.
Monitoring recommended.

KEY STRESSORS

- Sea Level Rise
- Introduced Weeds
- Grazing
- Vehicles
- Contaminants
- Property Development

Areas of duneland are relatively common above high water along many sections of the coast, particularly the Kapiti Coast. They occupy 3 situations (Partridge 1992): narrow strips in sheltered bays, thin strips bordering long sections of the coast, and wider dune systems.

In the Kapiti section, the broadest and most extensive duneland areas are located north of Waikanae. In the southern section, the dune areas are narrow and located at Titahi, Lyall, and Fitzroy Bays and Petone Beach. At most sites, the backdunes have been converted to pasture or developed for urban use, and the foredunes are dominated by the introduced sand-binding grass, marram grass (*Ammophila arenaria*). However, most areas have also had significant replanting with native sand-binders spinifex (*Spinifex serceus*) and, to a lesser extent, pingao (*Desmoschoenus spiralis*).

In a 1990 survey of the whole coast (Partridge 1992), no dune systems of outstanding value were identified. The systems with the highest value were the Spinifex/lupin dominated community between Otaki River Mouth and Peka Peka, the marram-dominated system at Whareroa Beach (Queen Elizabeth Park) and the mixed native spinach, grass, creeping *Muehlenbeckia* and a notable forest fragment at Paekakariki Beach.

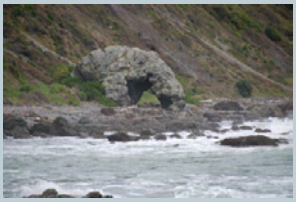
From the perspective of coastal management, dunes protect low lying coastal areas from flooding and also act as a buffer against erosion: they form a reservoir of sand, replenished when beach levels are high and released to nourish the foreshore during storm erosion. They are also areas of considerable scientific, conservation, landscape and recreational value. Because of these attributes they are important to a wide range of human activities, and their monitoring and management is seen as an important objective in planning and usage of the coastal zone.

In NZ history, early heavy grazing of dunes resulted in the disappearance of native dune cover and subsequent sand movement inland. To stop the sand drift, dune reclamation through marram grass and lupin (to provide nitrogen) plantings were undertaken. Marram was more prolific than the native sand-binders, so tended to outcompete them. Since their introduction, marram grass and lupin have become the major sand binders and dune builders in New Zealand and have been the dominant species used for erosion control and dune stabilisation. Although they have been relatively successful at limiting coastal erosion and stabilising sand drift they do have drawbacks of which the main one is that because marram dunes are generally taller, have a steeper front and occupy more area than either spinifex or pingao, they have tended to result in overstabilisation and a consequent reduced ability of active dunes to release sand to the foreshore during storm erosion. They also tend to contribute to the loss of biodiversity and natural character (Hilton 2006). As a consequence of their invasive nature and threat to active dune function, as well as threats to ecology and biodiversity, there is now a growing move to minimize any further marram grass invasion of active dunes and to replant with native species.

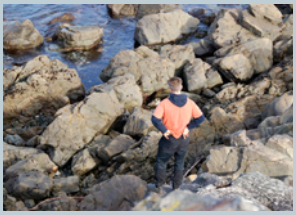
The key stressors were identified as: introduced marram grass (and weeds) outcompeting natives, sea level rise, vehicle damage, grazing, and urban and agricultural development. Habitat loss or degradation was the main ecological threat.

3. COASTAL HABITAT TYPES (CONTINUED)

ROCKY SHORES



Rocky shore, near Pukerua Bay



Rocky shore near Palmer Head

SUMMARY

Typically rugged, rocky and exposed SW and W coastline.
Sheltered in the Harbour.
Broad range of rocky shore types.

KEY STRESSORS

- Sea Level Rise
- Discharges
- Sea walls
- Seafood Collection
- Vehicles

The rocky shores of the Wellington coast can be divided into two main categories based on degree of exposure.

(1) Sheltered Rocky Shores. These occur within the relatively sheltered confines of Wellington Harbour. Water clarity tends to be more variable, depending on wind and catchment rainfall (particularly the Hutt River), as does water currents. Rock types are generally hard, with low susceptibility to weathering and have a characteristic and diverse ecology.

(2) Exposed Rocky Shores. The rocky shores of the SW and South Wellington Coasts can be classified as exposed, high-energy shores. They consist of hard greywacke type rocks with high biodiversity. Water is relatively clear and currents are generally strong. In some areas, wave impact can be broken by outer reefs.

In general, the human pressure on shellfish, crayfish and fish through harvesting from inshore rocky areas was high throughout the region. But considering the fact that they are supposed to be harvested under strict fishery management guidelines, the ecological effect of this harvesting was considered relatively low (although additional information is needed to confirm this).

The key stressors were identified as: sea level and sea temperature increases, and seafood collection. Habitat changes and effects on rocky shore biodiversity was the primary ecological threat.

Wellington Harbour rocky shore near Shelly Bay

3. COASTAL HABITAT TYPES (CONTINUED)

ESTUARIES

Estuaries are coastal waterbodies that are formed when freshwater from rivers flows into and mixes with saltwater from the ocean. Because New Zealand is a narrow, mountainous country with good rainfall it has a both a large number of estuaries relative to its size and a huge variety of estuary types (McLay 1976, Kirk and Lauder 2000, Hume et al. in press). Three types of estuary were found along the Wellington Harbour, Kapiti, western and southern Wellington coasts; tidal lagoons (e.g. Porirua Harbour), tidal river mouth (e.g. Mangaone Estuary), and tidal river estuaries (e.g. Hutt Estuary). Most are highly valued and widely used by humans. They often contain a wide variety of plant and animal life and, when in good condition, provide more life per square metre than the richest New Zealand farmland. Their high value lies in two main characteristics;

- the wide diversity of habitats they offer, and
- their natural ability to collect and assimilate sediment and nutrients from the surrounding catchment and inflowing tidal waters.

If either of these features are degraded, then the estuary condition deteriorates and the value to humans and aquatic life is lessened. The main problems affecting New Zealand estuaries are; excessive sedimentation, excessive nutrients, disease risk, toxic contamination, and habitat loss.

Key Estuary Issues	
Sedimentation	Because estuaries are a sink for sediments, their natural cycle is to slowly infill with fine muds and clays. Prior to European settlement they were dominated by sandy sediments and had low sedimentation rates (<1 mm/year). In the last 150 years, with catchment clearance, wetland drainage, and land development for agriculture and settlements, New Zealand's estuaries have begun to infill rapidly. Today, average sedimentation rates in our estuaries are typically 10 times or more higher than before humans arrived.
Nutrients	Increased nutrient richness of estuarine ecosystems stimulates the production and abundance of fast-growing algae, such as phytoplankton, and short-lived macroalgae (e.g. sea lettuce). Fortunately, because most New Zealand's estuaries are well flushed, phytoplankton blooms are generally not a major problem. Of greater concern is the mass blooms of green and red macroalgae, mainly of the genera *Enteromorpha, Cladophora, Ulva*, and *Gracilaria* which are now widespread on intertidal flats and shallow subtidal areas of nutrient-enriched New Zealand estuaries. They present a significant nuisance problem, especially when loose mats accumulate on shorelines and decompose. Blooms also have major ecological impacts on water and sediment quality and the animals that live there.
Disease Risk	Runoff from farmland and human wastewater often carries a variety of disease-causing organisms or pathogens (including viruses, bacteria and protozoans) that, once discharged into the estuarine environment, can survive for some time. Every time humans come into contact with seawater that has been contaminated with human and animal faeces, we expose ourselves to these organisms and risk getting sick. Aside from serious health risks to recreational users and human consumers, pathogen contamination causes economic loss due to closed shellfishing beds, affecting an important industry in some estuaries. Diseases linked to pathogens include gastroenteritis, salmonellosis, and hepatitis A.
Toxic Contamination	In the last 60 years, New Zealand has seen a huge range of synthetic chemicals introduced to estuaries through urban and agricultural stormwater runoff, industrial discharges and air pollution. Many of them are toxic in minute concentrations. Of particular concern are polycyclic aromatic hydrocarbons (PAHs), toxic heavy metals, polychlorinated biphenyls (PCBs), and pesticides. These chemicals collect in sediments and bio-accumulate in fish and shellfish, causing health risks to people and marine life.
Habitat Loss	Estuaries have many different types of habitats including shellfish beds, sea grass meadows, salt marshes (rushlands, herbfields, reedlands etc.), forested wetlands, beaches, river deltas, and rocky shores. The continued health and biodiversity of estuarine systems depends on the maintenance of high-quality habitat. Loss of habitat negatively effects fisheries, animal populations, filtering of water pollutants, and the ability of shorelines to resist storm-related erosion. Within New Zealand, habitat degradation or loss is commonplace with the major causes cited as sea level rise, population pressures on margins, dredging, drainage, reclamation, pest and weed invasion, reduced flows (damming and irrigation), over-fishing, polluted runoff and wastewater discharges.

3. COASTAL HABITAT TYPES (CONTINUED)

1. TIDAL RIVER MOUTH ESTUARIES (HAPUA)

Waitohu estuary

The majority of estuaries of the Kapiti, western and southern Wellington coasts and Wellington Harbour are small and occur where streams approach the coast as a single channel, but their entry is restricted (or sometimes blocked completely) by a sand or gravel barrier located just short of the ocean (e.g. Waitohu, Mangaone and Waikanae Estuaries on Kapiti coast and Kaiwharawhara Estuary in Wellington Harbour). Such estuaries are of the "tidal river mouth" type. In such estuaries, a small brackish lagoon may form on the river side of the barrier, whose size, salinity and water quality varies depending on the degree of restriction or choking the river mouth may be experiencing at the time, as well as the river flow and the slope of the coastal plain. On the Kapiti coast, the opening of the estuary mouths is often managed artificially. The majority of these estuaries are short and narrow, with saline water intrusion extending only a few hundred metres upstream or not at all. In many cases the estuary channels have been modified by past drainage and channelistion actions.

The habitats available for aquatic life in such systems are very limited: tidal flats and salt marsh are generally small or absent and the water and sediments experience regular cycles of degradation and rejuvenation. When the mouth is restricted and streamflows are low, the estuarine lagoon may experience symptoms of eutrophication and sedimentation (i.e. muddy, anoxic, black sulphide-rich sediments, algal blooms, low dissolved oxygen and low clarity). When the mouth is open and flows are high, the small narrow channel and lagoon is flushed clean. Although they are likely to be a natural occurrence, such low water quality conditions are exacerbated when sediment, nutrient and pathogen loadings to the estuaries are elevated (e.g. in catchments with intensive agriculture, urban development, or catchments with high erosion). Because of intensification of agriculture and urban development on the Kapiti coast, estuary loadings in this section of the coast are generally elevated.

KEY STRESSORS

- Catchment Runoff
- Drainage, Reclamation
- Sea Level Rise
- Discharges
- Introduced species
- Seafood Collection

RECOMMENDED MONITORING	
Objectives	• Monitor major stressors leading to low estuary water quality. • Monitor condition of representative estuary with highest biodiversity.
Design	• Monitor intensive landuse development in estuary catchments. • Monitor input water quality in representative catchments. • Monitor condition (habitat mapping, fine scale indicators) of one high biodiversity estuary e.g. Waikanae Estuary. 3 yr baseline then 5 yrly.

Ngarara Estuary near Waikanae.

3. COASTAL HABITAT TYPES (CONTINUED)

2. TIDAL LAGOON ESTUARIES

Porirua Harbour

KEY STRESSORS

- Catchment Runoff
- Drainage, Reclamation
- Sea Level Rise
- Discharges
- Introduced species
- Seawalls
- Seafood Collection

Porirua Harbour fits into the "tidal lagoon estuary" category. These estuaries are shallow, with large basins and simple shorelines with extensive tidal flats. They generally have a narrow entrance to the sea that is often constricted by a sand bar. Most of the estuary water volume is drained each tidal cycle and hence they have low water residence times (often <3 days) and good flushing. The volume of river water inflow is generally small in comparison to marine inputs. Wind has a large influence and effects currents, mixing and sediment resuspension. The combination of wave resuspension and good flushing means that the majority of sediments tend to be sandy and homogeneous. However, muddy sediments can be present near freshwater inputs and in sheltered arms. These estuaries are also well-mixed and salinity is close to that of the sea. The coastal plumes from such estuaries are generally much cleaner than from tidal river lagoons. Biodiversity is generally high.

RECOMMENDED MONITORING	
Objectives	Monitor long term condition of representative estuary with highest biodiversity and risk to ecology (e.g. Porirua Estuary).
Design	• Monitor intensive landuse development in estuary catchments. • Monitor input water quality in representatitve catchments. • Monitor condition (habitat mapping 5 yrly, fine scale indicators 3 yr baseline then 5 yrly) of one high biodiversity estuary e.g. Porirua Estuary.

3. TIDAL RIVER ESTUARIES

Hutt Estuary

KEY STRESSORS

- Catchment Runoff
- Drainage, Reclamation,
- Sea Level Rise
- Discharges
- Introduced species
- Seawalls
- Seafood Collection

Two of the estuaries fits into the "tidal river estuary" category (i.e. Hutt and Otaki Estuaries). They are characterised by an elongated shallow basin, with river-dominated (rather than tide-dominated) circulation. Flushing is good because the mouth is always open and river flow relatively large. Tidal flats are present but not broad and expansive. Salinity is generally much less than the sea and waters can be fresh during floods (Kirk and Lauder 2000). Such estuaries can be quite productive and have good fisheries but the absence of large areas of salt marsh limits their ecological value, particularly for birdlife. The high river flow, large catchments and well flushed nature of the estuaries, means that the river plumes from such estuaries can have a large impact on adjacent coastal waters (i.e. salinity, clarity, nutrients and disease risk).

RECOMMENDED MONITORING	
Objectives	Monitor long term condition of representative estuary with highest biodiversity and risk to ecology (e.g. Hutt Estuary).
Design	• Monitor intensive landuse development in estuary catchments. • Monitor input water quality in representatitve catchments. • Monitor condition (habitat mapping 5 yrly, fine scale indicators 3 yr baseline then 5 yrly) of one high biodiversity estuary e.g. Hutt Estuary.

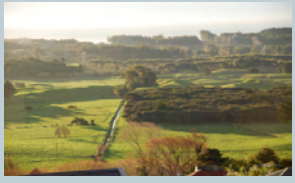
4. KAPITI COAST

BEACHES AND DUNES

Kapiti Coastline (GWRC)

Shoreline north of Peka Peka.

Ngarara Estuary



Drained sandhills and peat soils near Waikanae.

In general terms the Kapiti coastline is a 40km long, thin strip of beach, duneland and small estuaries, situated on a narrow band of coastal lowland between the Tasman Sea and the upland hard rock of the Tararua Ranges. The coastal lowland generally comprises a narrow band of alluvial gravels near the base of the uplands which merge into a mix of sandhills and peaty soils and swamps in the hollows, before reaching the beach and foredunes. The main beach areas include Paekakariki, Raumati, Paraparaumu, Waikanae, Peka Peka, Te Horo and Otaki. The beach and subtidal area is sandy, gradually sloping (dissipative type beach), except for a small section of a steeper gravel beach (intermediate type) near the Otaki River Mouth.

Above high water, the terrestrial margin consists primarily of dune-land (much of it narrow) and dominated by introduced marram grass (*Ammophila arenaria*), the native knobby club-rush (*Isolepis nodosa*). Other species include lupins (*Lupinus arboreus*), spinifex (*Spinifex serriceus*), flax (*Phormium tenax*), coastal coprosma (*Coprosma propinqua*) and introduced weeds (broom, ice plants, blackberry, boxthorn, boneseed). The most extensive area of duneland exists in the QEII Park reserve (Stevens and Robertson 2006) and near Otaki. In moderately developed sections of the coast, dunes are generally still present but are restricted in extent by roading or housing (e.g. South Otaki and Te Horo Beach). In highly developed areas (e.g. Raumati South and Paraparaumu), dunes have been lost with the top of the beach dominated by seawalls and residential development situated amongst previous dune habitat. Vegetation immediately inland of the dune area is primarily grassland used for horticulture and agriculture, or gardens situated within the extensive areas of moderate and low density urban landuse. The dune and beach areas are generally fenced from stock access but vehicles are often present on northern beaches.

Since the local sea level stabilised at its present level, about 6000 years ago, the Kapiti coastline has been generally advancing seawards at an average rate of 0.48 m/yr as a result of deposition of sediments (Hawke and McConchie 2006). However, despite the long term history of accretion, the coastal foredune is relatively unstable and goes through long term cycles of dune-building and erosion. Currently, the foredune is in an erosion phase in many areas. For example, the QE park coastline has been eroding 0.8m/yr at least since construction of the Raumati seawall following the 1976 storms (Boffa Miskell Ltd 2001).

Various streams and moderate sized rivers cross the lowland and form small, shallow estuaries adjacent to the beach. At times, many of the Kapiti estuaries become constricted or close off to the sea. The rivers and streams include; Whareroa Stream, Wharemakau Stream, Tikotu Stream, Waikanae River, Ngaroa Stream, Peka Peka Stream, Mangaone Stream, Otaki River and Waitohu Stream.

4. KAPITI COAST (CONTINUED)

BEACHES AND DUNES (CONTINUED)

Erosion of dune face. and replanting (Waitohu)

Spinifex foredune, marram near Peka Peka

Birds eating shellfish at Ngarara mouth.

Pipi, dog cockle, *Mactra* and wedge shells common.

The streams have small catchments situated in the lowland area, and drain primarily high producing pasture-land and, in some cases, urban areas (e.g. Wharemakau Stream situated in Raumati and Ngarara Stream in Waikanae). The two rivers (Otaki and Waikanae) have large, primarily native forest catchments (including lowland and upland areas) and tend to have good water quality whereas those draining intensive agricultural/urban catchments (e.g. Peka Peka, Mangaone, Ngarara, Tikotu and Wharemakau Streams) have low water quality. The respective estuaries tend to reflect the same conditions unless they are closed to the sea. During such times they are particularly susceptible to water and sediment quality degradation, in particular, enrichment with nutrients, sediment and pathogens. To minimise such occurrences and as a flood and erosion control measure, the mouths are manually cleared.

Human Uses and Values

Human use of the beach areas and dunes is high in a national context. They are used for walking, bathing, surfing, diving, scientific interest, surf-casting, whitebaiting, inshore fishing, shellfish collection, picnicing, sitting, fossicking and bird-watching. Public access is generally good, but in many areas north of Paraparaumu vehicles drive along the beach (often over shellfish habitat). At Paraparaumu, boats are launched off the beach.

Ecological Values

Ecologically, beach and dune habitat diversity is relatively high in many areas (extensive dune systems, gravel and sand beach types with a good drift component) but in others (especially in built up areas) it is low-moderate. The beach and dunes provide valuable habitat for a diverse range of plants and animals. Because of the dissipative nature of much of the beach and the high loadings of organic matter from the catchment, the ecological productivity and diversity of beach life is relatively high. This is reflected in large numbers of shellfish, fish (including whitebait) and birdlife present along the beaches and estuary mouths. Where the dune system is in good condition (i.e. a *Spinifex/Pingao* association foredune which is devoid of outcompeting weeds and human disturbance), it provides sustainable habitat for a variety of fauna (e.g. beetles, sand hoppers, spiders, birds etc).

Beach and Dune Existing Condition:

Beach sediment quality is good (Stevens and Robertson 2006). However, the condition of the beaches and inshore waters is only moderate, given that the water is generally turbid, that shellfish disease risk criteria are often exceeded and that shellfish and bird habitat is degraded by vehicles. Dune condition has been heavily influenced by property development in foredune areas and the presence of marram grass as the dominant sand-binding species (with the consequent overstabilisation and reduced ability to release sand to the foreshore). More recently, large areas have been successfully improved by revegetating foredunes and blow-outs with spinifex and occasionally pingao using local council and community involvement. However, there are still large areas that still require foredune development.

4. KAPITI COAST (CONTINUED)

BEACHES AND DUNES (CONTINUED)

OVERALL VULNERABILITY RATING

Moderate

Presence of Stressors:
The main stressors on beaches, inshore waters and dunes are:

- Nonpoint source inputs of faecal bacteria from grazing animals in the coastal lowland catchments causing river plume effects.
- Runoff of fine clays with low settling characteristics (erosion product of greywacke) from the catchments.
- Vehicles driving on the beach.
- Runoff of fine bark particles from the catchment forested catchments and subsequent accumulation on the beach and surf zone.
- Point source discharges degrading water quality. Urban stormwater is discharged onto the beach through various outfalls (Waikanae, Paraparaumu, Raumati, Paekakariki) and a large tertiary treated wastewater discharge enters the Waikanae Estuary via the Mazengarb Drain.
- 7 km of seawalls south of Paraparaumu degrading beach habitat.

Given the high human use and ecological values of the Kapiti beaches and dunes and the threats to their condition, it is recommended that monitoring and management be undertaken as follows;

Issue	Monitoring	Management
Degradation of beach habitat and water quality through run-off from intensive catchment landuse, and loss of wetland filters (in particular, shellfish quality and bathing near stream and river plumes).	• Map intensive landuse (urban, high production pasture) in all catchments at 5 yearly intervals. • Map area of wetlands in catchments at regular intervals (5 yearly). • Map (at a broad scale) areas where exposed soils produce suspended solids in runoff with low settling rates. • Monitor disease risk (shellfish and water)	• Limit intensive landuse development and/or manage to ensure impacts don't degrade beach habitat and WQ. • Maintain and improve habitat diversity and filtering capacity of existing wetlands in all catchments. • Limit the extent of exposed soil in catchments where SS in runoff has low settling rates.
Reduction in biodiversity of high biodiversity beaches through multiple stressors.	Monitor physical, chemical and biological parameters on one dissipative beach (most species rich), e.g. between Waikanae Estuary and Ngarara Estuary. Establish 3 yr baseline then at 5 yearly intervals.	• Develop trigger criteria for beach condition indicators and evaluation and response plan should trigger criteria be breached (impact of vehicles on beaches needs evaluation).
Degradation of duneland through sea level rise, erosion, grazing, weed invasions, property development.	Map dominant species cover and condition of duneland, and change in position of seaward margin of dune. Repeat broadscale mapping at 5-10 yearly intervals. Identify hot spots for management.	• Undertake remedial management of identified hotspots using soft Best Manapement Practices (e.g. revegetation with native sand-binders, weed eradication) wherever possible.

KAPITI COAST BEACHES AND DUNES	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low	Moderate	Moderate	Low
Susceptibility Rating	Moderate	Low	Moderate	Moderate	Moderate	Moderate	Moderate

4. KAPITI COAST (CONTINUED)

WAITOHU ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	54 km^2 (forest, pasture)
Dairy cows	1560 cows
Nitrogen loading	Mod-High: 14-20 kg/ha/yr
Catchment geology	Greywacke, alluvium, peat
Saltmarsh (ha)	1-2ha (dunes on margins)
Salinity	Varies depending on mouth closure
Mean depth (m)	0.5-1m
Tidal flats	None (lagoon floods sand flats on beach berm)
Uses/Values	Fishing, swimming, birds, whitebaiting.

Waitohu Estuary and mouth

OVERALL VULNERABILITY RATING

Low

Details Appendix 3

The Waitohu Estuary is a small "tidal river mouth" type estuary (area = 5ha), just north of the Otaki River. The estuary is narrow and shallow (mean depth approx 0.5-1m), situated between high marram dunes near the beach and further inland bordered by a thin margin of three square, jointed wire rush, flax, and sea rush near the sea and raupo further upstream. Beyond the thin marginal band of estuarine vegetation the landuse was grassland. Human use of the estuary is low-moderate but is seasonally popular for whitebaiting. Ecologically, habitat diversity is moderate, given the presence of medium sized areas of tidal flats and salt marsh. Salinities vary depending on the extent of tidal inflow. The water is generally clear but humic stained, and the sediments a soft sandy mud with little sign of anoxic conditions. Currently the water quality in the stream is fair (moderate nutrient and elevated *e.coli* concentrations), reflecting the mix of intensive pastoral and native forest landuse. Estimated nitrogen (the major driver of eutrophication) loadings are moderate to high. Because the estuary is small and dominated by freshwater inputs, its quality is expected to be similar to that of the stream for much of the time. However, the position of the estuary and mouth shifts up and down the beach and periodically the mouth constricts or closes. At such times, it is susceptible to eutrophication (nuisance algal blooms, low dissolved oxygen and smelly black sediments), muddy sediments, low clarity and high disease risk to bathers. To minimise water quality deterioration, dune erosion and flood risk, the mouth opening is artificially managed. A consequence of such management, is that natural development of stable lagoon areas behind the dunes is discouraged, which reduces habitat diversity and assimilative capacity. However, revegetation of the adjacent poor condition dune systems with native *Spinifex* is being currently undertaken to provide a more stable estuary configuration.

Given these characteristics, the estuary ecology is susceptible to: major earthmoving practices to control mouth dynamics, and any increase in the intensity of landuse in the catchment. Dune management to stabilise the mouth, minimising extent of earthmoving associated with mouth opening, and landuse monitoring is therefore recommended as a means of identifying potential threats to the values of this estuary.

Issues	Monitoring	Management
Mouth silting up. Earthworks modifying estuary and mouth. Natural cycle of low to high water quality as degree of mouth restriction varies. Estuary habitat diversity, water quality and dune deterioration.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals. • Map dominant species cover and condition of duneland, and change in position of seaward margin of dune. Repeat broadscale mapping at 5-10 yearly intervals. Identify hot spots for management.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ. • Encourage dune revegetation with native sand-binding species and weed management to stabilise estuary. • Allow minimal earthworks to open mouth when required.

WAITOHU ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low	Moderate	Moderate	Low
Susceptibility Rating	Low	Moderate	Moderate	Low	Moderate	Moderate	Low

4. KAPITI COAST (CONTINUED)

OTAKI ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	348 km^2 (native forest)
Dairy cows	1670 cows
Nitrogen loading	Low: 5-8 kg/ha/yr
Catchment geology	Greywacke, alluvium
Saltmarsh (ha)	1-3ha
Salinity	<5ppt
Mean depth (m)	1 to >2m
Tidal flats	None
Uses/Values	Fishing, swimming, birds, whitebaiting.

Otaki Estuary and whitebaiters

OVERALL VULNERABILITY RATING

Low

Details Appendix 3

The Otaki catchment drains over 400km^2 of the western slopes of the Tararua Ranges. The Otaki Estuary is a shallow, medium-sized "tidal river mouth" estuary that is always open to the sea (details Appendix 2). The estuary is dominated by river flows and is well-flushed. Such estuaries have low susceptibility to eutrophication or sedimentation issues. Due to the coarse nature of the bed, low habitat diversity (absence of salt marsh or intertidal flats), strong salinity fluctuations and water currents, the productivity and biodiversity is expected to be low. The estuary margin vegetation is dominated by gorse and flax scrub and grassland.

Human use of the estuary is low-moderate but is seasonally popular for fishing and whitebaiting. Ecologically, habitat diversity is low, given the absence of tidal flats and salt marsh.

Salinities vary depending on the extent of tidal inflow. The water is generally clear, and the sediments coarse with little sign of anoxic conditions. Currently the water quality in the stream is high (low nutrient and *e.coli* concentrations), reflecting the dominant native forest landuse and large catchment area. Estimated nitrogen (the major driver of eutrophication) loadings are low but the output of suspended solids is in the moderate range. Because the estuary is primarily riverine, its quality is expected to be similar to that of the river.

The major stressors on this type of estuary are intensification of landuse in the catchment, weed invasion of margins and flood control gates on drains/streams entering the estuary area. To minimise water quality deterioration and maximize available habitat (e.g. access to upstream breeding habitat for native fish), appropriate monitoring and management is recommended.

Rangiuru Drain and whitebaiters

Issues	Monitoring	Management
Estuary habitat diversity and WQ deterioration. • Margins of estuary lagoon degraded (weeds). • Drain blocked off by floodgates (access). • Intensive landuse on lowland	• Map intensive landuse (urban, high production pasture) at 5 yearly intervals. • Map dominant species cover and condition of margins at 5-10 yearly intervals. Identify hot spots for management.	• Lagoon margin revegetation and weed control. • Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ.

OTAKI ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Low	Low	Moderate	Moderate	Low
Susceptibility Rating	Low	Low	Low	Low	Moderate	Moderate	Low

4. KAPITI COAST (CONTINUED)

MANGAONE ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	53 km^2 (intensive pasture)
Dairy cows	2020 cows
Nitrogen loading	High: 14-30 kg/ha/yr
Catchment geology	Greywacke, alluvium, peat, sand
Saltmarsh (ha)	<0.1ha
Salinity	Varies depending on mouth closure
Mean depth (m)	0.5m
Tidal flats	None (lagoon floods sand flats on beach berm)
Uses/Values	Fishing, swimming, birds, whitebaiting, picnicing, fossicking.

Mangaone Estuary and mouth

OVERALL VULNERABILITY RATING

Low

Details Appendix 3

Figure 13. Managone Estuary channelised

The Mangaone Estuary is a small "tidal river mouth" type estuary located on a cobble/gravel beach just south of the Otaki River. The estuary is narrow and shallow (mean depth approx 0.5m), situated between scrubby grassland near the beach to the north and flax, karo, grassland mix to the south (details Appendix 2). Further inland the estuary was highly modified, channelised and bordered by introduced grasses, raupo and flax. Beyond this margin landuse was grassland.

Human use of the estuary is low-moderate but is seasonally popular for whitebaiting. Ecologically, habitat diversity is low, given the highly modified upstream channels and the absence of tidal flats, salt marsh vegetation and high incidence of weeds on gravel beach berms.

Salinities vary depending on the extent of tidal inflow. The water is generally turbid both in the estuary and offshore, and the sediments a soft sandy mud with little sign of anoxic conditions. Currently the water quality in the stream is poor (high nutrient and *e.coli* concentrations), reflecting the dominant intensive pastoral landuse, small catchment, lack of wetland filtering and high cow numbers. Estimated nitrogen (the major driver of eutrophication) loadings are high. Because the estuary is small and dominated by freshwater inputs, its quality is expected to be similar to that of the stream for much of the time. However, the mouth constricts or closes periodically and therefore is susceptible to eutrophication (nuisance algal blooms, low oxygen and smelly black sediments), muddy sediments, low clarity and high disease risk to bathers. To minimise water quality deterioration and flood risk, the mouth opening is artificially managed.

Given these characteristics there is potential to improve habitat condition and diversity through management of landuse intensity in the catchment, margin revegetation and weed control.

Issues	Monitoring	Management
Mouth blocks. Natural cycle of low to high water quality as degree of mouth restriction varies. Low habitat diversity, water quality and berm vegetation deterioration.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals. • Map dominant species cover and condition of gravel berm vegetation, and change in position of seaward margin of vegetation. Repeat broadscale mapping at 5-10 yearly intervals. Identify hot spots for management. • Map likely natural extent of estuary.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ. • Encourage berm revegetation with appropriate species and weed management to improve habitat and stabilise sand. • Allow minimal earthworks to open mouth when required.

MANGAONE ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low	Moderate	Moderate	Low
Susceptibility Rating	Low	Moderate	Moderate	Low	Moderate	Moderate	Low

4. KAPITI COAST (CONTINUED)

PEKA PEKA (HADFIELD DRAIN) ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	15 km^2 (intensive pasture)
Dairy cows	0 cows
Nitrogen loading	Mod - High: 14-20 kg/ha/yr
Catchment geology	Sand, greywacke, loess, peat
Saltmarsh (ha)	<0.1ha
Salinity	Varies depending on mouth closure
Mean depth (m)	0.5m
Tidal flats	None (lagoon floods sand flats on beach berm)
Uses/Values	Fishing, paddling, birds, whitebaiting, picnicing, fossicking.

Peka Peka Estuary just inland of beach

OVERALL VULNERABILITY RATING

Details Appendix 3

The Peka Peka Estuary is a small "tidal river mouth" estuary located on a sandy beach just south of the Mangaone Estuary (details Appendix 2). The estuary is narrow (5-10m) and shallow (approx 0.5m), situated between low spinifex/marram dunes near the beach. Further inland the estuary was highly modified, channelised and bordered by introduced grasses, flax, gorse and toitoi. Beyond this margin, the landuse was grassland.

Human use of the estuary is low-moderate but is seasonally popular for whitebaiting. Ecologically, habitat diversity is low, given the highly modified upstream channels and the absence of tidal flats, salt marsh vegetation, the regularly modified beach channel and lagoon and the high incidence of weeds. The catchment, however, includes large freshwater wetland areas which provide good habitat for certain varieties of native fish. The long term survival of these fish, however relies on a good condition estuary (i.e. one with good water quality, tidal flats, and presence of salt marsh areas).

The Peka Peka Estuary has been channelised and consequently has very little available habitat for salt marsh, fish and tidal flat organisms.

Salinities vary depending on the extent of tidal inflow. The water is humic stained, turbid and the sediments a soft sandy mud with little sign of anoxic conditions. Currently the water quality in the stream is unknown (not monitored), but given the dominant intensive pastoral landuse, small catchment, presence of wetland filtering and low cow numbers, it is expected to be fair.

Estimated nitrogen (the major driver of eutrophication) loadings are moderate-high. Because the estuary is small and dominated by freshwater inputs, its quality is expected to be similar to that of the stream for much of the time. However, the mouth constricts or closes periodically and therefore is susceptible to eutrophication (nuisance algal blooms, low oxygen and smelly black sediments), muddy sediments, low clarity and high disease risk to bathers. To minimise water quality deterioration and flood risk, the mouth opening is artificially managed.

Given these characteristics there is potential to improve habitat condition and diversity through management of landuse intensity in the catchment, margin revegetation and profiling and weed control.

Issues	Monitoring	Management
Mouth blocks. Natural cycle of low to high water quality as degree of mouth restriction varies. Low habitat diversity, water quality and dune vegetation deterioration.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals. • Map dominant species cover and condition of gravel berm vegetation, and change in position of seaward margin of vegetation. Repeat broadscale mapping at 5-10 yearly intervals. Identify hot spots for management. • Map likely natural extent of estuary.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary /beachWQ. • Improve margin habitat incl. dune and weed management. • Allow minimal earthworks to open mouth when required.

PEKA PEKA ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low	Moderate	Moderate	Low
Susceptibility Rating	Low	Moderate	Moderate	Low	Moderate	Moderate	Low

4. KAPITI COAST (CONTINUED)

NGARARA (WAIMEHA) ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	15 km^2 (intensive pasture)
Dairy cows	0 cows
Nitrogen loading	Mod - High: 14-20 kg/ha/yr
Catchment geology	Sand, urban, greywacke, peat
Saltmarsh (ha)	<0.5ha
Salinity	Varies depending on mouth closure
Mean depth (m)	0.5m
Tidal flats	None (lagoon floods sand flats on beach berm)
Uses/Values	Fishing, paddling, birds, whitebaiting, picnicing, fossicking, shellfish.

Ngarara Estuary and inland of beach

OVERALL VULNERABILITY RATING

Low

Details Appendix 3

The Ngarara Estuary is a small "tidal river mouth" type estuary located on a sandy beach just north of the Waikanae Estuary (details Appendix 2). The estuary is narrow (5-10m) and shallow (approx 0.5m), situated between high marram, grass and lupin dunes near the beach, which show blowout areas. Further along the beach, spinifex plantings are present on the foredunes. Further inland the estuary is highly modified, channelised and bordered by houses and parkland.

Human use of the estuary is moderate; it is a picnic focal point and is used for bathing, and whitebaiting. Ecologically, habitat diversity is low, given the highly modified upstream channels and the absence of tidal flats, salt marsh vegetation, the regularly modified beach channel and lagoon and the high incidence of weeds. The catchment, however, includes large freshwater wetland areas which provide good habitat for certain varieties of native fish. The long term survival of these fish, however relies on a good condition estuary (i.e. one with good water quality, tidal flats, and presence of salt marsh areas). The Ngarara Estuary has been channelised and consequently has very little available habitat for salt marsh, fish and tidal flat organisms.

Salinities vary depending on the extent of tidal inflow. The water is humic stained, clear and the sediments a soft sandy mud with little sign of anoxic conditions. Currently the water quality in the stream is moderate (moderate nutrient and e.coli concentrations), reflecting the dominant intensive pastoral landuse, small catchment, presence of wetland filtering and low cow numbers. Estimated nitrogen (the major driver of eutrophication) loadings are moderate-high. Because the estuary is small and dominated by freshwater inputs, its quality is expected to be similar to that of the stream for much of the time. However, the mouth constricts or closes periodically and therefore is susceptible to eutrophication (nuisance algal blooms, low oxygen and smelly black sediments), muddy sediments, low clarity and high disease risk to bathers. To minimise water quality deterioration and flood risk, the mouth opening is artificially managed. Given these characteristics there is potential to improve habitat condition and diversity through management of landuse intensity in the catchment, margin revegetation and profiling and weed control.

Issues	Monitoring	Management
Mouth blocks. Natural cycle of low to high water quality as degree of mouth restriction varies. Low habitat diversity, water quality and dune vegetation deterioration.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals. • Map dominant species cover and condition of gravel berm vegetation, and change in position of seaward margin of vegetation. Repeat broadscale mapping at 5-10 yearly intervals. Identify hot spots for management. • Map likely natural extent of estuary.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary/beach WQ. • Improve margin habitat incl. dune and weed management. • Allow minimal earthworks to open mouth when required.

WHAKATAKI ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low	Moderate	Moderate	Low
Susceptibility Rating	Low	Moderate	Moderate	Low	Moderate	Moderate	Low

4. KAPITI COAST (CONTINUED)

WAIKANAE ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	149 km^2 (native forest)
Dairy cows	0 cows
Nitrogen loading	Low 5-8 kg/ha/yr
Catchment geology	Greywacke, alluvium, peat, sand
Saltmarsh (ha)	10-20ha
Salinity	Varies depending on mouth closure
Mean depth (m)	1-3m
Tidal flats	Moderate (lagoon floods beach)
Uses/Values	Fishing, bathing, birds, whitebait, picnics, conservation, shellfish.

Waikanae Estuary

OVERALL VULNERABILITY RATING

Moderate

Details Appendix 3

The Waikanae Estuary is a moderate-sized "tidal river mouth" type estuary located on a sandy beach and old dune system (details Appendix 2). The estuary is 40-50m wide, 1-3m deep, 1.5km long and situated between high marram, grass and lupin dunes near the beach, which show blowout areas. Further inland, the margins of the estuary are modified and vegetated with various saltmarsh and weed species. There are also various freshwater lakelets around the margins.

Human use of the estuary is moderate-high; it is a local focal point and is used for conservation, boating, birdwatching, bathing, and whitebaiting. Ecologically, habitat diversity is moderate, given the modified upstream and beach channels and the presence of tidal flats, salt marsh vegetation, and weeds. Such conditions provide reasonable habitat for native fish and tidal flat organisms.

Salinities vary depending on the extent of tidal inflow. The water is clear and the sediments a soft sandy mud with little sign of anoxic conditions. Currently the water quality in the stream is good (low nutrient and e.coli concentrations), reflecting the dominant native forest landuse (but also significant pastoral use), large catchment, and low cow numbers. Estimated nitrogen (the major driver of eutrophication) loadings are low. Because the estuary also receives a large tertiary treated wastewater discharge (via the Mazengarb Drain), its water quality is expected to be lower for much of the time (particularly nutrient levels). The presence of algal mats on the intertidal margins confirms this possibility. Also, because the mouth constricts at times it is susceptible to eutrophication (nuisance algal blooms, low oxygen and smelly black sediments), muddy sediments, low clarity and higher disease risk to bathers. To minimise water quality deterioration and flood risk, the mouth constriction is artificially managed.

Given these characteristics there is potential to improve habitat condition and diversity through management of landuse intensity in the catchment, margin revegetation and profiling, minimising wastewater impacts and weed control.

Issues	Monitoring	Management
Water extraction. Mouth blocks. Receives high volume wastewater discharge. Flood-gates on drains. Natural cycle of low to high water quality as degree of mouth restriction varies. Low habitat diversity, low water quality and dune vegetation deterioration.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals. • Map dominant species cover and condition of dune and saltmarsh vegetation, at 5-10 yearly intervals. Identify hot spots for management. • Map likely natural extent of estuary. • Monitor impact of wastewater discharge on estuary WQ (consent)	• Limit wastewater inputs and intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ. • Improve margin habitat incl. dune and weed management. • Allow minimal earthworks to open mouth when required.
Reduction in condition of high biodiversity estuaries.	• Monitor key indicators of one high biodiversity estuary e.g. Waikanae Estuary. 3 yr baseline then 5 yrly.	• Develop trigger criteria for estuary condition indicators and evaluation and response plan should trigger criteria be breached.

WAIKANAE ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low	Moderate	Moderate	Low
Susceptibility Rating	Low	Moderate	Moderate	Low	Moderate	Moderate	Low

4. KAPITI COAST (CONTINUED)

WAIKANAE ESTUARY

Waikanae Estuary, presence of floodgates limiting access to adjacent stream, and green algal mats in intertidal zone.

Waikanae Estuary, presence of salmarsh, and birdlife

Waikanae Estuary, presence of tidal flats and dunes

Waikanae Estuary is in direct connection with the Kapiti Marine Reserve

4. KAPITI COAST (CONTINUED)

TIKOTU ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	17 km^2 (urban)
Dairy cows	0 cows
Nitrogen loading	Mod : 8-20 kg/ha/yr
Catchment geology	Urban, sand
Saltmarsh (ha)	<0.1ha
Salinity	Varies depending on mouth closure
Mean depth (m)	0.5m
Tidal flats	None (lagoon floods sand flats on beach berm)
Uses/Values	Low

Tikotu Estuary

OVERALL VULNERABILITY RATING

Details Appendix 3

The Tikotu Estuary is a small "tidal river mouth" estuary located on a sandy beach at Paraparaumu (details Appendix 2). The estuary is 3-5m wide and shallow (<0.5m), situated between low narrow, spinifex dunes near the beach. Further inland the estuary is highly modified, bounded by wooden walls, channelised and bordered by introduced grasses, roads, houses etc.

Human use of the estuary is low. Ecologically, habitat diversity is very low, given the highly modified upstream channels and the absence of tidal flats, salt marsh vegetation, and the regularly modified beach channel.

Salinities vary depending on the extent of tidal inflow. The water is humic stained, turbid and the sediments a soft sandy mud with signs of anoxic conditions. Given the dominant urban and intensive pastoral landuse, small catchment, absence of wetland filtering, water quality is expected to be fair to poor. Kapiti Coast District Council (KCDC) faecal monitoring data confirms high levels of faecal contamination. Estimated nitrogen (the major driver of eutrophication) loadings are moderate. Because the estuary is very small and dominated by freshwater inputs, its quality is expected to be similar to that of the stream for much of the time. However, the mouth constricts or closes periodically and therefore is susceptible to eutrophication (nuisance algal blooms, low oxygen and smelly black sediments), muddy sediments, low clarity and high disease risk to bathers. To minimise water quality deterioration and flood risk, the mouth opening is artificially managed.

Given these characteristics there is potential to improve habitat condition and diversity through management of landuse intensity in the catchment, margin revegetation and profiling, and weed control. However, because of the urban margins, roads, and walled channel, such improvements are likely to be difficult to achieve.

Tikotu Estuary

Issues	Monitoring	Management
Mouth constricts. Natural cycle of low to high water quality as degree of mouth restriction varies. Very low habitat diversity, water quality. Dunes built on.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ.

TIKOTU ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Moderate	Moderate	Low	Low
Susceptibility Rating	Low	Moderate	Moderate	Moderate	Moderate	Low	Low

WHAREMAKAU ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	12 km^2 (urban, intensive pastoral)
Dairy cows	0 cows
Nitrogen loading	Mod : 8-20 kg/ha/yr
Catchment geology	Greywacke, loess, peat, urban
Saltmarsh (ha)	<0.1ha
Salinity	Varies depending on mouth closure
Mean depth (m)	0.5m
Tidal flats	None (lagoon floods sand flats on beach berm)
Uses/Values	Low

Wharemakau Estuary

OVERALL VULNERABILITY RATING

Low

Details Appendix 3

The Wharemakau Estuary is a small "tidal river mouth" estuary located on a sandy beach at South Raumati (details Appendix 2). The estuary is 3-5m wide and shallow (<0.5m), situated between low narrow, seawalls and houses on foredunes near the beach. Further inland the estuary is highly modified, bounded by wooden walls, channelised and bordered by introduced grasses, roads, houses etc.

Human use of the estuary is low. Ecologically, habitat diversity is very low, given the highly modified upstream channels and the absence of tidal flats, salt marsh vegetation, and the regularly modified beach channel.

Salinities vary depending on the extent of tidal inflow. The water is humic stained, turbid and the sediments a soft sandy mud with no signs of anoxic conditions. Given the dominant urban and intensive pastoral landuse, small catchment, absence of wetland filtering, water quality is expected to be fair to poor. Kapiti Coast District Council (KCDC) faecal monitoring data confirms high levels of faecal contamination. Estimated nitrogen (the major driver of eutrophication) loadings are moderate. Because the estuary is very small and dominated by freshwater inputs, its quality is expected to be similar to that of the stream for much of the time. The mouth constricts but the estuary is too well flushed to be susceptible to eutrophication or sedimentation.

Given these characteristics there is potential to improve habitat condition and diversity through management of landuse intensity in the catchment, margin revegetation and profiling, and weed control. However, because of the urban margins, roads, and walled channel, such improvements are likely to be very difficult to achieve.

Wharemakau Estuary

Issues	Monitoring	Management
Very low habitat diversity, fair water quality. Dunes built on. Sea walls, beach erosion.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ.

WHAREMAKAU ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Moderate	Moderate	Low	Low
Susceptibility Rating	Low	Low	Moderate	Moderate	Moderate	Low	Low

4. KAPITI COAST (CONTINUED)

WHAREROA ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	16 km^2 (intensive pasture)
Dairy cows	0 cows
Nitrogen loading	Mod 8-20 kg/ha/yr
Catchment geology	Greywacke, loess, peat, sand
Saltmarsh (ha)	1ha
Salinity	Approx 1km
Mean depth (m)	1m
Tidal flats	None (lagoon floods sand flats on beach berm)
Uses/Values	Fishing, paddling, birds, whitebaiting, picnicing, conservation.

Whareroa Estuary

OVERALL VULNERABILITY RATING

Details Appendix 3

The Whareroa Estuary is a small "tidal river mouth" estuary located on a sandy beach in Queen Elizabeth Park (details Appendix 2). The estuary is 10-20m wide and shallow (approx 1-2m), situated between high marram dunes near the beach with frequent blowouts. Further inland the estuary is modified, channelised and bordered by introduced grasses, flax, gorse and lupins. Beyond this margin, the landuse is grassland.

Human use of the estuary is low-moderate but is seasonally popular for whitebaiting. Ecologically, habitat diversity is moderate, given its channelised nature, and the absence of tidal flats, significant salt marsh vegetation, and the high incidence of weeds. However, it provides good habitat for whitebait (overhanging grasses). Because the long term survival of native fish relies on a good condition estuary (i.e. one with good water quality, tidal flats, and presence of salt marsh areas), the current estuary situation has room for improvement.

Salinities vary depending on the extent of tidal inflow. The water is humic stained, and the sediments a soft sandy mud with little sign of anoxic conditions. Currently the water quality in the stream is moderate (moderate nutrient and *e.coli* concentrations), reflecting the dominant high productivity pastoral landuse, small catchment, lack of significant wetland filtering. Estimated nitrogen (the major driver of eutrophication) loadings are moderate. Because the estuary is small and dominated by freshwater inputs, its quality is expected to be similar to that of the stream for much of the time. However, the mouth constricts or closes periodically which can cause lowered water quality for short periods. To minimise water quality deterioration and flood risk, the mouth opening is artificially managed.

Given these characteristics there is a good potential to improve habitat condition and diversity through management of landuse intensity in the catchment, margin revegetation and profiling, and weed control.

Whareroa Estuary

Issues	Monitoring	Management
Mouth constricts. Natural cycle of low to high water quality as degree of mouth restriction varies. Low-mod habitat diversity, water quality and dune vegetation deterioration.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals. • Map dominant species cover and condition of salt marsh and dune vegetation at 5-10 yearly intervals. Identify hot spots for management. • Map likely natural extent of estuary.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ. • Improve margin habitat incl. dune and weed management. • Allow minimal earthworks to open mouth when required.

WHAREROA ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low	Moderate	Moderate	Low
Susceptibility Rating	Low	Moderate	Moderate	Low	Moderate	Moderate	Low

5. PAEKAKARIKI TO MANA

BEACHES AND ROCKY SHORES

South of Paekakariki, coastal lowlands are no longer present. Instead, the hard greywacke uplands extend to the edge of the coastal margin and consequently the shoreline is dominated by steep cliffs, hard rocky shores and steep gravel beaches, except within the larger valleys like those of Porirua and Wellington Harbour. Extensive duneland areas are absent.

Paekakariki to Mana (Google)

South of Pukerua Bay Towards Te Rewarewa Point

South of Paekakariki

Pukerua Bay

South of Pukerua Bay

PAEKAKARIKI TO PUKERUA BAY

This small section consists of hard rocky shores and reefs and relatively turbid inshore waters. A concrete wall separates the rocky shore from the main highway and main rail line and high grass and bush covered cliffs. Access to the area is difficult, but the view is appreciated by thousands per day. Human use of the area is low-moderate (scenic, walking, diving, and inshore fishing). Ecologically, the area has diverse intertidal rocky shore habitat, a highly modified margin above high water and is likely to have good (although often turbid) water quality. The key stressors are road runoff and human seafood collection.

PUKERUA BAY

Pukerua Bay includes a steep gravel/coarse sand beach, rocky shores and inshore reefs, bordered by grass verges, seawalls, road, houses and steep bush covered hills. Pukerua Bay is popular locally for swimming, scenic, fishing, boating, picnics, and walking. Ecologically, the area has diverse intertidal rocky shore habitat, a highly modified margin above high water and good water quality. The key stressors are urban stormwater and human seafood collection.

PUKERUA BAY TO HONGOEKA BAY

This section is more isolated and consists of clear inshore waters, rocky shores and reefs, and bordered by steep scrub (*Muhlenbeckia*, Tauhinu and flax) covered hills. The area has poor access except by boat and walking. The main human use is for fishing, aquaculture and diving although a gravel quarry has been operating in the past near Hongoeka Bay. Ecologically, the area has diverse intertidal rocky shore habitat and good water quality. The key stressor is human seafood collection.

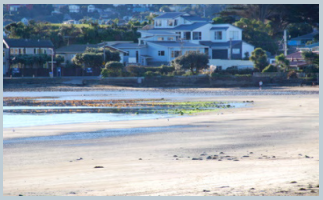
PAEKAKARIKI TO MANA	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low	Low	Moderate	Moderate
Susceptibility Rating	Low	Low	Moderate	Low	Low	Moderate	Moderate

5. PAEKAKARIKI TO MANA (CONTINUED)

BEACHES AND ROCKY SHORES

Hongoeka Bay

Plimmerton Beach high water



Plimmerton Beach low water

OVERALL VULNERABILITY RATING

Low
Moderate

Details Appendix 3

HONGOEKA BAY TO KAREHANA BAY

This section consists of clear inshore waters, steep reflective cobble/gravel/coarse sand beaches and rocky shores, bordered by narrow vegetated margins (and seawalls in places), the road, houses and steep bush covered hills, A small stream enters through a valley at Hongoeka Bay. The area is popular locally for swimming, scenic, fishing, boating, picnics, and walking. Ecologically, the area has diverse intertidal rocky shore habitat, a highly modified margin above high water and good water quality. The key stressors are urban stormwater and human seafood collection.

Karehana Bay to Plimmerton

PLIMMERTON BEACH

Plimmerton Beach consists of turbid inshore waters, a gradual sloping dissipative sand (with gravel and cobble patches) beach bordered by sea walls and houses built on old foredunes. Local opinion considers the beach to be losing sand and exposing hard substrate. A small stream (Taupo Stream) enters near the middle of the beach and is known to influence beach water quality. The area is popular for swimming, windsurfing, scenic, fishing, boating, picnics, and walking. Ecologically, the area is expected to have low biodiversity and moderate water quality (regularly exceeds bathing bacterial criteria) given its absence of dunes, seawalls and proximity to the Porirua Harbour mouth. However, subtidally a much greater diversity is expected given the high productivity associated with many river mouth areas (sea lettuce growing in bay). Key stressors are stormwater, proximity to estuary plume (Porirua Harbour) and human seafood collection.

MANA BEACH AND MARINA

Mana Beach and marina are located at the mouth of Porirua Harbour and are bathed by moderately turbid waters. The beach is sand with patches of gravel, relatively steep and bordered by a narrow strip of steep marram dunes with frequent blowouts. Revegetation is currently being undertaken along the beach/foredune edge. Matures trees and a park border the dunes. The marina occupies 6 ha of old estuary mouth and beach. The area is popular locally for fishing, shellfish, boating, picnics, walking and some swimming. Ecologically, the area is expected to have moderate biodiversity and water quality given its proximity to the Porirua Harbour mouth. The key stressors are urban stormwater, presence of structures and human seafood collection.

Issues	Monitoring	Management
Historical loss of dune, and margins habitat. Seawalls limiting beach habitat and lowering diversity. Seafood collection reducing abundance. Urban stormwater/sewage by-pass onto beach areas reducing water quality.	• Map coastal margin at 5-10 yearly intervals to assess habitat change and identify hot spots for management. • Monitor disease risk at bathing beaches.	• Limit contaminants entry to urban SW to ensure impacts don't degrade beach water quality. • Encourage margin revegetation.

TAUPO ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	9 km² (urban, intensive pastoral)
Dairy cows	0 cows
Nitrogen loading	Mod : 8-20 kg/ha/yr
Catchment geology	Greywacke, loess, clays
Saltmarsh (ha)	<0.1ha
Salinity	Varies depending on mouth closure
Mean depth (m)	0.5m
Tidal flats	None (lagoon floods sand flats on beach berm)
Uses/Values	Low

Taupo Estuary

OVERALL VULNERABILITY RATING

Details Appendix 3

The Taupo Estuary is a small "tidal river mouth" estuary located on a sandy/gravel beach at Plimmerton (details Appendix 2). The estuary is 3m wide and shallow (<0.5m), situated between low narrow, seawalls and houses on foredunes near the beach. Further inland the estuary is highly modified (initially bounded by concrete walls, channelised and then bordered by introduced grasses, roads, and buildings.

Human use of the estuary is low. Ecologically, habitat diversity is low, given the highly modified upstream channels, the absence of tidal flats and salt marsh vegetation, and the regularly modified beach channel. However, there is some overhanging vegetation that provides suitable whitebait spawning habitat.

Salinities vary depending on the extent of tidal inflow. The water is humic stained, turbid and the sediments a soft sandy mud with no signs of anoxic conditions. Given the dominant high productivity pastoral landuse, some urban and industrial use, small catchment, and presence of wetland filtering, water quality is expected to be fair to poor (Porirua City Council monitoring data indicates elevated faecal bacteria). Estimated nitrogen (the major driver of eutrophication) loadings are moderate. Because the estuary is very small and dominated by freshwater inputs, its quality is expected to be similar to that of the stream for much of the time. The mouth constricts at times, but the estuary is too well flushed to be susceptible to eutrophication or sedimentation.

Given these characteristics there is potential to improve habitat condition and diversity through management of landuse intensity in the catchment, margin revegetation and profiling, and weed control. However, because of the urban margins, roads, and walled channel, most of these improvements are likely to be very difficult to achieve.

Taupo Estuary

Issues	Monitoring	Management
Very low habitat diversity. Fair water quality. Dunes built on.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals.	• Limit intensive landuse development (including industrial and/or manage to ensure impacts don't degrade estuary WQ. • Encourage margin vegetation and reprofiling of banks.

TAUPO ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Moderate	Moderate	Low	Low
Susceptibility Rating	Low	Low	Moderate	Moderate	Moderate	Low	Low

6. PORIRUA HARBOUR

Pauatahanui Estuary	
Estuary Type/Area	Tidal River Mouth
Catchment	105 km^2 (native forest)
Dairy cows	0 cows
Nitrogen loading	Low - mod 5-14 kg/ha/yr
Catchment geology	Greywacke, loess
Saltmarsh (ha)	Moderate
Salinity	Varies depending on mouth closure
Mean depth (m)	1-3m
Tidal flats	Moderate
Uses/Values	Fishing, bathing, birds, whitebait, picnics, conservation, shellfish.

Porirua Harbour Arm	
Estuary Type/Area	Tidal River Mouth
Catchment	105 km^2 (native forest)
Dairy cows	0 cows
Nitrogen loading	Low - mod 5-14 kg/ha/yr
Catchment geology	Greywacke, loess
Saltmarsh (ha)	Low
Salinity	Varies depending on mouth closure
Mean depth (m)	1-3m
Tidal flats	Moderate
Uses/Values	Fishing, bathing, birds, whitebait, picnics, conservation, shellfish.

Pauatahanui Estuary

Porirua Harbour Arm

The Porirua Harbour is a large, shallow, well flushed "tidal lagoon" type estuary consisting of two arms, Porirua Inlet and Pauatahanui Inlet. It has strong spiritual and cultural affinities and is widely used for fishing, boating, swimming, water skiing andwalking. It also provides a natural focal point for the thousands of people that live near or visit its shores. The harbour has been extensively modified over the years, particularly the Porirua Inlet where the once vegetated arms have been reclaimed, and now most of the inlet is lined with rockwalls. The Pauatahanui Inlet is much less modified and has extensive areas of saltmarsh, a large percentage of which has been improved through local community efforts. Catchment landuse is dominated by urban use in the Porirua Inlet and by grazing in the steeper Pauatahanui Inlet catchment, although urban (residential) development is significant in some areas

Both inlets are shallow and well-flushed (residence time less than 3 days), with extensive areas of tidal flats which are primarily sandy in Pauatahanui Inlet and slightly muddier in Porirua Inlet. Both inlets have relatively simple shapes, lacking sheltered tidal arms where muddy sediments tend to settle and accumulate.

Although such estuaries are relatively robust, they will experience problems if exposed to certain stressors. In particular, excessive sediment, nutrients, toxins, or disease causing organisms, and loss or damage to habitat (e.g. salt marsh) and vegetated margins.

EXISTING CONDITION AND STRESSORS

The available information for Porirua Harbour (Robertson and Stevens 2007) indicates that both arms have a naturally low susceptibility to sedimentation and nutrient enrichment effects based on dilution and flushing rates (i.e. in terms of its physical characteristics, it is not prone to sedimentation and enrichment effects). However, if inputs were high enough, then adverse effects could be expected. Fortunately, because Porirua Harbour has a primarily hard rock type catchment, dominated by grassland and to a lesser extent urban (Porirua City), exotic forest and bush landuses, it is expected to provide only low-moderate loads of sediment, nutrients, pathogens and potentially toxic contaminants to the inlets. Nevertheless, some activities in the catchment have the potential to increase loads to excessive levels, e.g. extensive urban earthworks, exotic forest clearance and sewer pump station overflows. This situation of low susceptibility and low-moderate inputs of nuisance materials (except for pathogens) to Porirua Harbour, has resulted in an estuary with condition ratings that also fall into the low or moderate range (except for disease risk) as follows:

- **Sediment:** The measured sedimentation rate for Pauatahanui Inlet fits into the low-moderate range, with the inferred rate for Porirua Inlet likely to be only slightly higher given the maturity of the city. The current area of soft muds in Pauatahanui Inlet is small, whereas in Porirua Harbour it is higher (as inferred from observations).
- **Nuisance Growths**: Macroalgal blooms (sea lettuce) are present in both inlets, with observations indicating that they are in the moderate range in terms of percentage cover and density. Porirua Arm has denser beds than the Pauatahanui Inlet.

6. PORIRUA HARBOUR (CONTINUED)

- **Disease Risk**: In terms of disease risk, the suitability for recreation grading for Pauatahanui Inlet is "poor" in one isolated area (Browns Bay) and better elsewhere. Rain and runoff are not likely to be the main issue at Browns Bay. The likely source has been identified as Brown's Creek. Sediment re-suspension may also be an issue in some parts of the Pauatahanui Inlet. For Porirua Inlet, the bathing site at the rowing club has a grade of "poor", with urban stormwater - either directly or indirectly via a nearby stream - the likely primary source of microbiological contamination. In very wet weather sewer overflows may also be a problem for Porirua Inlet. In terms of disease risk from shellfish consumption, the evidence points to regular exceedance of shellfish FC limit in the estuary waters but less exceedance in the shellfish themselves.
- **Contaminants**: Sediment heavy metal concentrations are in the low-moderate range. They have doubled in the last 150 years in Pauatahanui Inlet but are still less than 50% of ANZECC ISQGlo (ANZECC 2000). In Porirua Inlet, concentrations are higher but are still less than ANZECC ISQGlo, but exceed the Auckland Regional Council environmental response criteria for copper, lead and zinc. The major driver is likely to be urban stormwater.

Despite the low physical susceptibility of the Porirua Harbour to adverse effects from contaminant and other inputs, the Harbour has been very susceptible to actions which have altered its shape and led to a loss of important estuarine habitats.

- **Habitat Loss**: The major impact to the Harbour has been the progressive reclamation actions, particularly to Porirua Harbour that has resulted in the loss of extensive areas of saltmarsh habitat, which is well-known to provide the life-blood for any healthy estuary, and estuary margins. In terms of habitat loss, Porirua Harbour would sit in the high category and Pauatahanui Inlet (which has experienced rehabilitation of much of its salt marsh habitat) would sit in the low-moderate loss category.
- **Invasive Weeds**: The introduction of invasive weeds and pests (e.g. *Undaria, Spartina*) is also a threat to any estuary biodiversity. Currently, although *Undaria* is present near the inlet mouths it is not likely to spread given the absence of extensive areas of suitable habitat (i.e. submerged rock or piles). *Spartina* is currently not present.
- Although other issues are present (e.g. grazing in salt marsh, seafood collection, litter accumulation in the estuary), these are not considered to be at a level where estuary resources are directly threatened.

Pauatahanui Inlet	Sediment	Nuisance growths	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low-Mod	Low	Moderate	Low	Moderate	Low	Low

Porirua Inlet	Sediment	Nuisance growths	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Moderate	Moderate	High	Low-Mod	High	Low	Moderate

Pauatahanui Estuary

6. PORIRUA HARBOUR (CONTINUED)

Because of long term, low-moderate risks to Porirua Harbour from a number of sources (i.e. catchment landuse practices, invasive weeds and pests, margin development, sea level rise, sewer overflows, urban stormwater), as well as possible improvements that may change Harbour condition (i.e. increased salt marsh area, improved water quality), there is a need to collect further information, the bulk of which fits the description of a long term monitoring programme. This information will help guide any management actions, allow effectiveness to be monitored, and identify any need for revised actions.

MONITORING	MANAGEMENT
Long term monitoring of estuary condition; • Broad scale mapping of sediment types, estuary vegetation (including sea grass, salt marsh, and invasive weeds) and estuary margin landuse (200m wide strip around perimeter) at 5 yearly intervals. Also sedimentation rates, and macro-algae, annually. • Fine scale monitoring of key intertidal sediment condition indicators. 3 years baseline, then review. • Monitor disease risk in waters and shellfish. **Long term monitoring of catchment landuse** • Identify areas where a combination of different factors (e.g. land cover, slope, area, soil type, geology, rainfall, etc) highlight a high potential for immediate or potential inputs of sediment, contaminants or nutrients. Use existing catchment data to identify "hotspots" such as erosion prone areas, easily mobilised sediment reserves, or areas likely to result in elevated concentrations of pathogen indicators, nutrients and heavy metals. • Use broad scale GIS mapping to overlay existing and proposed land use (exotic forestry, urban development, intensive grazing, etc) and inputs (in particular, forest harvesting, earthworks, sewer overflows, urban stormwater, N fertilizer use, etc) to highlight where these activities coincide with the identified "hotspots" and establish management or monitoring priorities.	• Identify BMPS to reduce runoff from sediment source hotspots. • Identify and reduce significant sources of faecal bacteria to the estuaries. • Improve natural character of estuary margins and encourage salt marsh development and restoration, esp. Porirua Arm. • Identify options to deepen appropriate (natural channel) areas of Porirua Arm to better enable popular human uses (e.g. water skiing). • Develop trigger criteria for estuary condition indicators and evaluation and response plan should trigger criteria be breached. **OVERALL VULNERABILITY RATING** Moderate Details Appendix 3

Pauatahanui Estuary

Porirua Harbour Arm

7. SW COAST - PORIRUA HARBOUR TO OWHIRO BAY

BEACHES, ESTUARIES AND ROCKY SHORES

Southwest Coast (Google)

Sinclair Head.

OVERALL VULNERABILITY RATING

Low
Moderate

Details Appendix 3

The South West section of the coast was not included in the current coastal risk assessment except for the areas of Makara Estuary and Titahi Bay. However, based on expert opinion, the following preliminary assumptions have been made (prior to a more detailed assessment to be undertaken in the future):

South of Porirua Harbour the hard greywacke uplands extend to the edge of the coastal margin and consequently the shoreline is exposed and dominated by steep cliffs, hard rocky shores and steep gravel beaches, except within the larger valleys like those of Makara Estuary. A number of small streams enter the coast through small, freshwater dominated estuaries. Extensive duneland areas are absent.

Uses and Values

- Fishing, walking, surfing, shellfish, four wheel driving on beach, diving.

Ecological Values

- This section includes a large area of exposed rocky shore and shallow subtidal reef habitat with high biodiversity of animals and plants. Any beaches are steep with gravel, cobble substrate and hence are expected to have low biodiversity. Duneland areas are expected to be narrow or non-existent.

Existing Condition

- Existing condition of all habitat is expected to be generally "good" given its remoteness, and non intensive landuse in catchment. However, depletion of some rocky habitat biota stocks, weed growth around the terrestrial margin and within any dunelands is likely, as well as impacts to water quality and biota near the Karori wastewater outfall and impacts to beach and dune/ vegetated margin through driving on beaches.

Presence of Stressors

- The presence of stressors is expected to be "low-moderate". Stressors include human pressure on fish and shellfish stocks, change to water quality through climate change, weed and pest invasions, threat of offshore toxic algal blooms and oil spills, driving on beaches and Karori wastewater discharge.

Susceptibility to Stressors

- Susceptibility to stressors is expected to be "low-moderate" given that the area is well flushed, and relatively remote (but is close to a large population centre and is a popular fishing and diving destination). Rocky shore and shallow subtidal reef habitat has the highest ecological and human use value and is most susceptible to human pressure through overfishing, long term change in water quality (e.g. through climate change), oil spills, invasive pests and offshore algal blooms.

Issues	Monitoring	Management
Threat to high biodiversity rock habitat (esp. climate change, human take). Weed invasions around terrestrial margin.	• Monitor abundance and diversity of a remote and representative high biodiversity rocky intertidal habitat (e.g. Cape Terawhiti). • Map areas of invasive weeds, identify hot spots for management.	• Encourage management plans around climate change, oil spill, inshore fish quota, invasive pests, offshore algal blooms. • Develop trigger criteria for rock habitat, and evaluation and response plans • Encourage weed management.

PORIRUA TO OWHIRO	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Low	Low	Low	Low	Low
Susceptibility Rating	Low	Low-Mod	Moderate	Low	Low	Moderate	Moderate

7. SW COAST - PORIRUA HARBOUR TO OWHIRO BAY

TITAHI BAY

Titahi Bay (Nth end)

Titahi Bay (towards Sth end)

Titahi Bay (towards Kapiti)

OVERALL VULNERABILITY RATING

Low
Moderate

Details Appendix 3

South of Porirua Harbour , Titahi Bay is a relatively sheltered, crescent-shaped beach (intermediate-dissipative slope) dominated by sand, with a patch of cobble near the surf club. Boatsheds are present at both ends of the bay with ramps and access sites across the beach. Relatively steep marram and flax dunes surround the beach margin. To the south, the margin between beach and dune includes a seawall. Rocky headlands are present at either end of the bay. Residential properties and a park border the dune land. Vehicle access is allowed onto the beach at the north end. A 1000 year old sub-fossilised forest can be found in the middle of Titahi Bay beach. The remains of the forest are visible at very low tides.

Uses and Values

- Bathing, fishing, surfing, diving, shellfish, walking, picnics, scientific, driving on beach, scenic.

Ecological Values

- The primary habitats are sandy beach, dune and exposed rocky shore and shallow subtidal reef habitat. All have relatively high biodiversity of animals and plants.

Existing Condition

- Existing condition of beach habitat is generally "good" (low levels of metals and organic matter, moderate diversity of macroinvertebrates in non-vehicle access sites). Dune quality is moderate, given the dominance of the introduced marram grass and other invasive weeds. Depletion of some rocky habitat biota stocks is expected. Water quality is generally good (low faecal bacterial count) but is sometimes degraded through stormwater and/or stream discharges and possibly from the Porirua treated wastewater plume.

Presence of Stressors

- The presence of stressors is expected to be "low-moderate". Stressors include human pressure on fish and shellfish stocks, change to water quality through discharges, toxic algal blooms, weed and pest invasions, and driving on the beach and margins.

Susceptibility to Stressors

- Susceptibility to stressors is expected to be "moderate" given that the area is only moderately flushed (an embayment) and very accessible. All habitat has moderate to high values and and is most susceptible to human pressure through overfishing, change in water quality, weed invasion, and vehicle damage.

Issues	Monitoring	Management
Threat to moderate to high biodiversity rock, beach, dune habitat (esp. human overfishing, vehicles, weeds, water quality).	• Map areas of invasive weeds, identify hot spots for management. • Monitor disease risk in waters and shellfish	• Identify and reduce significant sources of faecal bacteria to the Bay. • Encourage management plans around beach, dune and rocky shore quality. • Develop trigger criteria for rock habitat, and evaluation and response plans

TITAHI BAY	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low-Mod	Low	Moderate	Low	Low	Moderate	Moderate
Susceptibility Rating	Moderate	Low-Mod	Moderate	Low	Low	Moderate	Moderate

7. SW COAST - PORIRUA HARBOUR TO OWHIRO BAY

MAKARA ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	149 km^2 (native forest)
Dairy cows	0 cows
Nitrogen loading	Low 3-8 kg/ha/yr
Catchment geology	Greywacke, alluvium, peat, sand
Saltmarsh (ha)	2-3ha
Salinity	Varies depending on mouth closure
Mean depth (m)	1-3m
Tidal flats	Moderate (lagoon floods beach)
Uses/Values	Fishing, bathing, birds, whitebait, picnics, conservation, shellfish.

Makara Estuary (Google)

OVERALL VULNERABILITY RATING

Low

Moderate

Details Appendix 3

The Makara Estuary is a moderate-sized "tidal river mouth" type estuary (area = 15ha), which drains onto a steep (reflective) cobble/gravel/coarse sand beach with a small area of natural (but managed) berm vegetation (details Appendix 2). The beach is situated in a bay between rocky headlands. The estuary is 30-50m wide, 1-4m deep, 1.5km long. The estuary margins are modified and vegetated with various scrub, saltmarsh, grass and weed species which provide reasonable habitat for whitebait spawning (Taylor and Kelly 2001). The intertidal area is relatively small and dominated by gravel flats.

Uses and Values

Human use of the estuary is moderate; a local focal point, is used for conservation, boating, birdwatching, bathing, and whitebaiting. Currently a 'Care Group" operates in the area.

Ecological Values

Ecologically, habitat diversity is moderate, given the modified upstream channel, the presence of small tidal flats, salt marsh vegetation, and weeds. Such conditions provide reasonable habitat for native fish and tidal flat organisms.

Existing Condition

Salinities vary depending on the extent of tidal inflow. The water is clear and the sediments a soft sandy mud with little sign of anoxic conditions. Currently the water quality in the stream is moderate (low nutrient and but elevated *e.coli* concentrations), reflecting the dominant high production pasture landuse. Estimated nitrogen loadings are low-moderate. Because the estuary is relatively well flushed (although its mouth can block at times) its quality is expected to be similar to the river. Estuary sediment quality is good (low metals and organic matter contents).

Presence of Stressors

The presence of stressors is expected to be "low-moderate". Stressors include; stock grazing salt marsh, change to water quality through nonpoint discharges, historical drainage, weed and pest invasions and mouth restrictions.

Susceptibility to Stressors

Susceptibility to stressors is expected to be low-moderate given that the area is well flushed, but salt marsh is accessible to stock.

Issues	Monitoring	Management
Natural cycle of low to high water quality as degree of mouth restriction varies, past drainage and weeds.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals. • Map dominant species cover and condition of dune and saltmarsh vegetation, at 5-10 yearly intervals. Identify hot spots for management. • Map likely natural extent of estuary.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ. • Develop management plan to improve saltmarsh habitat, and area of tidal flats.

MAKARA ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Moderate	Moderate	Low	Moderate	Moderate	Low
Susceptibility Rating	Low	Moderate	Moderate	Low	Moderate	Moderate	Low

8. STH COAST - OWHIRO BAY TO BREAKER BAY

BEACHES, ESTUARIES AND ROCKY SHORES

South Coast (Google)

Owhiro Bay

Collecting shellfish Lyall Bay

OVERALL VULNERABILITY RATING

Moderate

Details Appendix 3

Situated in Wellington city, this section of the coast is exposed and bathed by relatively clear, clean waters (except near Moa Pt outfall). It consists of a string of embayments (Owhiro, Island, Houghton, Lyall, Tarakena, Reef, Flax, Eve and Breaker Bays) separated by hard rocky shores and reefs. The sand/gravel beaches at the head of each bay are steep (reflective) with dumping waves. The inshore beach margin is narrow, with grasses, marram, flaxes and scrub species. Above the vegetated margin there is usually a road, houses and steep cliffs. The exception is the much larger Lyall Bay; a sandy, low gradient (intermediate/dissipative) beach with marram and pingao dunes, a rock wall at the western end, and backed by road and houses.

Uses and Values

- High Use. Bathing, fishing, scientific, boating, walking, picnics, scenic, surfing, shellfish, driving, diving.

Ecological Values

- This section includes a large area of exposed rocky shore and shallow subtidal reef habitat with high biodiversity of animals and plants. Biodiversity is expected to be low at the steep gravel beaches but higher at the sandy Lyall Bay. The duneland area of Lyall Bay has been extensively revegetated and is now in good condition, although still very narrow. The remaining vegetated margin is also managed, but in many areas very narrow with weeds.

Existing Condition

- Existing condition of all rocky and beach habitat is expected to be generally "good" given its well flushed nature and part inclusion in a marine reserve, apart from localised areas where stormwater and treated wastewater discharge and in particular cause exceedance of shellfish disease risk criteria (Lyall Bay, Tarakena Bay). Lyall Bay duneland is small but in good condition. The remaining vegetated areas between the road and the beaches and rocks have many weeds but are being actively managed.

Presence of Stressors

- The presence of stressors is expected to be "moderate". Stressors include human pressure on fish and shellfish stocks, change to water quality through stormwater and wastewater discharges (and in the long term climate change), weed and pest invasions (including toxic algal blooms), threat of offshore oil spills, and loss of natural upper beach berm/dunes and drift.

Susceptibility to Stressors

- Susceptibility to stressors is expected to be "low-moderate" for the rock habitat given that the area is well flushed, is spread over a large area and includes a marine reserve. The small area of dune and margin habitat makes it particularly susceptible to damage. The beaches have low susceptibility (exposed and well flushed).

Issues	Monitoring	Management
Threat to high biodiversity rock habitat (esp. climate change, seafood collection, discharges). Small area of dune/berm vegetated habitat. Weed invasions around terrestrial margin.	• Monitor abundance and diversity of representative high biodiversity rocky intertidal habitat (assume marine reserve). • Map areas of invasive weeds, identify hot spots for management. • Monitor disease risk in waters and shellfish.	• Identify and reduce significant sources of faecal bacteria to the area. • Encourage management plans around climate change, oil spill, inshore fish quota, invasive pests, offshore algal blooms, stormwater, wastewater. • Develop trigger criteria for rock habitat, and evaluation and response plans. • Encourage weed management.

OWHIRO TO BREAKER BAY	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Moderate	Low-Mod	Moderate	Low	Low	Moderate	Moderate
Susceptibility Rating	Moderate	Low-Mod	Moderate	Low	Low	Moderate	Moderate

9. WELLINGTON HARBOUR

Wellington Harbour (8,900ha) is a large sea-filled basin, 10-30 m deep, with the Hutt River flowing in to the northeast and the exit to Cook Strait to the southeast. The catchment is primarily greywacke (a hard sandstone), and loess (the yellow-brown clays). The harbour has a muddy bed and rocky or sand/gravel margin, except for the sandy Petone Beach at the mouth of the Hutt River.

HUMAN USES AND VALUES

- High Use. Shipping, bathing, fishing, scientific, boating, walking, picnics, scenic, shellfish, driving, diving, windsurfing.

ECOLOGICAL VALUES

- **Soft Sediment Habitat.** This forms the bulk of the harbour and includes a high macroinvertebrate diversity dominated by polychaete worms, small crustaceans and molluscs.
- **Rocky Shore Habitat (intertidal and subtidal)**. Includes a wide variety of animals (barnacles, mussels, sea stars, brittle stars, shield shells, crabs, limpets, chitons, snails, kina, and juvenile crayfish) and various seaweeds and the invasive kelp *Undaria*).
- **Beach Habitat.** Sandy beach habitat (e.g. Petone Beach) is generally highly modified by grooming activities but because the beach is relatively long, has a gentle slope and ample organic matter, it still includes a wide variety of sand dwelling invertebrates (sandhoppers, pipi, polychaete worms). Steep gravel cobble beaches, tend to have less diversity.
- **Dune/Vegetated Margin Habitat**. This habitat has been the most affected by change in the harbour over time. Dunes and salt marsh were common in the Petone Hutt River estuary area and now they have been reduced to very small areas. The area with the most unmodified edge is situated on the east side between Eastbourne and Pencarrow Hd. Much revegatation and shoreline management is however currently being undertaken to improve this important buffering zone.
- **Artificial Structure Habitat;** the harbour includes a large area of habitat on artificial structures which is home to a wide variety of of plants and animals.
- **Water Habitat.** Plant and animal life in the harbour waters is dominated by microscopic phytoplankton, zooplankton, various fish species (spotties, wrasse, leatherjackets, yellow-eyed mullet, flounder, stargazers, stingrays) and occasionally dolphins, seals and penguins.

STRESSORS

Most of the coast has been modifed by urban development of Wellington, Lower Hutt, Petone and Eastbourne and this has drastically altered the habitat values of the margin. The major stressors are:

- **Extensive seawalls**: approximately half of the harbour margin has been modified (seawalls and roads).
- **Reclamations**. Major sections of the harbour have been reclaimed in the Wellington dockyard area, at Kaiwharawhara, and at Seaview to the east of the Hutt River mouth. This has led to the loss of extensive saltmarsh and tidal flat areas.
- **Marinas**. Marinas are in the southwest section of Evans Bay, Oriental Bay, and near Lowry Bay.
- **Point Source Discharges**. Historically there were lots of discharges but the only point source discharges to the harbour at present are urban stormwater outfalls, which may, on occasion during very wet weather, include sewer overflows.
- **Nonpoint Source Discharges.** The Hutt River discharges a large amount of sediment, nutrients, pathogens and possibly toxicants to the harbour.
- **Invasive Pests**. The asian kelp *Undaria* is now common in the harbour.
- **Spills**. Exposed to spills from ships, boats and road transport.

SUSCEPTIBILITY TO STRESSORS.

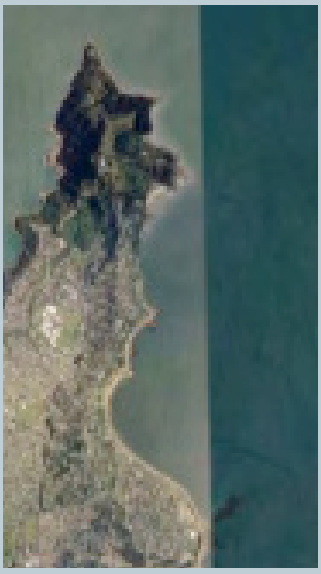
- Because the harbour is relatively deep and sheltered, it acts as a natural settling basin for sediment, nutrients, pathogens and toxicants. However, it is also relatively well flushed with clean seawater each tide and so has a certain resilience to degradation. The muddy harbour bed habitat is most susceptible to toxins and organic build-up. The rocky habitat is extensive and relatively resilient, but is susceptible to toxins (e.g. toxic algal blooms), excessive sediment, invasive pests and collection for seafood.

EXISTING CONDITION

- **Water and Sediment Quality**. Harbour waters are generally of good quality except in river plumes during rain events (particularly Hutt River) and near stormwater outfalls. Lowered water clarity, excessive sedimentation, faecal bacteria, nutrients and metals are the major impacts.
- **Biota**. Harbour plants and animals have been affected by the large changes to the harbour following urbanisation, however, biodiversity is still high in the main remaining habitats.

9. WELLINGTON HARBOUR - WORSER BAY TO KAU BAY

BEACHES AND ROCKY SHORES



Worser to Kau Bay (Google)

Worser Bay

OVERALL VULNERABILITY RATING

Low

Moderate

Details Appendix 3

Situated in Wellington Harbour, this section of the coast is sheltered and bathed by relatively clear, clean waters. It consists of a string of mainly urban embayments (Worser, Karaka, Scorching, Mahanga and Kau Bays) separated by hard rocky shores and reefs. The beaches are narrow, moderate gradient and a mix of sand and gravel. The inshore beach vegetated margin is either narrow or non-existent and dunes are rare. Above the vegetated margin there is usually a road and either houses or bush covered hills.

Uses and Values

- High Use. Bathing, fishing, boating, walking, picnics, scenic, shellfish, driving, diving.

Ecological Values

- This section includes a significant area of moderately sheltered rocky shore and shallow subtidal reef habitat with an expected moderate biodiversity of animals and plants. Biodiversity is expected to be low at the sand/gravel beaches. The duneland area is small (near Seatoun) and has been revegetated. The remaining vegetated margin is also managed, but in many areas very narrow with weeds.

Existing Condition

- Existing condition of all rocky and beach habitat is expected to be generally "good" given its well flushed nature. Duneland is small but in good condition. The remaining vegetated areas between the road and the beaches and rocks have many weeds but are being actively managed.

Presence of Stressors

- The presence of stressors is expected to be "moderate". Stressors include human pressure on fish and shellfish stocks, change to water quality through stormwater discharges (and in the long term climate change), weed and pest invasions (including toxic algal blooms), threat of offshore oil spills, and loss of natural upper beach berm/dunes and drift.

Susceptibility to Stressors

- Susceptibility to stressors is expected to be "low-moderate" for the rock habitat given that the area is well flushed and is spread over a large area. The small area of dune and margin habitat makes it particularly susceptible to damage. The beaches have low to moderate susceptibility (well flushed but high human use).

Issues	Monitoring	Management
Threat to moderate biodiversity rock habitat (esp. climate change, seafood collection, discharges). Small area of dune/berm vegetated habitat. Weed invasions around terrestrial margin.	• Map areas of invasive weeds, identify hot spots for management. • Monitor disease risk in waters and shellfish	• Identify and reduce significant sources of faecal bacteria to the area. • Encourage management plans around climate change, oil spill, inshore fish quota, invasive pests, offshore algal blooms, stormwater. • Encourage weed management.

WORSER BAY TO KAU BAY	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low-Mod	Moderate	Low	Low	Moderate	Moderate
Susceptibility Rating	Low	Low-Mod	Moderate	Low	Low	Moderate	Moderate

9. W. HARBOUR - PT HALSWELL TO PT JERNINGHAM

BEACHES AND ROCKY SHORES

Evans Bay (Google)

East side Evans Bay

OVERALL VULNERABILITY RATING

Moderate

Details Appendix 3

Situated in Wellington Harbour, this urbanised section of the coast is sheltered and bathed by relatively clear, clean waters. It is shaped like a horseshoe with Evans Bay at the head and small embayments and rocky shores running along each side (Shelly, Kio, Weka, Balaena and Little Karaka Bays). The beaches tend to be rocks and cobbles and are narrow, with a moderate gradient. Sand/gravel beaches are found at Haitaitai, and Kio Bay. The inshore beach vegetated margin is either narrow or non-existent and dunes are absent. Above the vegetated margin there is usually a road, and buildings or road and bush covered hills. A marina and wharf structures are present in several areas. Sea walls are common at the head of the bay and along the western edge.

Uses and Values

- High use in some areas. Bathing, fishing, boating, walking, picnics, scenic, driving, diving.

Ecological Values

- This section includes a significant area of moderately sheltered rocky shore and shallow subtidal reef habitat with an expected moderate biodiversity of animals and plants. Offshore the sediments are muddy. Biodiversity is expected to be moderate on the sheltered cobble/rock beaches. Where vegetated the margin is primarily grassed with trees.

Existing Condition

- Existing condition of all rocky and beach habitat is expected to be generally "good" given its moderately flushed nature. However, much is modified and exists as seawalls. The remaining vegetated areas between the road and the beaches and rocks are being actively managed. Inshore fine sediments may have elevated metal and PAH levels.

Presence of Stressors

- The presence of stressors is expected to be "moderate". Stressors include human pressure on fish and shellfish stocks, change to water quality through stormwater discharges (and in the long term climate change), weed and pest invasions (including toxic algal blooms), threat of offshore oil spills, and loss of natural upper beach berm/dunes.

Susceptibility to Stressors

- Susceptibility to stressors is expected to be "moderate" for the rock habitat given that the area is moderately flushed, is spread over a large area, and is relatively resilient. The small area of margin habitat makes it particularly susceptible to damage. The beaches have moderate susceptibility (well flushed but high human use). Soft subtidal sediments are likely to be contaminated from past and existing discharges.

Issues	Monitoring	Management
Threat to moderate biodiversity rock habitat (esp. climate change, seafood collection, discharges, toxic algal blooms, invaders) Small area of dune/berm vegetated habitat.	• Monitor disease risk in waters and shellfish	• Identify and reduce significant sources of faecal bacteria to the area. • Encourage management plans around climate change, oil spill, inshore fish quota, invasive pests, offshore algal blooms, stormwater. • Encourage weed management.

Pt HALSWELL TO JERNINGHAM	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low-Mod	Moderate	Low	Low	Moderate	Moderate
Susceptibility Rating	Low	Low-Mod	Moderate	Low	Low	Moderate	Moderate

9. W. HARBOUR - ORIENTAL BAY TO PETONE BEACH

BEACHES AND ROCKY SHORES

Oriental Bay to Petone (>Google)

Welington City

OVERALL VULNERABILITY RATING

Low
Moderate

Details Appendix 3

Situated in Wellington Harbour, this highly modified section of the coast is sheltered and bathed by relatively clear, clean waters (except during rainfall periods when urban stormwater is discharged in large amounts). The area includes Oriental Bay (which has seawalls and an artificial sand beach), a marina, the main port wharf facilities, Kaiwharawhara Estuary, and the long seawall between Kaiwharawhara and Petone Beach. Above high water, there is no vegetated margin, instead there is usually a road, and buildings or wharves. Midway along the seawall a small stream, Ngauranga Stream, discharges to the harbour via a built-over culvert. The stream has elevated nitrate, metals and faecal concentrations (Milne & Perrie 2005).

Uses and Values

- High use in some areas. Shipping, bathing, fishing, boating, walking, picnics, scenic, driving, diving.

Ecological Values

- Shoreline values are relatively low given the highly modified nature of the substrate and at times, water quality. However, they still provide habitat for a wide variety of plants and animals.

Existing Condition

- Existing condition of the available artificial habitat is moderate.

Presence of Stressors

- The presence of stressors is expected to be "moderate". Stressors include change to water quality through stormwater discharges (and in the long term climate change), weed and pest invasions (including toxic algal blooms), threat of spills, and loss of natural margin habitat.

Susceptibility to Stressors

- Susceptibility to stressors is expected to be "low-moderate" given the already highly modified nature of the available habitat.

Wharves, Welington Harbour

Issues	Monitoring	Management
Extensive artificial habitat. Urban stormwater discharges. Toxic algal blooms	• Monitor disease risk in waters. • Monitor loads of contaminants from urban SW and impacts.	• Identify and reduce significant sources of faecal bacteria to the area. • Encourage management plans around climate change, oil spill, inshore fish quota, invasive pests, offshore algal blooms, stormwater.

ORIENTAL BAY TO PETONE BEACH	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low-Mod	Low-Mod	High	Moderate	Low-Mod	Moderate	Moderate
Susceptibility Rating	Low-Mod	Low-Mod	High	Moderate	Low-Mod	Moderate	Moderate

9. WELLINGTON HARBOUR - ESTUARIES

KAIWHARAWHARA ESTUARY

Estuary Type/Area	Tidal River Mouth (0.5 ha)
Catchment	17 km^2 (urban, native forest)
Dairy cows	0 cows
Nitrogen loading	Low 5-8 kg/ha/yr
Catchment geology	Greywacke, urban
Saltmarsh (ha)	<0.1ha
Salinity	Varies
Mean depth (m)	0.5-1m
Tidal flats	Nil
Uses/Values	Conservation

Kaiwharawhara Estuary (Google)

OVERALL VULNERABILITY RATING

Details Appendix 3

The Kaiwharawhara Estuary is a very small "tidal river mouth" type estuary which drains into Wellington Harbour (details Appendix 2). It has a small area of salt marsh vegetation and gravel beach near the mouth but otherwise its margins are concrete culverts. The estuary is 10m wide, 1m deep, and <100m long. The intertidal area is relatively small and does not have tidal flats. Extensive catchment work is currently underway to improve the upstream freshwater habitat.

Uses and Values

Human use of the estuary is low; primarily used for conservation.

Ecological Values

Ecologically, habitat diversity is low, given the modified upstream channel, absence of tidal flats and salt marsh vegetation. Such conditions provide poor habitat for native fish and tidal flat organisms.

Existing Condition

Salinities vary depending on the extent of tidal inflow. The water is clear and the sediments gravel and mud with little sign of anoxic conditions. Currently the water quality in the stream is fair (moderate nutrient but elevated *e.coli* concentrations), reflecting the dominant urban/native forest landuse. Estimated nitrogen loadings are low-moderate. Because the estuary is relatively well flushed its quality is expected to be similar to the river. Estuary sediment quality is expected to be moderate (possibly elevated toxic contaminants).

Presence of Stressors

The presence of stressors is expected to be "low-moderate". Stressors include; concrete channels, absence of vegetated margins, change to water quality through urban SW discharges, and weed and pest invasions.

Susceptibility to Stressors

Susceptibility to stressors is expected to low-moderate given that the area is well flushed, and already highly modified.

Kaiwharawhara Estuary

Issues	Monitoring	Management
Concrete channels. Low habitat diversity. Urban SW	• Map intensive landuse (urban, high production pasture) in the catchment 5 yearly. • Monitor potential toxicants in sediment.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ.

KAIWHARAWHARA ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Moderate	Low-Mod	High	Moderate	Low
Susceptibility Rating	Low	Low	Moderate	Low-Mod	High	Moderate	Low

9. WELLINGTON HARBOUR - ESTUARIES

KOROKORO ESTUARY

Estuary Type/Area	Tidal River Mouth (1.5 ha)
Catchment	16 km^2 (native forest, pasture)
Dairy cows	0 cows
Nitrogen loading	Low 3-8 kg/ha/yr
Catchment geology	Greywacke, Loess
Saltmarsh (ha)	<0.1ha
Salinity	Varies
Mean depth (m)	0.5-1m
Tidal flats	Nil
Uses/Values	Swimming, picnics, conservation

Korokoro Estuary
(Google)

OVERALL VULNERABILITY RATING

Low

Details Appendix 3

The Korokoro Estuary is a very small "tidal river mouth" type estuary which drains into Wellington Harbour at Petone (details Appendix 2). It has a small area of planted salt marsh vegetation (available for inanga spawning) and gravel beach near the mouth but upstream its margins are concrete culverts. The estuary is 10m wide, 1m deep, and <100m long. The intertidal area is relatively small and does not have tidal flats. The upstream catchment is over 60% native bush.

Uses and Values

Human use of the estuary is moderate; primarily used for scenic, picnics, bathing.

Ecological Values

Ecologically, habitat diversity is low, given the modified upstream channel, absence of tidal flats, and limited salt marsh vegetation. Such conditions provide poor habitat for native fish and tidal flat organisms.

Existing Condition

Salinities vary depending on the extent of tidal inflow. The water is clear and the sediments gravel and mud with little sign of anoxic conditions. Currently the water quality in the stream is likely to be good reflecting the dominant native forest landuse. Estimated nitrogen loadings are low-moderate. Because the estuary is relatively well flushed its quality is expected to be similar to the river. Estuary sediment quality is expected to be high.

Presence of Stressors

The presence of stressors is expected to be "low-moderate". Stressors include; concrete channels, absence of vegetated margins, and weed and pest invasions.

Susceptibility to Stressors

Susceptibility to stressors is expected to low-moderate given that the area is well flushed, and already highly modified.

Korokoro Estuary

Issues	Monitoring	Management
Concrete channels. Low habitat diversity.	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ.

KOROKORO ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low	Low	Low-Mod	High	Moderate	Low
Susceptibility Rating	Low	Low	Low	Low-Mod	High	Moderate	Low

9. WELLINGTON HARBOUR - ESTUARIES

HUTT ESTUARY

Estuary Type/Area	Tidal River Mouth
Catchment	149 km^2 (native forest)
Dairy cows	0 cows
Nitrogen loading	Low 3-8 kg/ha/yr
Catchment geology	Greywacke, alluvium, peat, sand
Saltmarsh (ha)	1-2ha
Salinity	Varies depending on mouth closure
Mean depth (m)	1-3m
Tidal flats	Moderate (lagoon floods beach)
Uses/Values	Fishing, bathing, birds, whitebait, picnics, conservation, shellfish.

Hutt Estuary

OVERALL VULNERABILITY RATING

Moderate

Details Appendix 3

The Hutt Estuary is a moderate-sized "tidal river mouth" type estuary which drains into Wellington Harbour at Petone (details Appendix 2). It has been extensively reclaimed and modified, and the banks clad with large rip-rap (quarried boulders). Such substrate has low biodiversity and is unsuitable as inanga spawning substrate. However, where rip-rap is absent (two small areas, one near the Sladden Park boat ramp in Petone, and the other on the opposite bank along "Opahu" stream) margin vegetation is present providing reasonable spawning habitat (Taylor and Kelly 2001). The margins of the western arm are planted in native species. Saltmarsh habitat was once extensive but, through reclamations, has been reduced to a small planted area on the western bank. The area of tidal flats has also been reduced (now approx. 0.5ha).

Uses and Values

Human use of the estuary is moderate; a local focal point, is used for conservation, boating, birdwatching, whitebaiting.

Ecological Values

Ecologically, habitat diversity is low, given the modified channel, and the small area of tidal flats, salt marsh, and weedy banks.

Existing Condition.

Salinities vary depending on the extent of tidal inflow. The water is clear and the sediments a soft sandy mud with little sign of anoxic conditions. Currently the water quality in the stream is good (low nutrient and *e.coli* concentrations), reflecting the dominant native bush catchment. Estimated nitrogen loadings are low. However, because of the high volume, it is the major contributor of nutrients, sediment and contaminants to the estuary and harbour. Because the estuary is relatively well flushed its quality is expected to be similar to the river. Estuary sediment quality is good (low metals and moderate organic matter and nutrient contents).

Presence of Stressors

The presence of stressors is "moderate". Stressors include; stormwater, rip rap margins, change to water quality through nonpoint discharges (esp. urban streams), historical drainage/reclamation, weed and pest invasions.

Susceptibility to Stressors

Susceptibility to stressors is expected to be low-moderate given that the area is well flushed and habitats already highly modified.

Issues	Monitoring	Management
Water and sediment quality (particularly settling areas, e.g. stream mouths). Artificial rip rap estuary margins reduces habitat values. Loss of shallow areas for water to spread (wetland, tidal flat areas).	• Map intensive landuse (urban, high production pasture) in the catchment at 5 yearly intervals. • Broad scale mapping of sediment types, sed. rates, vegetation (5 yearly intervals). • Fine scale monitoring of key intertidal sediment condition indicators. 3 years baseline, then review. • Monitor disease risk in waters.	• Limit intensive landuse development and/or manage to ensure impacts don't degrade estuary WQ. • Develop management plan to improve saltmarsh habitat, and area of tidal flats (explore options for reshape and revegetation of margins in certain areas).

HUTT ESTUARY	Sedimentation	Eutrophication	Disease Risk	Contaminants	Habitat Loss	Invaders	Shellfish Issues
Existing Condition Rating	Low-Mod	Low	Moderate	Moderate	High	Low	Low
Susceptibility Rating	Low-Mod	Low	Moderate	Moderate	High	Low	Low

9. WELLINGTON HARBOUR - LOWRY BAY TO ROBINSON BAY

BEACHES AND ROCKY SHORES

Lowry to Robinson Bay (Google)

Robinson Bay

OVERALL VULNERABILITY RATING

Low
Moderate

Details Appendix 3

Situated along the eastern side of Wellington Harbour, this section of the coast consists of a string of mainly urban embayments (Lowry, York, Mahina, Sunshine, Days, Rona, Robinson Bays), separated by hard rocky shores and reefs. The beaches are narrow, moderate gradient and a mix of sand, gravel and cobbles. The inshore beach vegetated margin is either narrow or non-existent and dunes are rare. Above the vegetated margin there is usually a road, then either houses or bush covered hills.

Uses and Values

- High Use. Bathing, fishing, boating, walking, picnics, scenic, shellfish, diving.

Ecological Values

- This section includes a significant area of moderately sheltered rocky shore and shallow subtidal reef habitat with an expected moderate biodiversity of animals and plants. Biodiversity is expected to be low at the sand/gravel beaches. The duneland area is small and has been revegetated. The remaining vegetated margin is also managed, but in many areas very narrow with weeds.

Existing Condition

- Existing condition of all rocky and beach habitat is expected to be generally "good" given its well flushed nature. Duneland is small but in good condition. The remaining vegetated areas between the road and the beaches and rocks have many weeds but are being actively managed.

Presence of Stressors

- The presence of stressors is expected to be "moderate". Stressors include human pressure on fish and shellfish stocks, beach grooming, change to water quality through stormwater discharges (and in the long term climate change), weed and pest invasions (including toxic algal blooms), threat of offshore oil spills, and loss of natural upper beach berm/dunes and drift.

Susceptibility to Stressors

- Susceptibility to stressors is expected to be "low-moderate" for the rock habitat given that the area is well flushed and is spread over a large area. The small area of dune and margin habitat makes it particularly susceptible to damage. The beaches have low to moderate susceptibility (well flushed but high human use).

Issues	Monitoring	Management
Threat to moderate biodiversity rock habitat (esp. climate change, seafood collection, discharges). Small area of dune/berm vegetated habitat. Weed invasions around terrestrial margin.	• Map areas of invasive weeds, identify hot spots for management. • Monitor disease risk in waters and shellfish	• Identify and reduce significant sources of faecal bacteria to the area. • Encourage management plans around climate change, oil spill, inshore fish quota, invasive pests, offshore algal blooms, stormwater. • Encourage weed management.

LOWRY BAY TO ROBINSON BAY	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low	Low-Mod	Moderate	Low	Low	Moderate	Moderate
Susceptibility Rating	Low	Low-Mod	Moderate	Low	Low	Moderate	Moderate

9. WELLINGTON HARBOUR - CAMP BAY TO BARING HEAD

BEACHES AND ROCKY SHORE

Camp Bay to Baring Head (Google)

Camp Bay

OVERALL VULNERABILITY RATING

Low

Details Appendix 3

Situated along the eastern side and near the mouth of Wellington Harbour, this rural and uninhabited section of the coast begins with Camp Bay (a steep gravel cobble beach, with a small area of pingao dune field), then a 6km stretch of isolated rocky shore to Pencarrow Head (has private Council road on inner margin), and ends at Fitzroy Bay (an exposed, relatively wide, steep gravel beach, with roky reefs and outcrops and diverse vegetation along upper beach margin). Gravel is extracted from Fitzroy Beach and a large volume of treated wastewater is discharged at Pencarrow Head.

Uses and Values

- Moderate use. Wastewater assimilation, fishing, boating, walking, scenic, shellfish, diving and gravel mining.

Ecological Values

- This section includes a significant area of moderately sheltered rocky shore and shallow subtidal reef habitat with an expected high-moderate biodiversity of animals and plants. Biodiversity is expected to be low at the sand/gravel beaches. The duneland area is small. The remaining vegetated margins are relatively extensive and diverse at Fitzroy Bay but does include weed growth.

Existing Condition

- Existing condition of all rocky and beach habitat is expected to be generally "good" given its well flushed nature. Duneland is small but in moderate condition. The remaining vegetated areas between the road and beaches and rocks have many weeds.

Presence of Stressors

- The presence of stressors is expected to be "moderate". Stressors include human pressure on fish and shellfish stocks, change to water quality through wastewater discharges (and in the long term climate change), weed and pest invasions (including toxic algal blooms), threat of offshore oil spills, and loss of natural upper beach berm/dunes. Wastewater from urban areas in the Hutt and Wainuiomata is discharged to near-shore coastal waters at Bluff Point in Fitzroy Bay.

Susceptibility to Stressors

- Susceptibility to stressors is expected to be "low" for the rock habitat given that the area is well flushed and is spread over a large area. The small area of dune and margin habitat makes it particularly susceptible to damage, particularly from weeds. The beaches have low to moderate susceptibility.

Issues	Monitoring	Management
Threat to moderate biodiversity rock habitat (esp. climate change, seafood collection, discharges). Small area of dune/berm vegetated habitat. Weed invasions around terrestrial margin.	• Map areas of invasive weeds, identify hot spots for management. • Monitor disease risk in waters and shellfish • Monitor biodiversity in representative rock habitat in harbour environment (e.g. Camp Bay), 5 yearly.	• Identify and reduce significant sources of faecal bacteria to the area. • Encourage management plans around climate change, oil spill, inshore fish quota, invasive pests, offshore algal blooms, stormwater. • Encourage weed management.

CAMP BAY TO BARING HEAD	Disease Risk	Algal Blooms	Habitat Loss	Contamination	Clarity Issues	Invaders	Shellfish Issues
Existing Condition Rating	Low-Mod	Low-Mod	Low-Mod	Low-Mod	Low	Low-Mod	Low-Mod
Susceptibility Rating	Low-Mod	Low-Mod	Low-Mod	Low-Mod	Low	Low-Mod	Low-Mod

10. CONCLUSIONS

The risk assessment study of Wellington Harbour, Kapiti, Southwest and South Coasts was undertaken to identify ecological monitoring and management priorities for the Greater Wellington Regional Council. The study identified both sheltered and exposed coastlines with a wide range of coastal shoreline habitats including: estuaries, beaches, dunes, rocky shores, with a variety of hinterlands. For each of these broad habitats, the study has provided three main outputs: habitat summaries, vulnerability assessments, and monitoring priorities which are summarised as follows:

Estuaries	**(i) Habitat Mapping** The section Kapiti to Wellington Harbour includes 1 large tidal lagoon estuary (Porirua Harbour), 2 tidal river estuaries (Hutt and Otaki Estuaries) and 15-25 small tidal river mouth estuaries which generally have streams draining to them. These latter estuaries generally exhibited low habitat diversity, with salt marsh and tidal flats virtually absent, and lagoon size varying throughout the year (depending on the extent of mouth blockage). Porirua Harbour and Waikanae Estuaries exhibited the greatest habitat diversity. **(ii) Vulnerability Assessment** Vulnerability assessments of the small tidal river mouth estuaries indicated mainly low or low-moderate vulnerability to ecological damage from the major stressors (primarily because they are small and already highly modified), except for the larger Waikanae Estuary which exhibited moderate vulnerability (has greater habitat diversity). Of the tidal river estuaries the Otaki has low vulnerability (low habitat diversity), however, the Hutt Estuary, with its highly urbanised adjacent catchment and extensive past reclamations, has a moderate rating. Porirua Harbour (a large shallow tidal lagoon with broad habitat diversity and uses) also has a moderate rating. **(iii) Monitoring Recommendations** • Monitor major stressors (e.g. intensive landuse) in estuary catchments 5 yrly. • Monitor and manage long term condition of representative high biodiversity estuaries (Waikanae, Porirua and Hutt Estuaries) with moderate to high susceptibility to ecological change. • Develop management plans to improve habitat diversity and condition in small tidal river mouth estuaries (particularly those on Kapiti coast).
Beaches	**(i) Habitat Mapping** This coast included a wide range of beach types including: primarily broad, flat, sandy beaches with wide surf zones bathed by cloudy waters (Kapiti Coast), which progressively change on exposed shores towards the south to moderately steep beaches, with dark coarser grained sand and ultimately to very steep, gravel beaches (lacking a surf zone) and having clear waters. In the more sheltered embayments on the Sth Coast, intermediate gradient sand or sand/gravel beaches were present (e.g. Lyall Bay). Within the harbour, there were a range of small narrow beaches and one much larger beach (Petone Beach). Biodiversity was greatest in the less harsh environment of the dissipative and intermediate type beaches (Kapiti Coast, Lyall Bay, and Petone Beach). **(ii) Vulnerability Assessment** The majority of beaches had low or low-moderate vulnerability to ecological damage from the major stressors except for Kapiti and Petone beaches which had moderate vulnerability. Habitat degradation through sea level rise, vehicle access, stormwater discharges, river plumes, property development on dunes and seawalls were the major stressors. **(iii) Monitoring Recommendations** Monitor trends in biodiversity of beaches with highest biodiversity, (e.g. Nth Waikanae and Petone Beaches).

10. CONCLUSIONS

Dunes	**(i) Habitat Mapping** The Kapiti coast has the most extensive dune areas. In other sections they are present only as a very thin margin. Most of the dunes were dominated by the introduced and invasive marram grass. However, in many areas active dune management has been undertaken with significant areas planted in native duneland species. Biodiversity is expected to be greatest in the native dominated dunes where a more diverse range of habitats are present. **(ii) Vulnerability Assessment** Vulnerability assessments of the dune habitat indicated mainly low or low-moderate vulnerability. However, because these assessments were included in a combined beach, dune and rocky shore assessment for different sections of the coast, they will generally underestimate individual duneland vulnerability at a local scale. Major stressors on dune habitat include invasion of marram grass, vehicles and sea level rise and subsequent removal or inland migration of dunes through erosion. **(iii) Monitoring Recommendations** Monitor long term trends in dune area, dominant vegetation and invasive weeds.
Rocky shores	**(i) Habitat Mapping** Hard greywacke-dominated rocky shores were common in the SW, Sth Coasts and in Wellington Harbour. Biodiversity of rocky shores are expected to be moderate or high in all areas. **(ii) Vulnerability Assessment** Vulnerability assessments of the rocky shore habitat indicated mainly low or low-moderate vulnerability. The key stressors were identified as: sea level and sea temperature increases, and seafood collection. Habitat changes and effects on rocky shore biodiversity was the primary ecological threat. **(iii) Monitoring Recommendations** Monitor long term trends in biodiversity of high biodiversity rocky shores.
Margin (200m)	**(i) Habitat Mapping** The immediate coastal hinterland included grassland, roads, residential properties, wharves, and extensive urban areas. **(ii) Vulnerability Assessment** Vulnerability assessments were not undertaken specifically on hinterland. However, margin landuse was one of the stressors used in the vulnerability assessment. In general, it was an issue in relation to grazing pressure on dunelands (absence of fencing), property development on old dunelands and shore margins and spread of weeds. **(iii) Monitoring Recommendations** Monitor landuse of coastal margin land at 5 yearly intervals.

11. ACKNOWLEDGEMENTS

The field component of this project was undertaken during August 2007. To prepare for this, the staff of Greater Wellington Regional Council, Porirua City Council and Kapiti District Council provided a vast array of background information in double quick time and with very little forewarning, for which we are very grateful. In addition, we would like to especially thank Tim Park (GWRC ecologist) and Maz Robertson (Wriggle Coastal Management) for their extensive help in the field and with issues on the Kapiti coast.

12. LIST OF REFERENCES

ANZECC, 2000. Australian and New Zealand guidelines for fresh and marine water quality. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Bell R.T., Hume T.M. and D.M. Hicks. 2001. Planning for climate change effects on coastal margins. Ministry for the Environment Report ISBN 0-478-24040-6, ME 410.

Boffa Miskell Ltd. 2001. Queen Elizabeth Park coastal dunes management discussion document. Prepared for Wellington Regional Council. 70p.

Defeo, O. and A. McLachlan 2005. Patterns, processes and regulatory mechanisms in sandy beach macrofauna: a multi-scale analysis. Marine Ecological Progress Series, Vol 205, 1-20.

Hilton, M.J. 2006: The loss of New Zealand's active dunes and the spread of marram grass (Ammophila arenaria). NZ Geographer 62, 105-120.

Hawke, R.M. and J. A. McConchie. 2006. Dune phases in the Otaki-Te Horo area (New Zealand): a geomorphic history. Earth Surface Processes and Landforms. 31 (6), 633-645

Hume, T.M., Snelder, T., Weatherhead, M., and Liefting, R. (in press). A controlling factor approach to estuary classification. Ocean and Coastal Management.

Kirk, R.M., and Lauder, G.A. 2000. Significant coastal lagoon systems in the South Island, NZ - coastal processes and lagoon mouth closure. Published by Department of Conservation.

McLay, C. L. 1976: An inventory of the status and origin of New Zealand estuarine systems. Proceedings of the New Zealand Ecological Society 23: 8-26.

Milne, J.; Perrie, A. 2005. Freshwater quality monitoring technical report. Greater Wellington Regional Council, Publication No. GW/RINV-T-05/87.

Partridge, T. 1992: The Sand Dune and Beach Vegetation Inventory of New Zealand. I. North Island. DSIR Land Resources Scientific Report Number 15, DSIR Land Resources: Christchurch, 253p.

Perrie, A. 2007. The state of water quality in selected rivers and streams in the Wellington region, 2003-2006. Greater Wellington Regional Council, Publication No. GW/EMI-T-07/218.

Robertson, B.M. 2007. Porirua Harbour Issues and Additional Information Requirements. Report for Greater Wellington Regional Council and Porirua City Council. 12p.

Robertson, B.M.; Gillespie, P.A.; Asher, R.A.; Frisk, S.; Keeley, N.B.; Hopkins, G.A.; Thompson, S.J.; Tuckey, B.J. 2002. Estuarine environmental assessment and monitoring: A National Protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No. 5096. Part A. 93p. Part B. 159p. Part C. 40p plus field sheets.

Robertson, B.M. and Stevens, L. 2006a. A proposed method for assessing the effects of river plumes in the Hawke's Bay Region. Prepared for Hawke's Bay Regional Council.

Robertson, B.M. and Stevens, L. 2006b. Monitoring and Managing Beach and Dune Condition: Hawkes Bay Region. Prepared for Hawke's Bay Regional Council.

Robertson, B.M. and Stevens, L. 2007. Wairarapa Coastal Habitats: Mapping, Risk Assessment and Monitoring. Prepared for Greater Wellington Regional Council. 120p.

Scarsbrook, M. 2006: State and Trends in the National River Water Quality Network (1989-2005). Report published by the Ministry for the Environment. ISBN: 0-478-30109-X ME number: 778.

Stevens, L.; Robertson, B. 2005: Broad scale habitat mapping of the coastline of the Hawke's Bay region. Prepared for Hawke's Bay Regional Council. Cawthron Report No. 1034. 37p plus appendices.

Stevens, L. and Robertson, B.M. 2004: Broad scale mapping of intertidal habitat and ecology of 16 sandy beaches and 4 river estuaries in Wellington Harbour, 2004. Prepared for Greater Wellington Regional Council. Cawthron Report No. 913.

Stevens, L., and Robertson, B.M. 2006. Broad scale habitat mapping of Sandy Beaches and River Estuaries on the Western Wellington Coast. Prepared for Greater Wellington Regional Council.

Taylor, M.J. & Kelly, G.R. (2001) Inanga spawning habitats in the Wellington Region, and their potential for restoration. NIWA, report prepared for Wellington Regional Council.

UNESCO 2000 Guidelines for Vulnerability Mapping of Coastal Zones in the Indian Ocean. IOC Manuals and Guides No. 38.

APPENDIX 1. VULNERABILITY MATRIX DETAILS

The assessment criteria for key components of the vulnerability matrix are as follows:

1. Human Uses

Information on the human uses and values of the coastal habitat and its margins were based on local knowledge and available information. The human use rating is based primarily on the estimated number of persons involved:

- Low: < 10 per year.
- Medium: 10 to 50 per year (< 30 per day in summer).
- High: > 30 per day (maybe just in summer) but < 200 per day.
- Very High: > 200 per day.

2. Ecosystem Values

Ecosystem values (richness) defines an ecosystem's natural riches (generally interpreted as habitat diversity and biodiversity). It can be supposed that the more rich and diversified an ecosystem is, the greater the losses will be in the event of a disruption. The ecological richness component is divided into four subcategories; birds, vegetation, fish and other biota.

3. Presence of Stressors (Pressures)

The stressors (or pressures) are activities (often in the catchment) that affect the ecological condition of coastal habitat (e.g. terrestrial runoff, grazing, seawalls, reclamation). Because their harmful effects cause a variety of environmental deteriorations they are identified and their risk characterised according to their estimated effect on relevant condition indicators (e.g. loss of saltmarsh, macroalgal growth). The assignment of risk is based on existing data (e.g. landuse, sediment and nutrient areal loadings, rock type, erosion susceptibility), observation and expert opinion.

4. Ecosystem Existing Condition and Susceptibility

The **"existing condition"** is a measure or estimate of the existing condition of the coastal habitats as assessed by relevant condition indicators (e.g. signs of eutrophication, sedimentation, habitat loss). The existing condition of the coastal area was primarily assessed based on expert opinion, supported by available information and monitoring data.

"Susceptibility" is assessed to provide an estimate of the susceptibility of the ecosystem to degradation. For example, an estuary where the mouth closes regularly and is poorly flushed, is physically susceptible to water and sediment quality degradation. Where uncertainty existed over the presence or potential impact of stressors, a conservative (protective) estimate was used.

5. Vulnerability Matrix and Monitoring Recommendations

The combined information collected and assessed in components 1, 2, 3, and 4 is used to determine an overall "vulnerability" rating and identify the priority monitoring indicators. This information is then used to design a monitoring programme using various tools including those provided in the National Estuary Monitoring Protocol (Robertson et al. 2002) plus recent extensions developed by Wriggle (e.g. Robertson & Stevens 2007a, b). The risk assessment is designed as a framework to enable input by other parties and recalculation of risks, if required.

APPENDIX 2 SUMMARY ESTUARY CHARACTERISTICS

KEY TO TERMS	
Mouth Closure	*c = closed, o= open, m = managed, con = constricts*
Landuse	*Values are: native forest/scrub %, Hi prod/Lo Prod Pasture %, Exotic forest %, urban % respectively (data from GWRC)*
Input Water Quality	*Values are: mean turb NTU, TN mg/l, TP mg/l, e.coli cfu/100ml] respectively, data from GWRC monitoring.*
Sediment Quality;	*Values are: sediment type, metals, organic toxins, nutrients, orgC., sed rate respectively.*
Water Quality	*Values are: nutrients, chlorophyll, clarity, e. coli. respectively*
Catchment Rock Type	*Gw= greywacke, Al = alluvium, Sd = sand, Lo = loess, Pt = peat, Urb = urban.*
Residence Time and Flushing	*Time in days if available; otherwise poor, moderate or well flushed, Cl = periodically poorly flushed due to lagoon closure or constriction.*
SOURCES OF INFORMATION	*SS and TN Loads; NIWA website.* *Water quality, landuse, dairy cows, geology: GWRC monitoring data (Milne and Perry 2005, Perry 2007).*

APPENDIX 2. ESTUARY CHARACTERISTICS

		Waitohu	Otaki	Mangaone	Peka Peka	Ngarara
General	Type	Tidal river mouth	Tidal river mouth	Tidal river mouth	Tidal River Mouth	Tidal River Mouth
	Mouth Closure	c, m	o, con	c, m	c, m	c, m
	Mean depth (m)	1-2m	1-2m	>1m Narrow	<1m	<1m
	Depth of central basin (m)	1-1.5m	NA	>1m	<1m	<1m
	Estuary Area (ha)	<1ha	10ha	<1ha	<1ha	<1ha
	Salinity regime	<5ppt	<5ppt	<5ppt	<5ppt	<5ppt
	Length of salinity intrusion	<500m	<500m	<500m	<500m	<500m
	Residence Time and Flushing	<3 days,Cl	< 1 day,	<3 days, Cl	<3 days, Cl	<3 days, Cl
	Slope of Catchment	Flat	Mixed	Flat	Flat	Flat
	Wind Exposure	Low	Mod	Low	Low	Low
	Mean Tidal Range (m)	Small	Small	Small	Small	Small
	Mean Freshwater Inflow (l/s) estimated	1099	30073	967	203	351
	Catchment Area (km2)	54.1	348	53	14.6	23.1
	Limiting Nutrient (N or P)	N	N	N	N	N
Habitat Diversity	Sheltered fringe areas	Stranded lagoon	Wet area to Nth	Nil		
	Salt Marsh/Dune Area (ha)	2-3ha	2-4ha	<0.5ha	<0.5ha	<0.5ha
	Seagrass Abundance	Low	Low	Nil	Nil	Nil
	Tidal Flats present	Low	Nil	Low	Low	Low
	Sediments in Estuary	Sand/gravel	Gravels, cobbles	Gravels	Sands	Sands
	Margin buffer	Grassland	Grassland	Grassland	Grassland	Grassland
Stressors	Catchment Rock Type	Gw, Al, Pt	Gw, Al	Gw, Al, Sd	Sd, Gw, Lo, Pt	Sd, Urb, Gw, Pt
	Landuse	32, 43/3, 8, 6	87, 8/1, 2, 0.2	16,67/1, 11, 1.3	6.3, 53/10,24, 0	21, 44/4, 8.6, 18
	Number Dairy Cows	1560	1670	2020	0	0
	Catchment SS yield (t/km2/yr)	Low, 10-50	Mod, 200-300	Low, 10-50	Low, 10-50	Low, 10-50
	Catchment TN yield (kg/ha/yr)	Mod/Hi, 14-20	Low, 5-8	High, 14-30	Mod/hi, 14-20	Mod/hi 14-20
	Point Source Inputs		Drain			
	Input Water Quality	1.8, 0.88, 0.014, 530.	2.4, 0.1, 0.013, 25.	5.3, 2.7, 0.062, 520	No Data	14.2,1.43, 0.143, 350
	Sea Level Rise	Low				
	Other Stressors					
Existing Condition	Macroalgal Blooms	Low	Low	Low	Low-mod	Low-mod
	Phyto blooms	Low	Low	Low	Low	Low
	DO depletion	Low	Low	Low	Low	Low
	HABs offshore	Possible	Possible	Possible	Possible	Possible
	Anoxic sediments	Low	Low	Possible	Possible	Possible
	Sediment Quality	No Data	No Data	No Data	No Data	No Data
	Water Quality	No Data	No Data	No Data	No Data	No Data
Potential	Potential for Habitat Improvement	Dune and stream margin potential.	Good potential to revegetate margins	Dune plantings round mouth.	Dune plantings round mouth. Reverse channelisation	Dune plantings round mouth.

APPENDIX 2. ESTUARY CHARACTERISTICS

		Waikanae	Tikotu	Wharemakau	Whareroa	Taupo
General	Type	Tidal River Mouth	Tidal River Mouth	Tidal River Mouth	Tidal River Mouth	Tidal River Mouth
	Mouth Closure	c, m	c, m	c, m	c, m	o
	Mean depth (m)	1-2m	<1m	<1m	<1m	<1m
	Depth of central basin (m)	1-1.5m	<1m	<1m	<1m	<1m
	Estuary Area (ha)	30-40ha	<1ha	<1ha	<1ha	<1ha
	Salinity regime	Varies	<5ppt	<5ppt	<5ppt	<5ppt
	Length of salinity intrusion	1.5-2 km	<500m	<500m	<500m	<500m
	Residence Time and Flushing	<3 days,Cl	< 1 day,	< 1 day,	< 1 day, Cl	< 1 day Cl
	Slope of Catchment	Flat	Moderate	Flat	Flat	Moderate
	Wind Exposure	Mod	Mod	Mod	Mod	Mod
	Mean Tidal Range (m)	Small	Small	Small	Small	Small
	Mean Freshwater Inflow (l/s) estimated	4500	56	250	328	120
	Catchment Area (km2)	149	7.1	12.4	15.8	8.8
	Limiting Nutrient (N or P)	N	N	N	N	N
Habitat Diversity	Sheltered fringe areas	Lakelets	Nil	Nil	Nil	Nil
	Salt Marsh/Dune Area (ha)	10-20ha	<0.1ha	<0.1ha	Approx 1 ha	<0.1ha
	Seagrass Abundance	Low	Nil	Nil	Nil	Nil
	Tidal Flats present	Present	Low	Low	Low	Low
	Sediments in Estuary	Sand/ mud	Sand/ mud	Sand/ mud	Sand/ mud	Sand/ mud
	Margin buffer	Grassland, urban	Grassland,urban	Grassland, urban	Grassland	Urban
Stressors	Catchment Rock Type	Gw, Lo, Al.	Urb, Sd	Gw, Lo, Pt, Urb	Gw, Lo, Pt, Sd	Gw, Lo, clay
	Landuse	60, 23/0.5,14.5, 2	1.2, 33/0, 0.8, 62	16, 34/0.5, 22, 27	22, 64/1, 9, 4.5	21, 69/0, 4, 5.5
	Number Dairy Cows	0	0	0	0	0
	Catchment SS yield (t/km2/yr)	LowMod, 10-200	Low, 10-50	Low, 10-50	Low, 10-50	Low, 10-50
	Catchment TN yield (kg/ha/yr)	Low, 5-8	Mod 8-20	Mod 8-20	Mod 8-20	Mod 8-20
	Point Source Inputs	3ry wastewater, SW	SW	SW		SW
	Input Water Quality	1.0, 0.32, 0.016, 38	No Data	No Data	11.2,1.1, 0.1,300	No Data
	Sea Level Rise	Low	Low	Low	Low	Low
	Other Stressors					
Existing Condition	Macroalgal Blooms	Moderate	Low	Low	Low-mod	Low
	Phyto blooms	Low	Low	Low	Low	Low
	DO depletion	Possible	Low	Low	Low	Low
	HABs offshore	Possible	Possible	Possible	Possible	Possible
	Anoxic sediments	Possible	Possible	Possible	Possible	Possible
	Sediment Quality	No Data	No Data	No Data	No Data	No Data
	Water Quality	No Data	No Data	No Data	No Data	No Data
Potential	Potential for Habitat Improvement	Dune and estuary margin potential.	Dune plantings round mouth.	Dune plantings round mouth.	Dune and estuary margin potential.	Dune plantings round mouth.

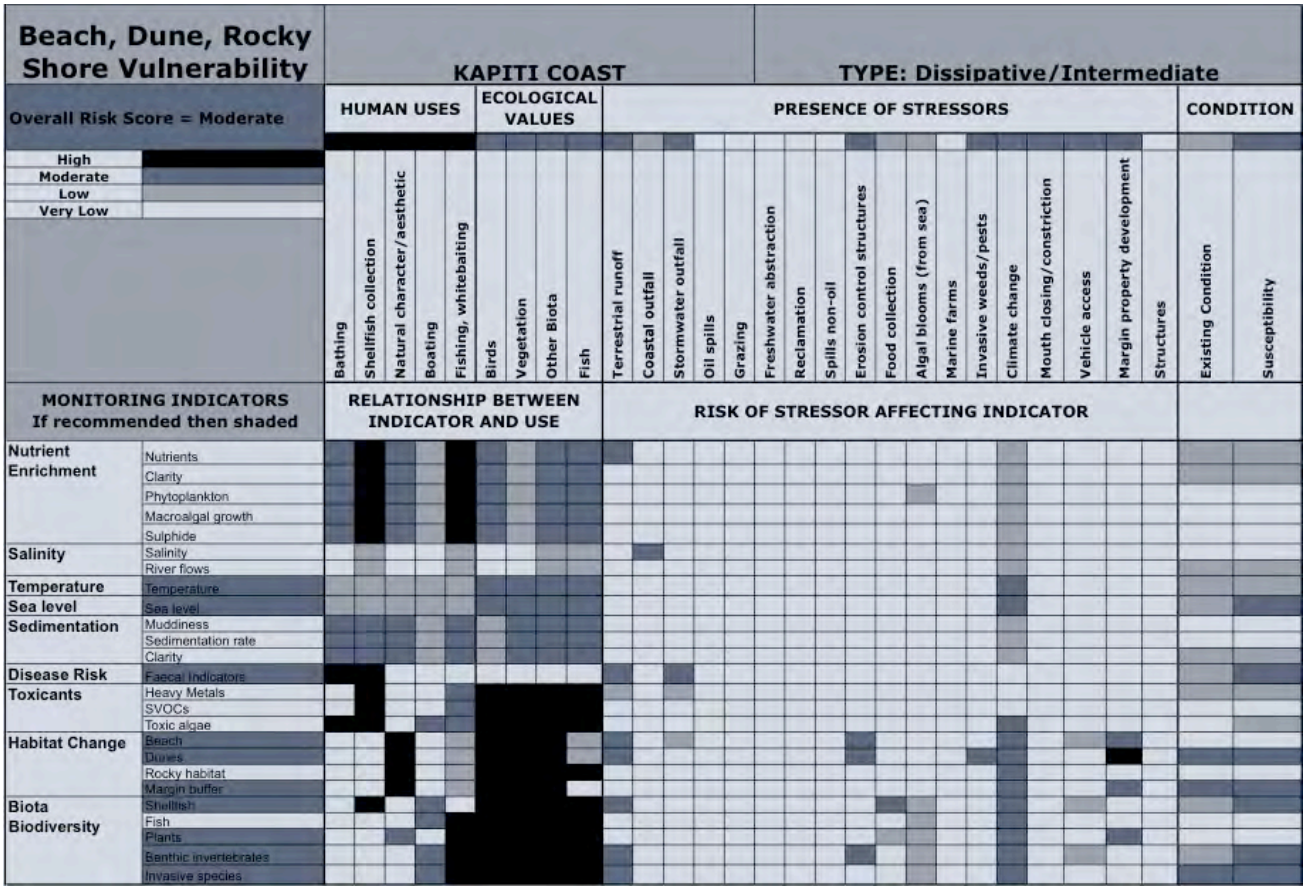
APPENDIX 2. ESTUARY CHARACTERISTICS

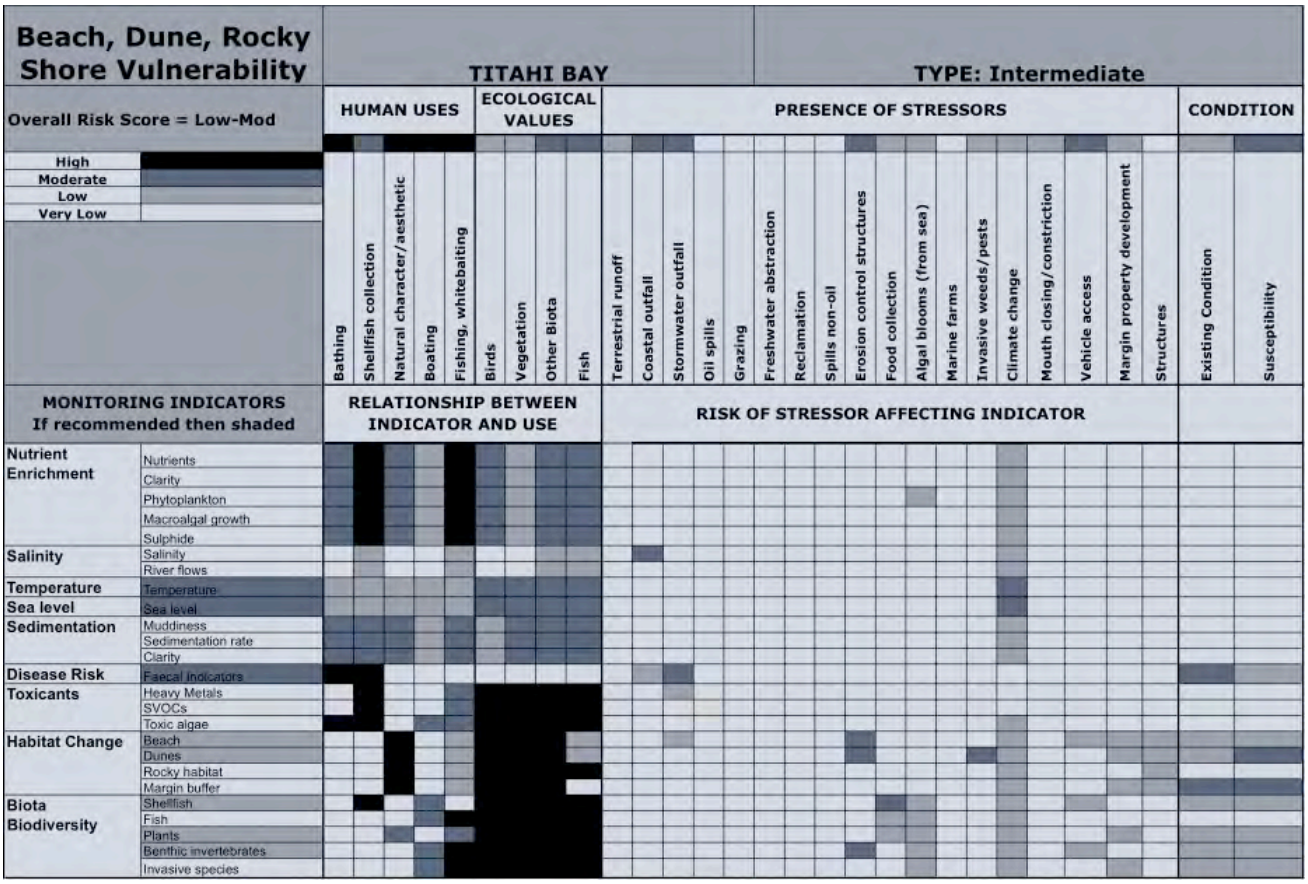
		Pauatahanui Arm	Porirua Arm
General	Type	Tidal Lagoon	Tidal Lagoon
	Mouth Closure	Open	Open
	Mean depth (m)	0.84m - 1.1m, max 10m.	Estimate 1m
	Depth of central basin (m)	approx 2-3m	approx 2-3m
	Estuary Area (ha)	450 ha	Estimate 250ha.
	Salinity regime	up to 30ppt	up to 30ppt
	Length of salinity intrusion	NA	NA
	Residence Time and Flushing	< 3days. Est vol, 3.8 - 5.1 million m3	<3 days
	Slope of Catchment	Mixed	Mixed
	Wind Exposure	Moderate	Moderate
	Mean Tidal Range (m)	1.4 m at springs, 0.4m at neaps.	1.4 m at springs, 0.4m at neaps.
	Mean Freshwater Inflow (l/s)	1400	890
	Catchment Area (km2)	105km2. 6 streams flow into estuary.	66km2
	Limiting Nutrient (N or P)	N	N
Habitat Diversity	Sheltered fringe areas	Low	Nil - reclaimed, causeways, sea walls
	Salt Marsh/Dune Area (ha)	Moderate, lost half. Some now managed.	Most lost, 1 small arm salt marsh.
	Seagrass Abundance	Present	Present
	Tidal Flats present	High; 110ha	High; Estimate 100ha
	Sediments in Estuary	Varied - mainly muddy sands	Muddy bed mainly
	Margin buffer	Moderate.	Poor; extensive reclamation, walls, roads
Stressors	Catchment Rock Type	Hard; Greywacke sandstone	Hard; Greywacke sandstone
	Landuse	29, 54/0, 18,4.	25, 37.5/0.2, 8, 29.
	Number Dairy Cows		
	Catchment SS yield (t/km2/yr)	Low - Moderate; Background 50 (native forest); 160 for last 20 yrs.	Moderate; Estimate 100-500 .
	Catchment TN yield (kg/ha/yr)	Low- Moderate 5-14	Low- Moderate 5-14
	Point Source Inputs	Urban stormwater - sediment during development	High Urban stormwater
	Input Water Quality	3, 0.59, 0.038, 690	4, 1.4, 0.045, 790
	Sea Level Rise	Low- Mod	Low- Mod
	Other Stressors	Moderate	Low
Existing Condition	Macroalgal Blooms	Moderate	Moderate
	Phyto blooms	Low	Low
	DO depletion	Low	Low
	HABs offshore	Low	Low
	Anoxic sediments	Low- Mod	Moderate
	Sediment Quality	Sand and mud. Metals <50% ISQGLo. SVOCs; DDT exceeds ISQGLo and ARC ERC. PAHs <ISQGLo. Sed Rate; Good-Moderate; 4.8 mm/yr.	Muddy bed. Metals; < ISQGLo but some exceed ARC ERC amber alert. SVOCs; DDT exceeds ISQGLo and ARC ERC. PAHs < ISQGLo.
	Water Quality	Good	Good
Potential	Potential for Habitat Improvement	Moderate; Salt marsh revegetation and maintenance. Reduce sediment runoff	High, terrestrial margin and salt marsh development (slope and vegetation). Improve SW quality. Reduce sediment runoff

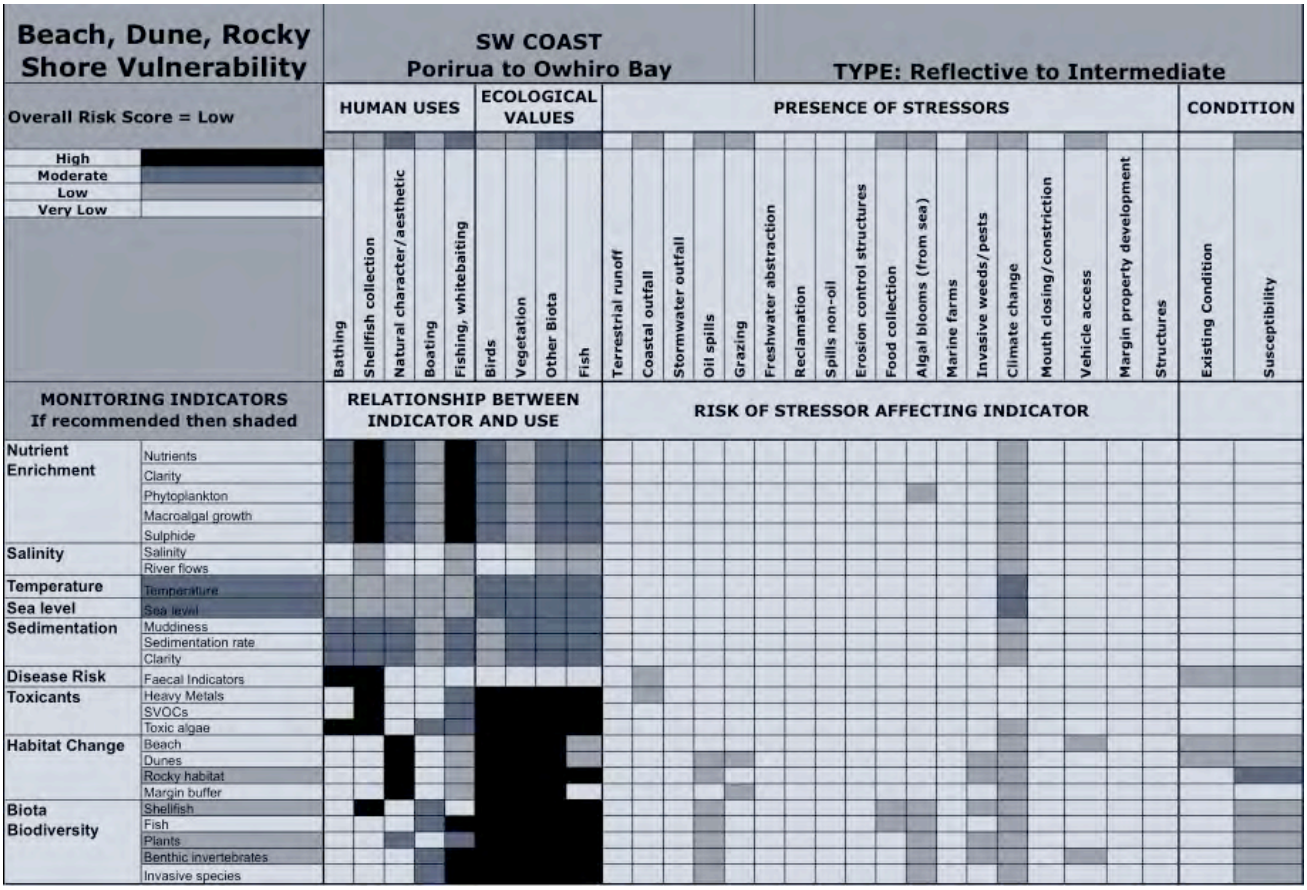
APPENDIX 2. ESTUARY CHARACTERISTICS

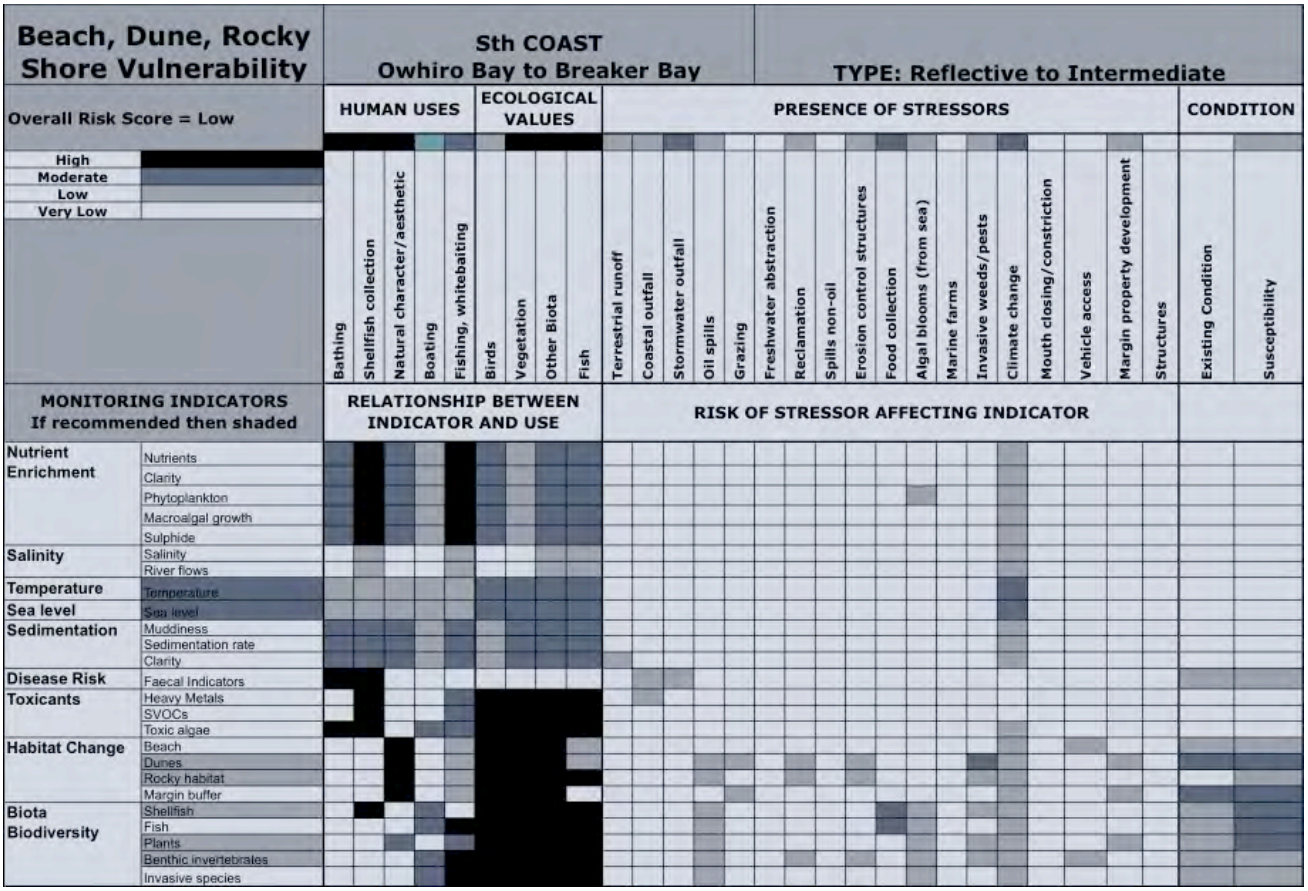
		Makara	Kaiwharawhara	Korokoro	Hutt
General	Type	Tidal River Mth	Tidal River Mth	Tidal River Mth	Tidal River Mth
	Mouth Closure	con	o	o	o
	Mean depth (m)	1-4m	0.5-1.5m	0.5-1.5m	1-3m
	Depth of central basin (m)	3-4m	1.5m	1.5m	?
	Estuary Area (ha)	15ha	0.5ha	1.5ha	
	Salinity regime	Varies	Varies	Varies	Salt wedge
	Length of salinity intrusion	1.5km	<100m	<100m	?
	Residence Time and Flushing	<3 days,Cl	<1day	<1day	<3days
	Slope of Catchment	Hilly	Hilly	Hilly	Varies
	Wind Exposure	Mod	Low	Low	Moderate
	Mean Tidal Range (m)	Small	0.8-1.4	0.8-1.4	
	Mean Freshwater Inflow (l/s)	1048	258	242	24,800
	Catchment Area (km2)	79	17	16	635
	Limiting Nutrient (N or P)	?	?	?	?
Habitat Diversity	Sheltered fringe areas	Low	None	None	Low
	Salt Marsh/Dune Area (ha)	2-3ha	<0.1ha	<0.1ha	1-2ha
	Seagrass Abundance	Low	Nil	Nil	Nil
	Tidal Flats present	Low/present	Very low	Very low	Low
	Sediments in Estuary	Sand/ mud	Gravels/mud	Gravels	Sands, Muds
	Margin buffer	Grassland	Hard roads	Park, grass, scrub	Rip rap banks
Stressors	Catchment Rock Type	Gw, Lo.	Gw, urban	Gw, Lo	Gw, Lo, urb
	Landuse	3, 67/0, 8,0.3	47,10/0,6,36	64,21/0, 12, 1.5	67, 12/1, 11, 6.4
	Number Dairy Cows	0	0	0	765
	Catchment SS yield (t/km2/yr)	LowMod, 50-200	Low-mod 10-200	Low-mod 10-200	Low-mod 10-200
	Catchment TN yield (kg/ha/yr)	Low, 3-8	Low 5-8	Low 3-8	Low 3-8
	Point Source Inputs	Low	Stormwater	Stormwater	Stormwater
	Input Water Quality	3.6, 0.67,0.029, 500	1.2,1.33,1.05,500	No data	1.9,0.33,0.015,57
	Sea Level Rise	Low	Low	Low	Low
	Other Stressors				
Existing Condition	Macroalgal Blooms	Low	Low	Low	Low
	Phyto blooms	Low	Low	Low	Low
	DO depletion	Low	Low	Low	Low
	HABs offshore	Possible	Possible	Possible	Possible
	Anoxic sediments	Low	Low	Low	Low
	Sediment Quality	Mud, low, low, low, ND, ND	No data	No data	Sand, low, ND, mod, mod, ND,
	Water Quality	No Data	No data	No data	No data
Potential	Potential for Habitat Improvement	Beach berm and estuary margin revegetaion potential. Estuary margin revegeta-tion.	Minimal area avail-able. Huge culverts limit scope.	Revegetation maintenance.	Margin revegetation and management. Options to reshape and vegetate banks.

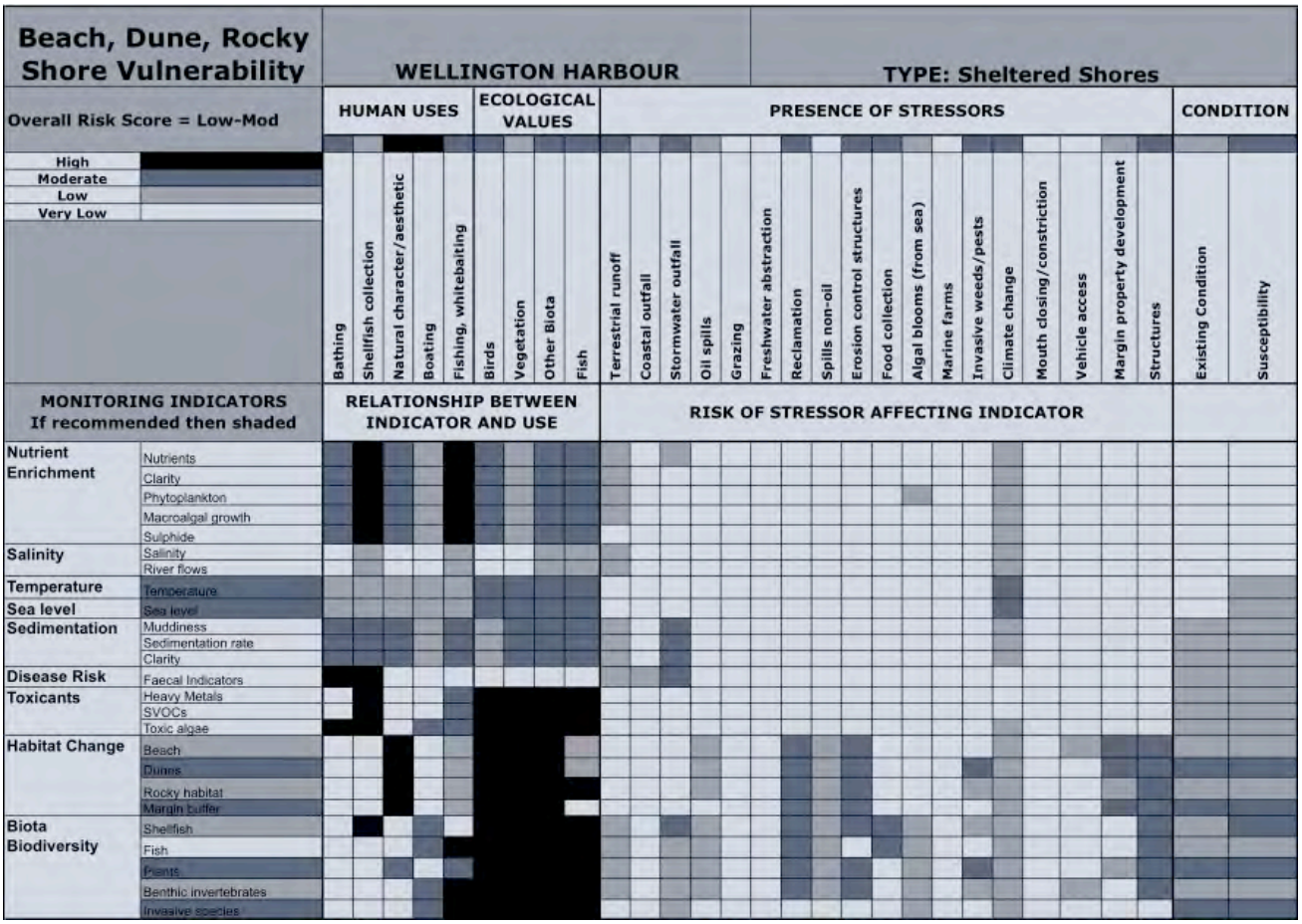
APPENDIX 3 COASTAL VULNERABILITY ASSESSMENTS

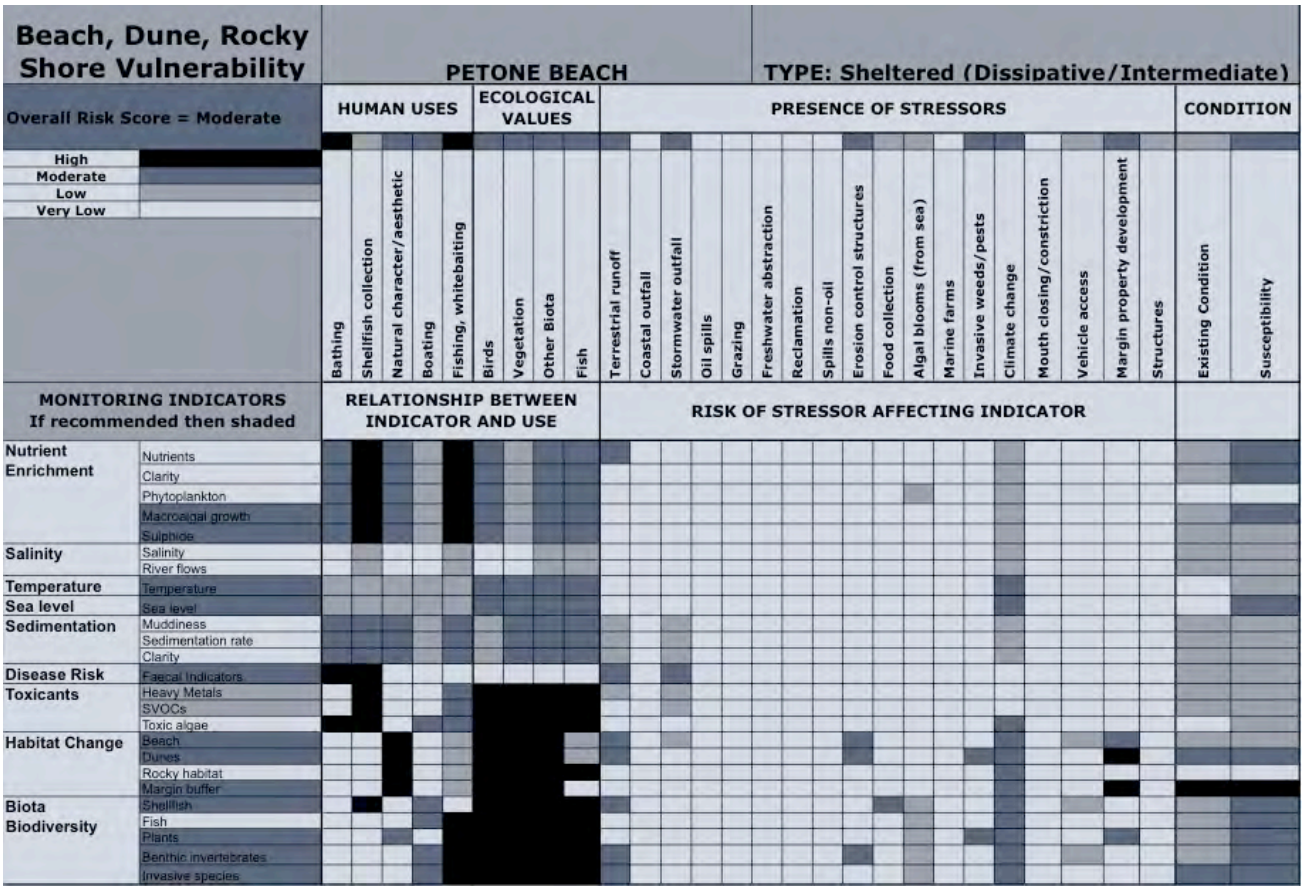

Beach, Dune, Rocky Shore Vulnerability
KAPITI COAST
TYPE: Dissipative/Intermediate
Overall Risk Score = Moderate
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Birds
Vegetation
Other Biota
Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RELATIONSHIP BETWEEN INDICATOR AND USE
RISK OF STRESSOR AFFECTING INDICATOR
Nutrient Enrichment
Nutrients
Clarity
Phytoplankton
Macroalgal growth
Sulphide
Salinity
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Beach
Dunes
Rocky habitat
Margin buffer
Biota Biodiversity
Shellfish
Fish
Plants
Benthic invertebrates
Invasive species

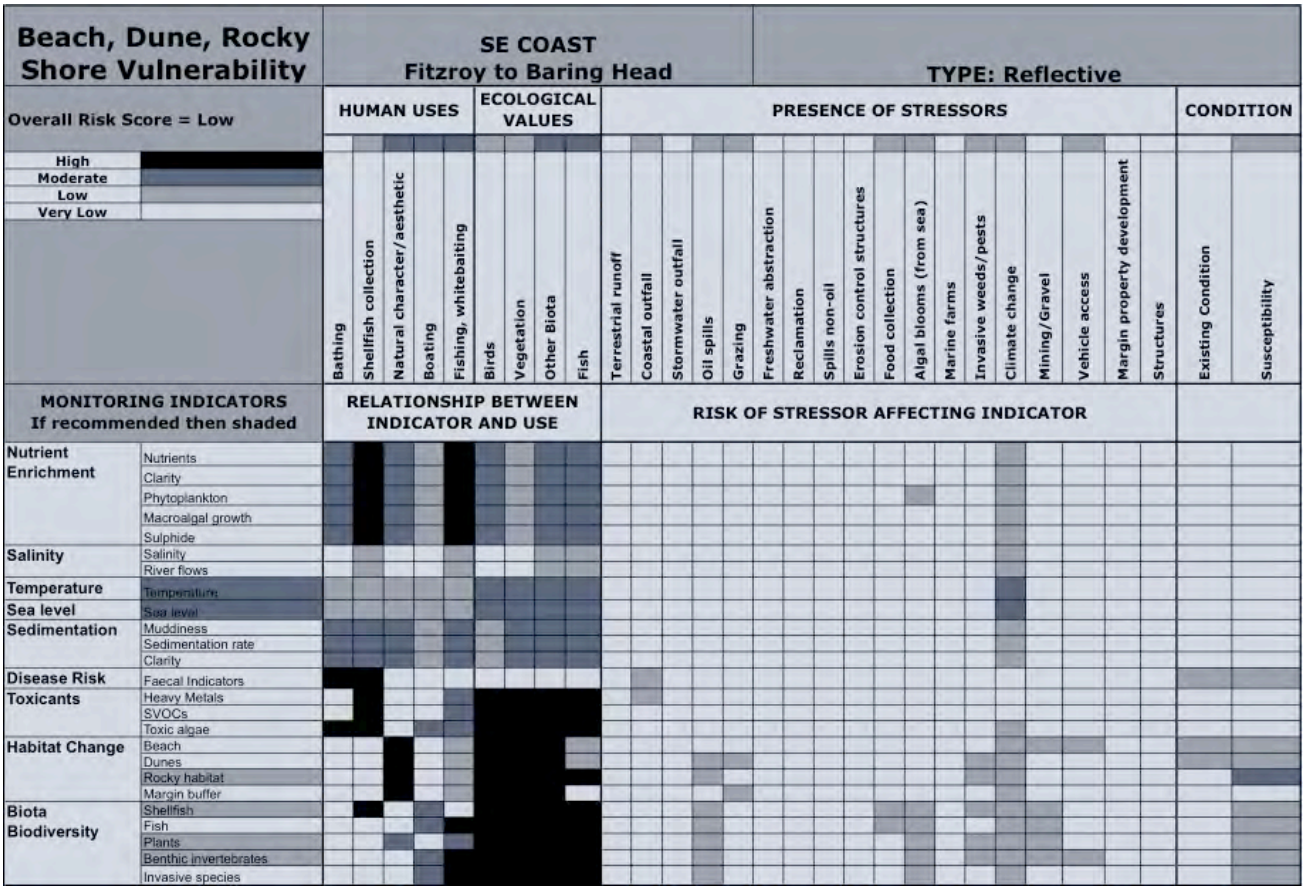

Beach, Dune, Rocky Shore Vulnerability
TITAHI BAY
TYPE: Intermediate
Overall Risk Score = Low-Mod
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Birds
Vegetation
Other Biota
Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RELATIONSHIP BETWEEN INDICATOR AND USE
RISK OF STRESSOR AFFECTING INDICATOR
Nutrient Enrichment
Nutrients
Clarity
Phytoplankton
Macroalgal growth
Sulphide
Salinity
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Beach
Dunes
Rocky habitat
Margin buffer
Biota Biodiversity
Shellfish
Fish
Plants
Benthic invertebrates
Invasive species

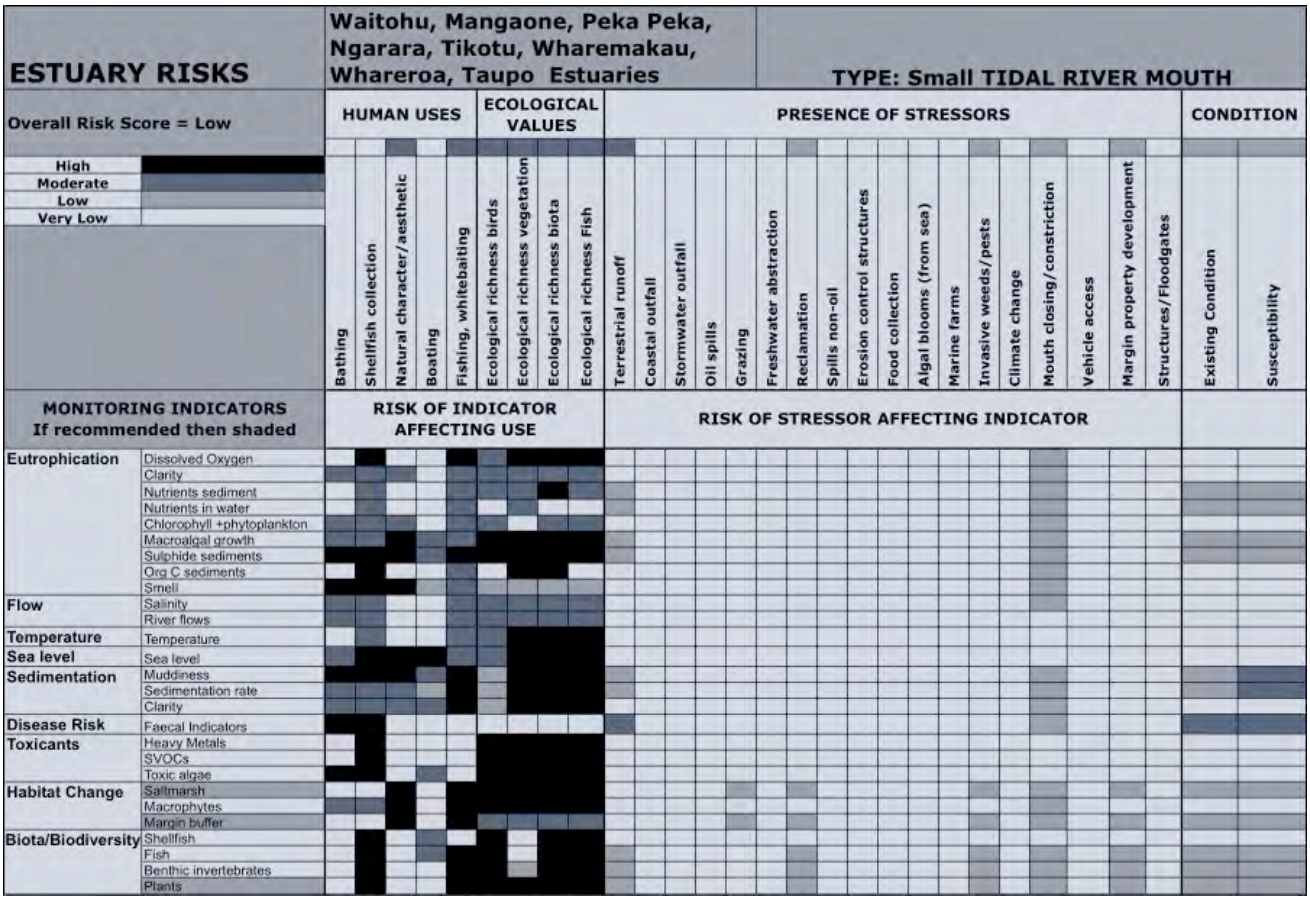

Beach, Dune, Rocky Shore Vulnerability
SW COAST
Porirua to Owhiro Bay
TYPE: Reflective to Intermediate
Overall Risk Score = Low
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Birds
Vegetation
Other Biota
Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RELATIONSHIP BETWEEN INDICATOR AND USE
RISK OF STRESSOR AFFECTING INDICATOR
Nutrient Enrichment
Nutrients
Clarity
Phytoplankton
Macroalgal growth
Sulphide
Salinity
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Beach
Dunes
Rocky habitat
Margin buffer
Biota Biodiversity
Shellfish
Fish
Plants
Benthic invertebrates
Invasive species

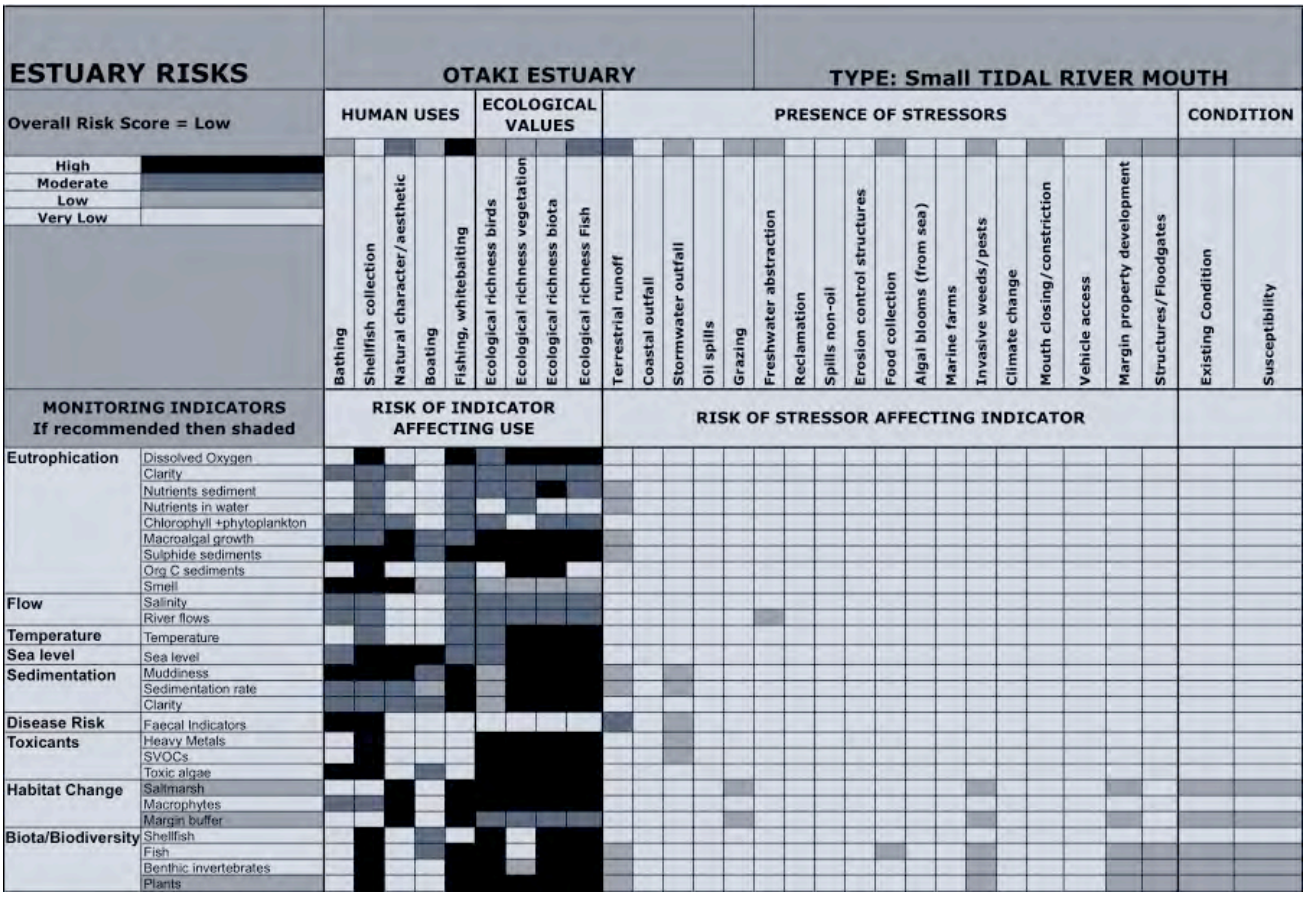

Beach, Dune, Rocky Shore Vulnerability
Sth COAST
Owhiro Bay to Breaker Bay
TYPE: Reflective to Intermediate
Overall Risk Score = Low
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Birds
Vegetation
Other Biota
Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RELATIONSHIP BETWEEN INDICATOR AND USE
RISK OF STRESSOR AFFECTING INDICATOR
Nutrient Enrichment
Nutrients
Clarity
Phytoplankton
Macroalgal growth
Sulphide
Salinity
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Beach
Dunes
Rocky habitat
Margin buffer
Biota Biodiversity
Shellfish
Fish
Plants
Benthic invertebrates
Invasive species

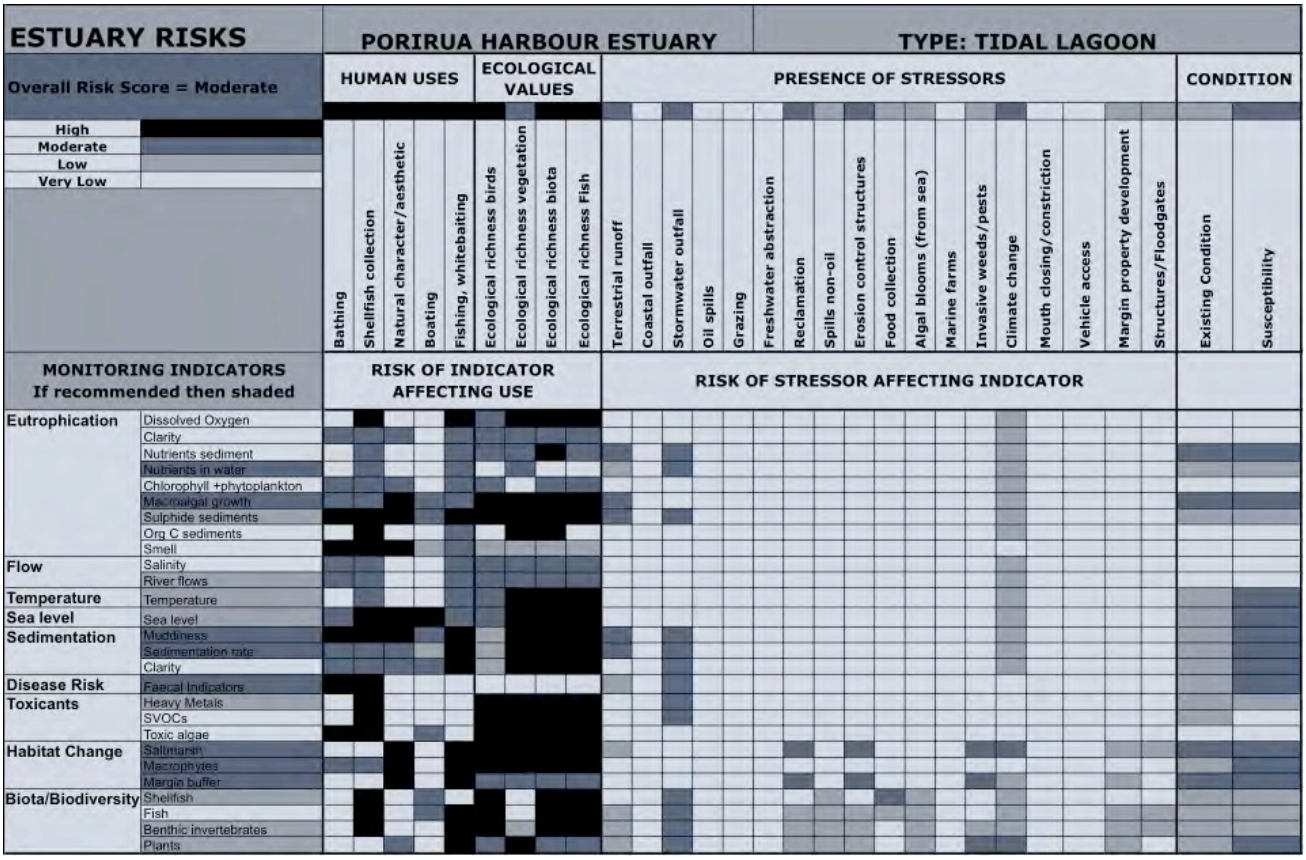

Beach, Dune, Rocky Shore Vulnerability
WELLINGTON HARBOUR
TYPE: Sheltered Shores
Overall Risk Score = Low-Mod
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Birds
Vegetation
Other Biota
Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RELATIONSHIP BETWEEN INDICATOR AND USE
RISK OF STRESSOR AFFECTING INDICATOR
Nutrient Enrichment
Nutrients
Clarity
Phytoplankton
Macroalgal growth
Sulphide
Salinity
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Beach
Dunes
Rocky habitat
Margin buffer
Biota Biodiversity
Shellfish
Fish
Plants
Benthic invertebrates
Invasive species

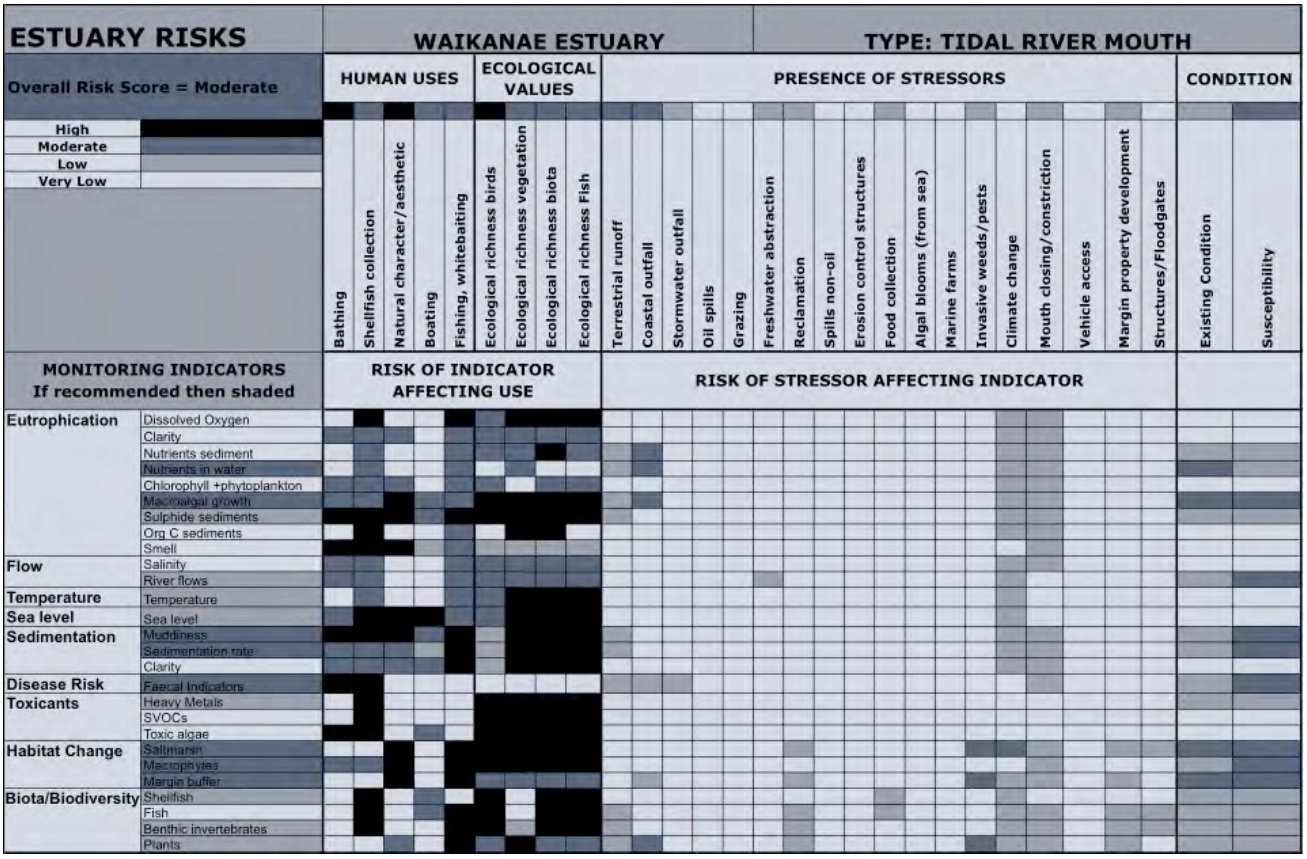

Beach, Dune, Rocky Shore Vulnerability
PETONE BEACH
TYPE: Sheltered (Dissipative/Intermediate)
Overall Risk Score = Moderate
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Birds
Vegetation
Other Biota
Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RELATIONSHIP BETWEEN INDICATOR AND USE
RISK OF STRESSOR AFFECTING INDICATOR
Nutrient Enrichment
Nutrients
Clarity
Phytoplankton
Macroalgal growth
Sulphide
Salinity
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Beach
Dunes
Rocky habitat
Margin buffer
Biota Biodiversity
Shellfish
Fish
Plants
Benthic invertebrates
Invasive species

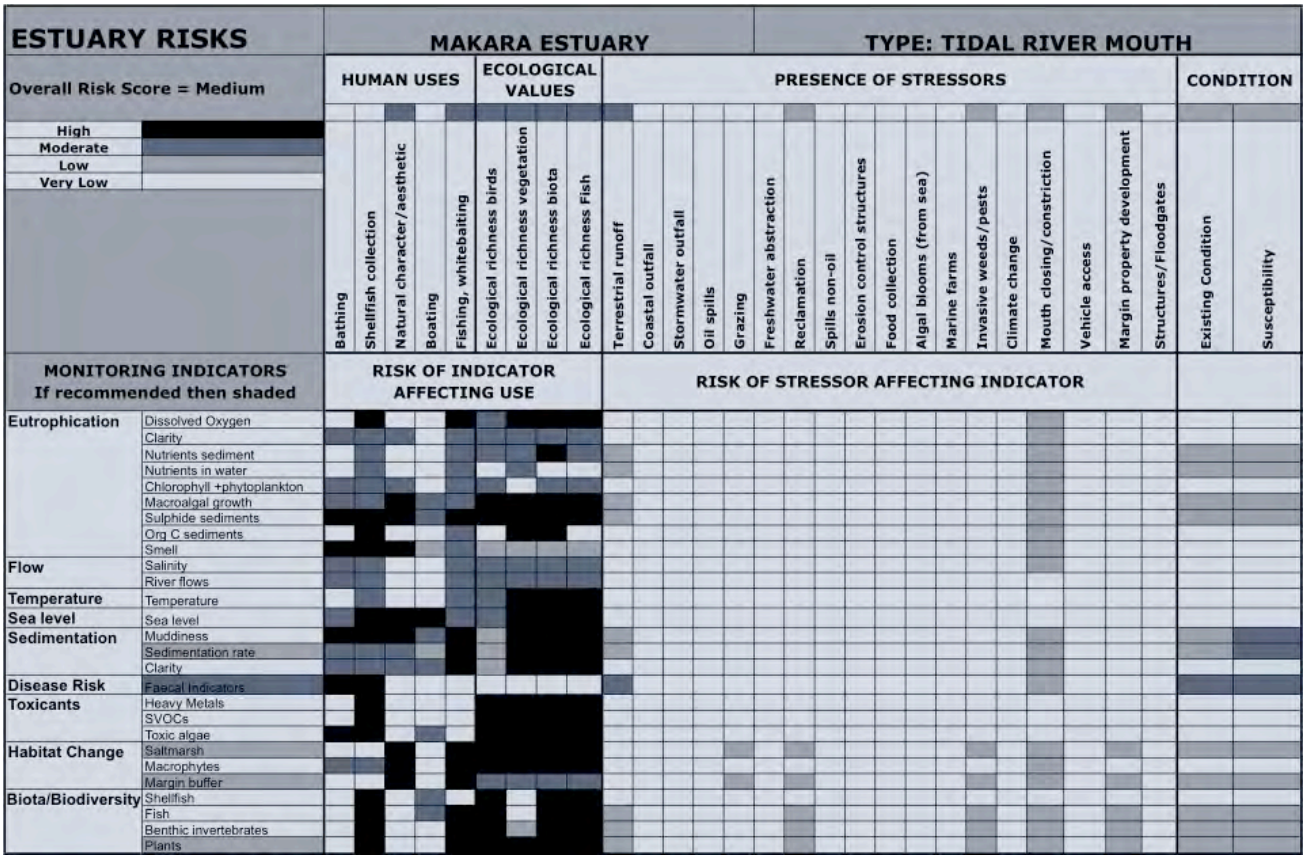

Beach, Dune, Rocky Shore Vulnerability
SE COAST
Fitzroy to Baring Head
TYPE: Reflective
Overall Risk Score = Low
High
Moderate
Low
Very Low
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Birds
Vegetation
Other Biota
Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mining/Gravel
Vehicle access
Margin property development
Structures
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RELATIONSHIP BETWEEN INDICATOR AND USE
RISK OF STRESSOR AFFECTING INDICATOR
Nutrient Enrichment
Nutrients
Clarity
Phytoplankton
Macroalgal growth
Sulphide
Salinity
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Beach
Dunes
Rocky habitat
Margin buffer
Biota Biodiversity
Shellfish
Fish
Plants
Benthic invertebrates
Invasive species

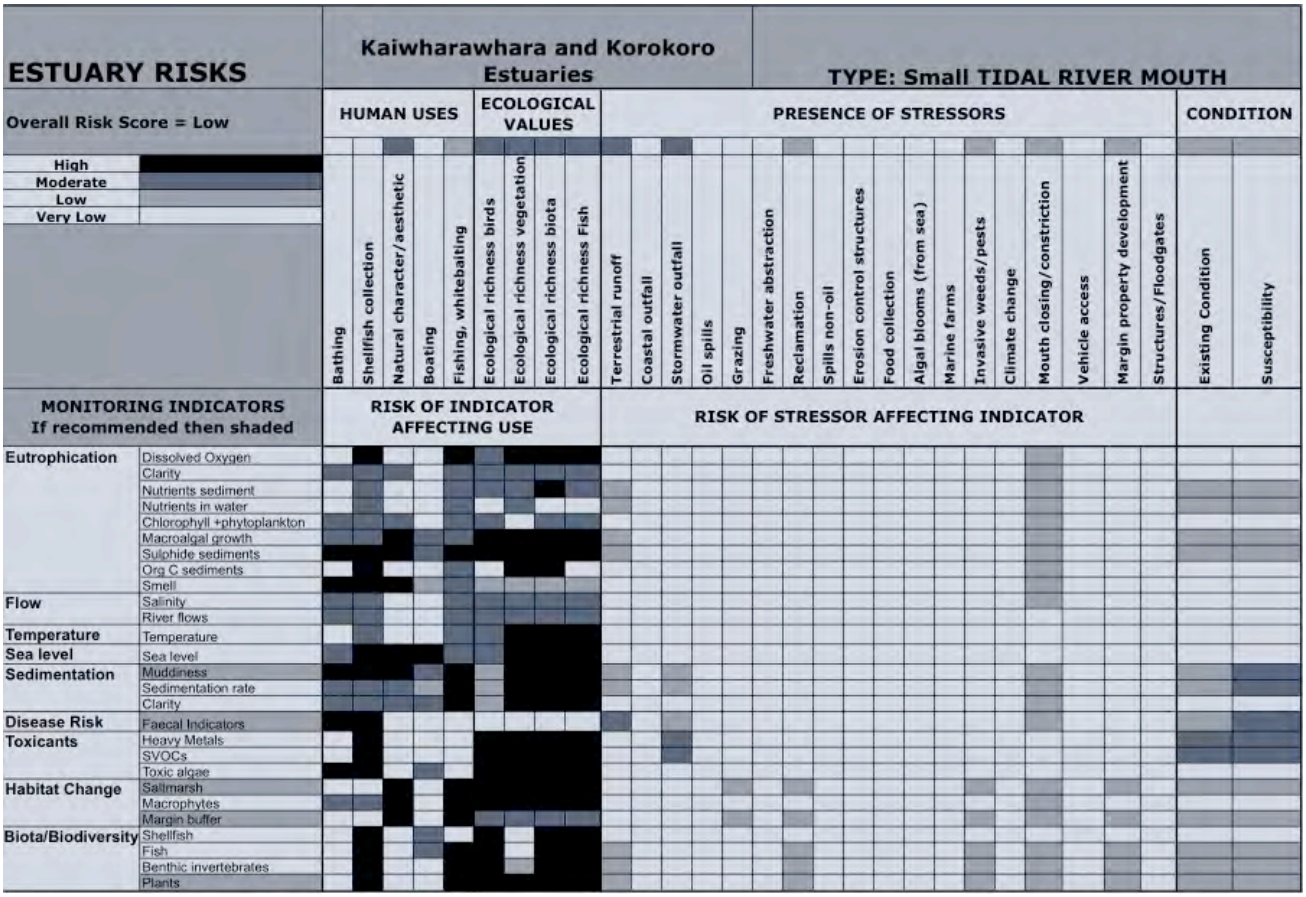

ESTUARY RISKS
Waitohu, Mangaone, Peka Peka, Ngarara, Tikotu, Wharemakau, Whareroa, Taupo Estuaries
TYPE: Small TIDAL RIVER MOUTH
Overall Risk Score = Low
High
Moderate
Low
Very Low
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Ecological richness birds
Ecological richness vegetation
Ecological richness biota
Ecological richness Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures/Floodgates
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RISK OF INDICATOR AFFECTING USE
RISK OF STRESSOR AFFECTING INDICATOR
Eutrophication
Dissolved Oxygen
Clarity
Nutrients sediment
Nutrients in water
Chlorophyll +phytoplankton
Macroalgal growth
Sulphide sediments
Org C sediments
Smell
Flow
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Saltmarsh
Macrophytes
Margin buffer
Biota/Biodiversity
Shellfish
Fish
Benthic invertebrates
Plants

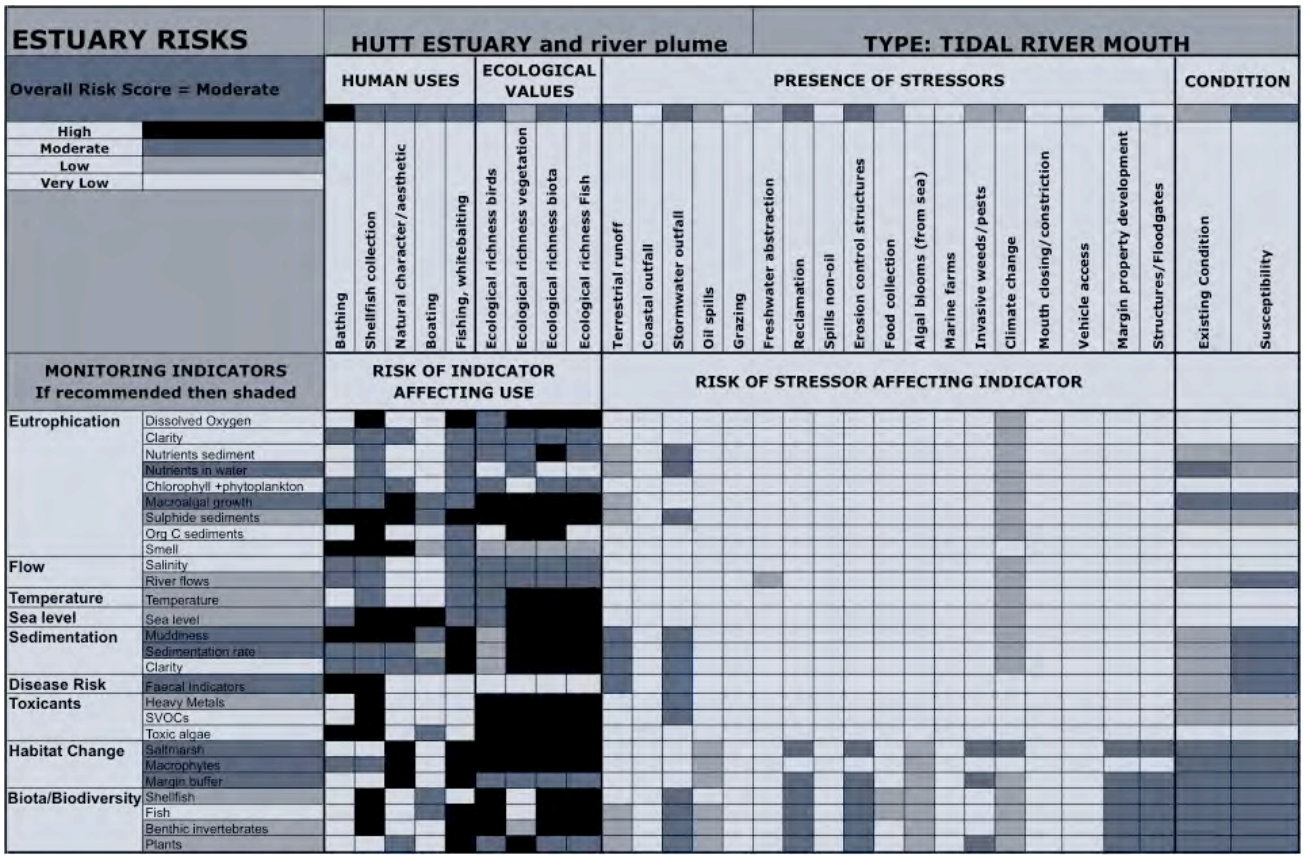

ESTUARY RISKS
OTAKI ESTUARY
TYPE: Small TIDAL RIVER MOUTH
Overall Risk Score = Low
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Ecological richness birds
Ecological richness vegetation
Ecological richness biota
Ecological richness Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures/Floodgates
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RISK OF INDICATOR AFFECTING USE
RISK OF STRESSOR AFFECTING INDICATOR
Eutrophication
Dissolved Oxygen
Clarity
Nutrients sediment
Nutrients in water
Chlorophyll +phytoplankton
Macroalgal growth
Sulphide sediments
Org C sediments
Smell
Flow
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Saltmarsh
Macrophytes
Margin buffer
Biota/Biodiversity
Shellfish
Fish
Benthic invertebrates
Plants


ESTUARY RISKS
PORIRUA HARBOUR ESTUARY
TYPE: TIDAL LAGOON
Overall Risk Score = Moderate
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Ecological richness birds
Ecological richness vegetation
Ecological richness biota
Ecological richness Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures/Floodgates
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RISK OF INDICATOR AFFECTING USE
RISK OF STRESSOR AFFECTING INDICATOR
Eutrophication
Dissolved Oxygen
Clarity
Nutrients sediment
Nutrients in water
Chlorophyll +phytoplankton
Macroalgal growth
Sulphide sediments
Org C sediments
Smell
Flow
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Saltmarsh
Macrophytes
Margin buffer
Biota/Biodiversity
Shellfish
Fish
Benthic invertebrates
Plants


ESTUARY RISKS
WAIKANAE ESTUARY
TYPE: TIDAL RIVER MOUTH
Overall Risk Score = Moderate
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Ecological richness birds
Ecological richness vegetation
Ecological richness biota
Ecological richness Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures/Floodgates
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RISK OF INDICATOR AFFECTING USE
RISK OF STRESSOR AFFECTING INDICATOR
Eutrophication
Dissolved Oxygen
Clarity
Nutrients sediment
Nutrients in water
Chlorophyll +phytoplankton
Macroalgal growth
Sulphide sediments
Org C sediments
Smell
Flow
Salinity
River flows
Temperature
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Saltmarsh
Macrophytes
Margin buffer
Biota/Biodiversity
Shellfish
Fish
Benthic invertebrates
Plants


ESTUARY RISKS
MAKARA ESTUARY
TYPE: TIDAL RIVER MOUTH
Overall Risk Score = Medium
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Ecological richness birds
Ecological richness vegetation
Ecological richness biota
Ecological richness Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures/Floodgates
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RISK OF INDICATOR AFFECTING USE
RISK OF STRESSOR AFFECTING INDICATOR
Eutrophication
Dissolved Oxygen
Clarity
Nutrients sediment
Nutrients in water
Chlorophyll +phytoplankton
Macroalgal growth
Sulphide sediments
Org C sediments
Smell
Flow
Salinity
River flows
Temperature
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Saltmarsh
Macrophytes
Margin buffer
Biota/Biodiversity
Shellfish
Fish
Benthic invertebrates
Plants


ESTUARY RISKS
Kaiwharawhara and Korokoro Estuaries
TYPE: Small TIDAL RIVER MOUTH
Overall Risk Score = Low
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Ecological richness birds
Ecological richness vegetation
Ecological richness biota
Ecological richness Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures/Floodgates
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RISK OF INDICATOR AFFECTING USE
RISK OF STRESSOR AFFECTING INDICATOR
Eutrophication
Dissolved Oxygen
Clarity
Nutrients sediment
Nutrients in water
Chlorophyll +phytoplankton
Macroalgal growth
Sulphide sediments
Org C sediments
Smell
Flow
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Saltmarsh
Macrophytes
Margin buffer
Biota/Biodiversity
Shellfish
Fish
Benthic invertebrates
Plants


ESTUARY RISKS
HUTT ESTUARY and river plume
TYPE: TIDAL RIVER MOUTH
Overall Risk Score = Moderate
HUMAN USES
ECOLOGICAL VALUES
PRESENCE OF STRESSORS
CONDITION
High
Moderate
Low
Very Low
Bathing
Shellfish collection
Natural character/aesthetic
Boating
Fishing, whitebaiting
Ecological richness birds
Ecological richness vegetation
Ecological richness biota
Ecological richness Fish
Terrestrial runoff
Coastal outfall
Stormwater outfall
Oil spills
Grazing
Freshwater abstraction
Reclamation
Spills non-oil
Erosion control structures
Food collection
Algal blooms (from sea)
Marine farms
Invasive weeds/pests
Climate change
Mouth closing/constriction
Vehicle access
Margin property development
Structures/Floodgates
Existing Condition
Susceptibility
MONITORING INDICATORS
If recommended then shaded
RISK OF INDICATOR AFFECTING USE
RISK OF STRESSOR AFFECTING INDICATOR
Eutrophication
Dissolved Oxygen
Clarity
Nutrients sediment
Nutrients in water
Chlorophyll +phytoplankton
Macroalgal growth
Sulphide sediments
Org C sediments
Smell
Flow
Salinity
River flows
Temperature
Temperature
Sea level
Sea level
Sedimentation
Muddiness
Sedimentation rate
Clarity
Disease Risk
Faecal Indicators
Toxicants
Heavy Metals
SVOCs
Toxic algae
Habitat Change
Saltmarsh
Macrophytes
Margin buffer
Biota/Biodiversity
Shellfish
Fish
Benthic invertebrates
Plants